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3,398,558

FINGERPRINT CONTROL SYSTEM

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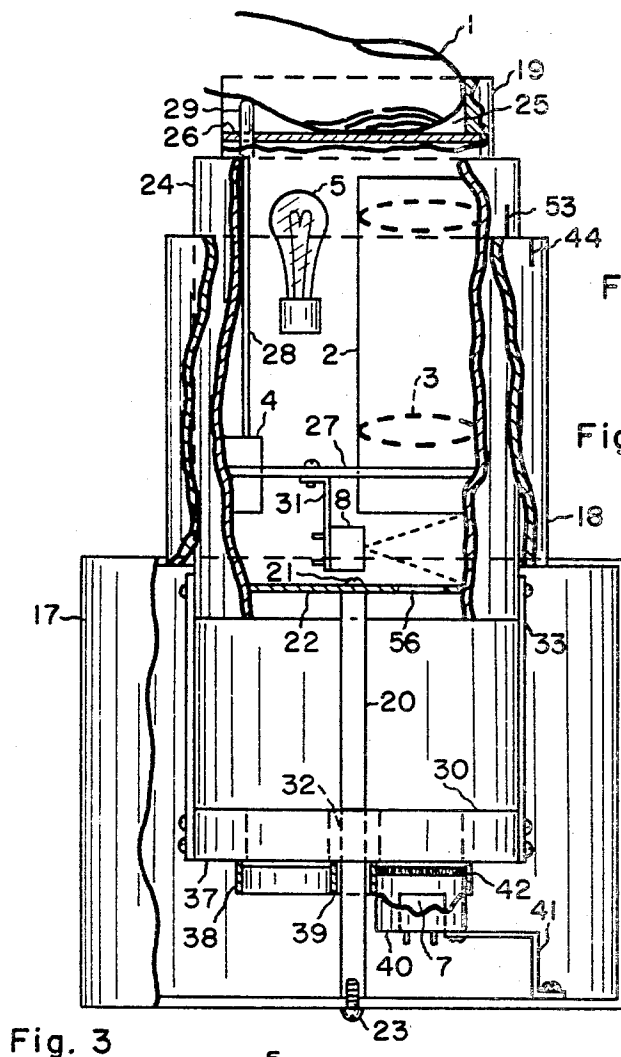


Fig. 3

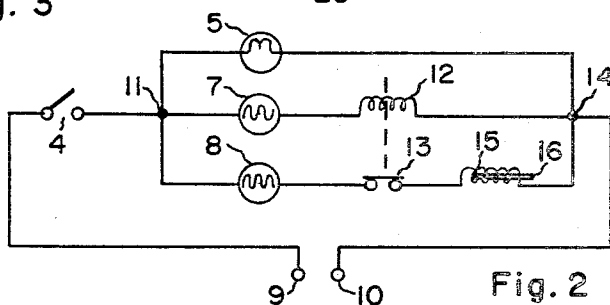


Fig. 2

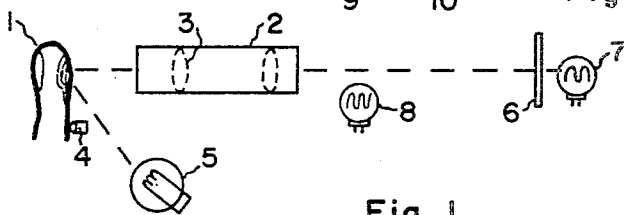


Fig. 1

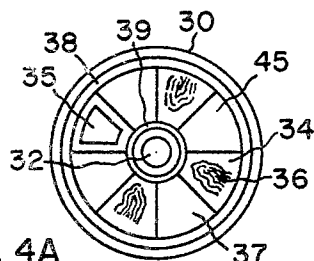


Fig. 4A

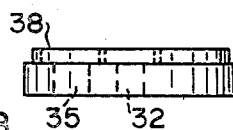


Fig. 4B

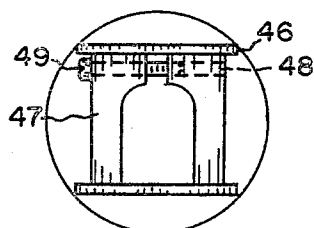


Fig. 5

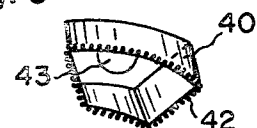


Fig. 6

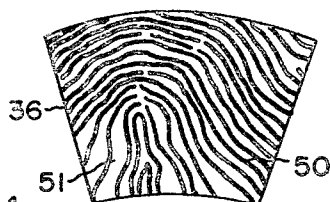


Fig. 7

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FINGERPRINT CONTROL SYSTEM

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ABSTRACT OF THE DISCLOSURE

A control system for operating a door lock in response to a predetermined fingerprint pattern comprises means for projecting a light image of a person's finger onto one surface of a reference mask containing a master fingerprint pattern composed of opaque and transparent portions. A photosensitive device is positioned on the other side of the mask and responds to a light null, produced by correspondence of the light image and the master pattern, to actuate a control mechanism that unlocks the door. In order to make the system tamper-proof, a second photo-sensitive device is arranged to receive a portion of the light image before it reaches the mask. The second photosensitive device inhibits the operation of the lock unless it receives a given minimum quantity of light.

This invention relates to automatic control systems and, more particularly, to a novel door control system which operates in response to a predetermined fingerprint pattern.

Conventional key-operated door locks are subject to certain well known disadvantages. For example, a person may lose his key and thus be prevented from gaining admittance to his home without a great deal of inconvenience. Furthermore, a lost or stolen key may fall into the hands of an unauthorized person who may then gain admittance for some unlawful purpose. It is therefore evident that a key-operated lock does not provide a perfect degree of safety for the home or other premises to be protected.

This problem has been solved in at least one system by utilizing the characteristic fingerprint pattern of an authorized person to automatically control the door lock upon presentation of the authorized fingertip to the door control system. The prior art door control system includes means for optically scanning, point-by-point, a fingertip presented to the system and generating a first electric signal corresponding to the pattern thereof, means for simultaneously scanning a reference fingerprint and generating a second signal corresponding to the pattern thereof, and means responsive to correspondence of the first and second signals for operating the door control member only upon substantial identity between the two patterns. However, that system utilizes a relatively slow mechanical optical scanning technique as well as some very complex and expensive electronic circuitry for achieving the desired result.

It is therefore an object of the present invention to provide an automatic control system which operates in response to a predetermined characteristic fingerprint pattern.

It is another object of the invention to provide an automatic fingerprint door control system which is of relatively simple construction but nevertheless provides a high degree of safety.

It is still another object of the invention to provide a door control system which does not require the use of a key to operate it, and which operates in response to the characteristic fingerprint patterns of one or more predetermined individuals.

A further object of the invention is to provide a photoelectric door control system in which the entire fingerprint pattern presented to the system is simultaneously com-

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pared with a master or reference fingerprint pattern at a single instant of time thereby to operate the door control system upon substantial identity thereof.

The foregoing and other objects are accomplished by projecting a light image of the entire fingerprint pattern of interest onto a mask containing a reference fingerprint pattern. A photoresponsive device is positioned so as to be responsive to a high degree of correspondence of the light image and the reference pattern thereby to operate the control system to open a door or provide some other desired control operation in response thereto. It is a feature of the invention that the light image of the unknown fingerprint pattern may be compared directly with the reference fingerprint pattern by simple optical techniques without the need for optical or electronic scanning apparatus.

In order to provide a completely tamper proof system, the invention is further characterized by the provision of a second photoresponsive device for checking the operation of the system. The second photoresponsive device is arranged to receive a portion of the fingerprint light image before it reaches the mask containing the reference pattern. In accordance with the quantity of light received, the second photoresponsive device will control the operation of the door control system.

It is therefore a further object of the invention to provide an automatic fingerprint door control system or the like having means for automatically checking the operation thereof to prevent operation of the system by unauthorized persons.

The foregoing and other objects and features of the invention will become apparent from the following detailed description of the invention, taken in connection with the accompanying drawing, wherein like reference numerals denote like parts throughout the various views and in which:

FIG. 1 is a diagrammatic representation illustrating the broad features of the invention;

FIG. 2 is a circuit diagram of the electrical control system of the invention;

FIG. 3 is a front elevation view of a preferred embodiment of the invention;

FIGS. 4A and 4B illustrate a preferred form of reference mask employed in the apparatus of FIG. 3;

FIG. 5 illustrates one form of finger centering apparatus for use in the invention;

FIG. 6 illustrates the details of the master photocell housing of the apparatus of FIG. 3; and

FIG. 7 illustrates a film negative containing a typical reference fingerprint pattern.

Referring now to the accompanying drawing, there is shown in the figures an illustrative embodiment of the invention used to control the unlocking of a door. In FIG. 1, a finger 1 of a person desiring admittance to a locked room or the like is placed in front of an objective 2 having a lens system 3. Presentation of the finger to the system closes a switch 4 to energize the system. A light source 5 is then energized and illuminates a substantial area on the finger. The finger reflects the light beam towards the objective 2 which focuses a positive light image of the illuminated fingerprint onto a negative mask 6. The mask 6 contains a master or reference fingerprint pattern thereon of the authorized person to be admitted to the locked room. The mask may be an ordinary photographic film negative having transparent and opaque portions in accordance with the authorized fingerprint pattern. If the fingerprint pattern of the finger is identical to the reference pattern on the mask 6, then no light passes through the mask to the photosensitive device 7.

A second photosensitive device 8 is arranged to intercept a portion of the light image before it reaches the

reference mask 6. The purpose of photocell 8 is to check the operation of the system to prevent tampering therewith by unauthorized persons, as will become apparent from the discussion to follow.

Referring now to FIG. 2, there is shown an electrical schematic of the door control system. A pair of input terminals 9, 10 are provided for connection to a source of alternating or direct current, not shown. Terminal 9 is connected to one side of switch 4. The other side of switch 4 is connected to the common connection 11 of light source 5 and photocells 7 and 8.

A relay 12 having a normally closed contact 13 is connected in series with photocell 7 between junction point 11 and a junction point 14. A door solenoid 15 is connected in series with photocell 8 and relay contact 13 between junction points 11 and 14. The other terminal of light source 5 is connected to junction 14. Junction point 14 is directly connected to input terminal 10.

The door control system operates in the following manner. A person desiring admittance places his finger in a finger centering device (not shown in FIG. 1) which automatically aligns the fingertip with the light source 5, the objective 2 and the negative mask 6. Switch 4 is closed thereby energizing light source 5. A light image of the reflected fingerprint pattern is focused onto the reference mask 6 by means of objective 2. If the pattern of the fingerprint image matches the reference pattern on mask 6, no light strikes photoresponsive device 7 which thereby presents a high impedance to current flow. As a result, a very small current flows through photoresponsive device 7 and relay winding 12. This current is too small to pick-up the relay and contact 13 remains closed.

However, photosensitive device 8 receives a sufficient quantity of light so that its impedance is relatively low. A fairly large current flows from terminals 9 and 10 through switch 4, photocell 8, contact 13 and solenoid 15. This latter current is sufficient to energize solenoid 15 to retract a latch bolt 16 to unlock the door.

If, on the other hand, an unauthorized person attempts to gain entry, there will be a mismatch of the fingerprint light image and the reference fingerprint pattern on negative mask 6. A small amount of light then passes through the mask 6 and strikes master photocell 7. The impedance of photoresponsive device 7 is reduced to a sufficiently low value such that the current flow in relay winding 12 picks up the contact 13 and opens the circuit to the door solenoid. The door remains locked to the unauthorized person.

The purpose and function of check photocell 8 will now be described. Let us assume that lamp 5 burns out. If switch 4 is closed by an unauthorized person, no light can strike master photocell 7 and therefore its impedance is high, relay 12 does not pick up and contact 13 is closed. At the same time, no light can strike check photocell 8 either and so its impedance is also high. The current flow through door solenoid 15 is now too low to energize it and the door remains locked.

As a second example, let us assume that an unauthorized person attempts to gain admittance by placing a black non-reflecting object in the finger-centering device and closes switch 4. In this case, very little, if any, light will strike master photocell 7, and as described above, contact 13 remains closed. However, light does not strike check photocell 8 either and its impedance therefore remains high. As a result, door solenoid 15 will not be energized and the door remains locked. It is thus seen that the system is virtually tamper-proof and thereby provides a high degree of security.

A specific embodiment of the invention will now be described with reference to the remaining figures of the drawing. In FIG. 3 there is shown a light tight container 17 having a hollow tubular extension 18. Positioned within the tubular portion 18 is a cylindrical housing 19. The cylindrical housing 19 is mounted on a shaft 20 by means of a screw 21 passing through the rear wall 22 of the

housing. The shaft 20 is mounted to the rear wall of the container 17 by means of a screw 23.

A hollow tubular member 24 is rotatably mounted between the cylindrical housing 19 and the tubular extension 18 of the container.

The front face of housing 19 is recessed to provide a comparison or test station 25 for the finger. A glass window 26 forms the bottom wall thereof. The comparison station preferably includes a finger centering device, for example, of the type shown in FIG. 5. The finger centering device comprises a pair of parallel guides 46 and a pair of finger positioning members 47. One or both of the members 47 are arranged to slide within the guides 46 thereby to adjust the device to different size fingers. In order to hold a finger in position, the members 47 may be spring loaded so that they are urged towards one another and clamp the finger in place. Alternatively, one of the members 47 may include a threaded hole 48. A threaded bolt 49 passes through a hole in the other member 47 and is screwed into the threaded hole 48 so as to displace the members 47 relative to one another.

Within housing 19 is a wall 27 which seals off the interior of container 17 from extraneous light. The wall 27 has a mounting hole for switch 4. Extending from the switch is a shaft 28 which terminates in a button 29 protruding through the window and into the test station. Upon presentation of a finger 1 to the test station 25, the switch 4 is actuated, and by means of the circuit shown in FIG. 2, the lamp 5 is energized. The lamp 5 is mounted within housing 19 by any convenient means (not shown). Lamp 5 illuminates the finger through the glass window 26. A fingerprint image is reflected towards the objective 2 having a suitable lens system 3 for focusing the light image through a hole 56 in the rear wall 22 of the housing towards a transparent disc 30. The disc 30 may be composed of lucite or other suitable transparent material. The objective 2 is mounted in a hole in wall 27 and is fixed to the housing 19 by means of a bracket or other suitable means (not shown). The relay 12 may be mounted at any convenient location within the container 17, or it may even be located outside of the container.

A check photocell 8 is mounted on the wall 27 by means of a bracket 31. The check photocell is positioned so as to intercept a portion of the light image passing out of objective 2.

The transparent disc 30 has a hole through its center and is thereby rotatably mounted about shaft 20. The disc 30 is also mounted on the rotatable tubular member 24 by means of a plurality of parallel mounting brackets 33 spaced about the periphery of the disc 30 and the tubular member 24.

In order to provide a door control system which can be operated by several different persons, for example, all the members of a family, the disc 30 is subdivided into a plurality of identical sections, for example, four sections, as shown in FIG. 4. FIG. 4A is a view of the disc 30 looking at the rear face 37 of the disc. In each of the four sections 34 there is an opening 35 which allows the light image to pass through the disc 30. On the rear face 37 of the disc, over each hole 35, there is fastened a photographic film negative 36 of a different authorized fingerprint pattern. The film negative 36 is shown in greater detail in FIG. 7. The film negative comprises opaque portions 50 and transparent portions 51 arranged in accordance with the characteristic fingerprint pattern of an authorized person who is to control the door lock. Also on the rear face 37 of the disc there are two raised rails 38 and 39 coaxially arranged thereon. FIG. 4B is an elevation view of the disc 30.

Returning now to FIG. 3, a sector-shaped housing 40 is shown mounted to the rear wall of container 17 by means of a bracket 41. Housing 40 is positioned within the rails 38 and 39 of disc 30. A brush 42 is fastened about the circumference of housing 40 in contact with

the master negative 36 and serves to provide a light seal between the master negative and the housing 40. The brush also serves to clean off any dust or dirt on the negative whenever the cylinder 24 is rotated. In the back wall of the housing 40 there is a hole 43 in which the master photocell 7 is mounted. The construction of housing 40 can be seen in greater detail by reference to FIG. 6.

A single index mark 53 is scribed on the outer surface of the rotatable cylinder 24. About the periphery of the cylindrical extension 18 are four equally spaced index marks 44, only one of which is shown in FIG. 3. An authorized person desiring admittance to the locked premises rotates cylinder 24 until index mark 43 is in alignment with a predetermined one of the index marks 44. As a result, the disc 30 is rotated so that the authorized persons master negative 36 is aligned with the master photocell 7 and with the light image projected by objective 2. Identity of the fingerprint image and the reference fingerprint pattern on film negative 36 operates the door lock as described above. A suitable detent arrangement may be provided to positively and accurately hold the cylinder 24 in a predetermined condition of alignment for each of the four film negative positions.

It was previously mentioned that disc 30 is composed of lucite or other transparent material. The purpose of this construction will now be discussed. If the intermediate portions 45 of disc 30 between the film negative 36 were opaque, then an unauthorized person could rotate cylinder 24 to a position between two adjacent index marks 44 so that an opaque portion 45 of the disc was directly in the path of the light image. In this case, upon closure of switch 4, check photocell 8 would receive light and master photocell 7 would be in the dark because the opaque portion 45 of the disc 30 would prevent the light from reaching photocell 7. As can be seen from FIG. 2, the set of conditions for energizing door solenoid 15 so as to unlock the door are thereby fulfilled and an unauthorized person could then gain admittance to the locked premises. However, since all of disc 30 is in fact transparent, light will pass through the portion 45 and strike master photocell 7. Relay 12 will pick up and by means of contact 13 open the circuit to the door solenoid 15. Entry by unauthorized persons is thereby prevented.

Although the control system of my invention has been described with reference to a door control system, it will be obvious that the invention has utility to perform a wide variety of control functions other than the control of a door. Furthermore, for greater security, the system can be arranged to respond to the simultaneous presentation of two or more fingerprint patterns of one or more persons.

While the invention has been described with reference to a particular embodiment thereof, it will be obvious that numerous modifications will appear to those skilled in the art without departing from the spirit and scope of the invention, which is limited only as defined in the appended claims.

I claim:

1. A control system for actuating a control member in response to a predetermined authorized characteristic fingerprint pattern of a finger comprising, means for illuminating a finger presented to said control system, first photosensitive means positioned to receive a light image fingerprint pattern reflected from said finger, a reference mask positioned in front of the photosensitive means in the path of the reflected light image and containing said predetermined characteristic fingerprint pattern delineated by opaque and transparent portions arranged to produce a light null at said first photosensitive means only upon substantial identity between the reflected light image pattern and the reference mask pattern, means responsive to said first photosensitive means for actuating said control member upon the occurrence of said light null thereat, and means for checking the system operation to

prevent tampering by unauthorized persons, said checking means comprising second photosensitive means positioned to receive a portion of said authorized reflected light image fingerprint pattern before it strikes said reference mask and connected to said control member so as to inhibit the operation thereof unless a predetermined minimum quantity of light is received by said second photosensitive means.

2. A system as described in claim 1 further comprising means for focusing said reflected light image onto said reference mask.

3. A door control system comprising a control member for operating the door lock automatically in response to a predetermined characteristic fingerprint pattern, means for illuminating a finger presented to the system by a person desiring to operate said control member, a reference mask including thereon a master copy of said predetermined characteristic fingerprint pattern, said fingerprint pattern and said mask having substantially opposite light transmissive properties, means positioned in the path of the light image reflected by said finger for focusing a light pattern of the fingerprint onto said reference mask, first photoelectric means positioned to receive light energy passing through the reference mask, said reference mask being arranged to produce a light null at said first photosensitive means only upon substantial identity between the fingerprint light pattern focused on said mask and the master fingerprint pattern thereon, means controlled by said first photosensitive means for actuating said control member upon the occurrence of said light null at the first photosensitive means, second photoelectric means positioned to receive a portion of all reflected light images before they reach said first photoelectric means, and means connecting said second photosensitive means in circuit with said control member so as to inhibit the operation thereof unless a quantity of light is received by said second photosensitive means which is above a given minimum threshold level.

4. A door control system comprising a control member for operating said door automatically in response to a predetermined characteristic fingerprint pattern, a test station including means for receiving a finger, means for illuminating said test station, first photosensitive means positioned to receive a light image pattern of a fingerprint reflected from the finger positioned in said test station, a reference mask positioned between said test station and said first photosensitive means in the path of the reflected light image, said reference mask comprising opaque and transparent portions arranged in accordance with said predetermined characteristic fingerprint pattern so that said reference mask prevents the light image from striking said first photosensitive means only if the light image pattern matches the pattern on said mask, second photosensitive means positioned to receive a portion of said reflected light image before it strikes said reference mask, and means including said first and second photosensitive means for actuating said control member only in response to the simultaneous occurrence of a light null at said first photosensitive means and a predetermined minimum threshold level of light at said second photosensitive means.

5. A system as described in claim 4 wherein said control member comprises a door solenoid and said actuating means comprises relay means serially connected with said first photosensitive means and a source of electric current, said relay means having a switch contact connected in series circuit with said second photosensitive means, said door solenoid and said source of electric current.

6. A system as described in claim 4 wherein said test station comprises means for aligning said finger in a predetermined position and switch means arranged to operate upon insertion of said finger in the test station thereby to supply electric current to said illuminating means and to said actuating means.

7. A door control system for actuating a control mem-

ber in response to one or more predetermined characteristic fingerprint patterns comprising, a closed container including a finger test station comprising a window, a light source mounted within said container so as to project a light beam towards said window, first photosensitive means mounted within said container in the path of a light image pattern of the fingerprint reflected from the finger positioned in said test station, a tubular member rotatable about its longitudinal axis and positioned within said container and extending to the outside of the container, a transparent disc mounted on said cylinder in front of said first photosensitive means and including a plurality of spaced reference masks at least two of which comprise different characteristic fingerprint patterns composed of transparent and opaque portions, said tubular member being rotatable from the outside of said container so as to align different ones of said reference masks with the fingerprint light image reflected from the test station whereby a reference mask prevents the light image from striking said first photosensitive means only if the light image pattern matches the pattern on said mask, and means including said first photosensitive means for actuating said control member in response to a light null at said first photosensitive means produced by a substantial identity between the fingerprint light image pattern and the reference mask fingerprint pattern aligned therewith.

8. A system as described in claim 7 further comprising a housing for mounting said first photosensitive means, said housing comprising brush means on one face thereof, said housing being positioned so that said brush means is closely adjacent said disc and contacts said reference masks whereby said brush means provides a light seal for said housing.

9. A system as described in claim 7 further comprising second photosensitive means mounted within said container so as to receive a portion of said reflected light image before it reaches said disc, and means connecting said second photosensitive means in circuit with said control member so as to inhibit the operation thereof unless a given minimum quantity of light is received by said second photosensitive means.

10. A system as described in claim 9 wherein said container further comprises a tubular portion coaxially arranged about said rotatable tubular member and a second tubular member mounted in said container and coaxially arranged within said rotatable tubular member, said tubular portion and said second tubular member being arranged to coact with said rotatable tubular member so as to rotatably support same in the container.

11. A control system for actuating a control member in response to one or more predetermined characteristic fingerprint patterns comprising, a sealed container including a finger test station comprising a window, a light source mounted within said container so as to project a light beam towards said window, first photosensitive means mounted within said container in the path of a light image pattern of the fingerprint reflected from a finger positioned in said test station, a transparent disc rotatably mounted in said container in front of said first photosensitive means and including a plurality of spaced reference masks at least two of which comprise different characteristic finger-

print patterns composed of transparent and opaque portions, an actuating member coupled to said disc and extending outside the container for rotating the disc so as to align different ones of said reference masks with the fingerprint light image reflected from the test station, an aligned reference mask being arranged to block the light image from striking said first photosensitive means only if the light image pattern matches the pattern on said mask, and means including said first photosensitive means for actuating said control member in response to a light null at said first photosensitive means produced by a substantial identity between the fingerprint light image pattern and the reference mask fingerprint pattern aligned therewith.

12. A system as described in claim 11 further comprising second photosensitive means mounted within said container so as to receive a portion of all reflected light images before they reach said disc, and means connecting said second photosensitive means in series circuit with said control member so as to inhibit the operation thereof unless a given minimum quantity of light is received by said second photosensitive means.

13. A door control system comprising a control member for automatically operating the door lock in response to a predetermined characteristic fingerprint pattern, a test station including a window for receiving a finger presented to the system by a person desiring to operate the door, means located on the other side of the window for illuminating said finger presented to the test station, first photosensitive means positioned to receive a positive light image pattern reflected from said finger in the test station, a reference mask positioned in front of said photosensitive means in the path of the reflected positive light image, said mask comprising a photographic film having a negative pattern of said predetermined characteristic fingerprint and composed only of opaque and transparent portions arranged to produce a light null at said photosensitive means only upon substantial identity between the reflected positive light image pattern and the negative reference mask pattern, second photosensitive means positioned to receive a portion of said reflected light image before it strikes said reference mask, and means including said first and second photosensitive means for actuating said control member in response to the occurrence of a light null at said first photosensitive means and a predetermined minimum quantity of light at said second photosensitive means.

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