May 31, 1960 E. L. CRISCUOLO ET AL 2,938,374

PROTECTION OF COMBINATION LOCKS AGAINST ENTRY BY RADIOGRAPHY

Filed June 24, 1957

FIG.1.

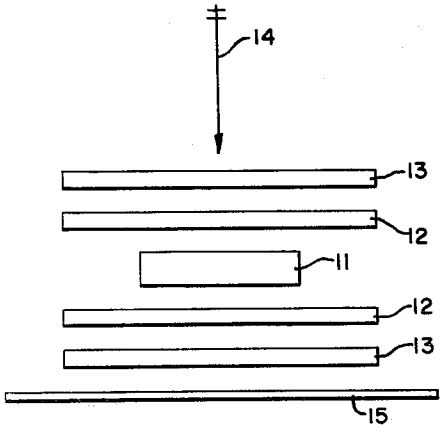



FIG.4.

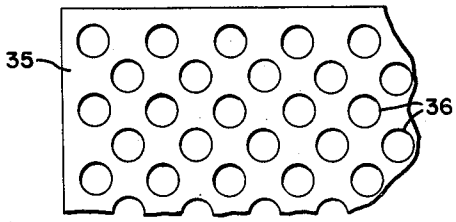



FIG.5

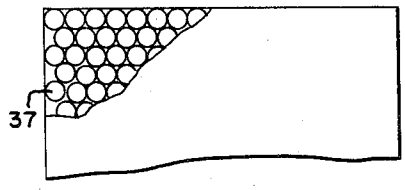



FIG.2.

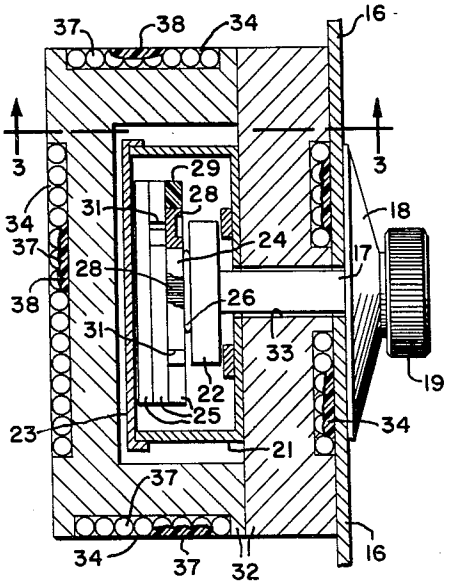
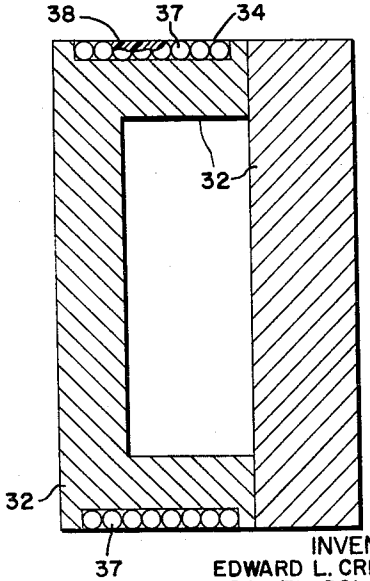



FIG.3.

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# PROTECTION OF COMBINATION LOCKS AGAINST ENTRY BY RADIOGRAPHY

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8 Claims. (Cl. 70—333)

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to a protected combination lock, and more particularly to the protection of a combination lock against entry thereof by radiography, and a method and means for affording said protection.

Present day combination locks employ tumblers and arrange them in a manner that the lock is fairly well protected against mechanical manipulation thereof. However, X-rays or other penetrating radiation may be used to locate the positions of the openings or gates in the tumblers and thereby determine the combination of the lock. Moreover, with the development made in portable penetrating radiation sources in recent years, a safe or container protected by a combination lock may be entered on the premises by a radiographic method and the combination setting of the lock can be obtained within a relatively short period of time without leaving any visible evidence of such compromise. This possibility has been recognized by those working in the lock art and it has been proposed to modify the construction of the tumblers to the end that the tumbler openings cannot be rendered visible from the exterior of the lock casing by the use of X-ray or the rays of radioactive isotopes, see U.S. Patents 1,847,071, 1,925,980 and 1,928,853 to William F. Doenges. However, such measures were not completely successful for the reason that the X-ray absorption characteristics of the materials employed were such that a sufficient definition of the tumblers could be obtained under appropriate conditions with the result that the combination could be determined for unlocking the lock.

In accordance with the present invention, the tumblers of the lock are formed of material having low X-ray absorption characteristics, a shield of material having high X-ray absorption characteristics is provided around the lock, and finally the shielded lock is located between members of material having X-ray scattering characteristics.

It is therefore an object of the present invention to provide a lock protected against entry by radiography.

Another object is the provision of a lock having tumblers therein of a suitable plastic material, such, for example, as Teflon or nylon.

A further object is to provide a lock having tumblers of a material having low X-ray absorption characteristics, such as nylon and a shield thereabout of material having high X-ray absorption characteristics, such as lead.

A final object of the present invention is the provision of a lock having plastic tumblers and lead shielding, and disposed between members of X-ray scattering material, for the purpose of preventing sufficient definition of the tumblers and thereby preventing compromise thereof by radiography.

With these and other objects in view, as will hereinafter more fully appear, and which will be more particularly pointed out in the appended claims, reference is now made to the following description taken in connection with the accompanying drawing in which:



Fig. 1 illustrates schematically the arrangement of the critical parts of a lock protected in accordance with the present invention, and the relation thereof with respect to an X-ray source and an X-ray film;

Fig. 2 is a side elevation, in section, of a conventional combination or permutation lock protected in accordance with the invention;

Fig. 3 is a sectional view taken on line 3—3 of Fig. 2, looking in the direction of the arrows;

Fig. 4 is a fragmentary view of one form of X-ray scattering material; and

Fig. 5 is a fragmentary view of another form of X-ray scattering material.

Referring now to the drawings, wherein like reference characters designate like or corresponding parts throughout the several views, therein is shown in Fig. 1 a schematic arrangement serving to illustrate the principle of operation of the present invention, the reference character **11** designating lock tumbler material having low X-ray absorption characteristics, which in turn is flanked on all sides by shield material having high X-ray absorption characteristics and designated by reference character **12**. The tumbler material is also flanked on all sides by material **13** which has the properties of scattering X-rays, the shield material **12** being disposed between the scattering material **13** and the tumbler material **11**. A suitable source of X-rays, or radiation from a radioactive isotope, is designated by reference character **14**, while reference character **15** designates suitable film for exposure to the radiation which passes through the lock and associated parts to form a radiograph thereof.

Turning now to Fig. 2, which shows the invention applied to a conventional combination or permutation lock, with parts in section for a better understanding of the relationship therebetween, reference character **16** designates a portion or panel of the safe or container upon which the lock is mounted, the lock, except for the tumblers thereof, being of conventional character and having the usual operating shaft **17**, one end thereof being disposed within the safe or container, the other end disposed exteriorly thereof. The exterior end of the operating shaft **17** carries a conventional numbered dial **18** and an operating knob **19**, the safe or container panel **16** having thereon a suitable index mark [not shown] at the periphery of the dial.

The inner end of the operating shaft **17** extends into a box or casing **21** and is secured to a primary driving wheel **22** disposed in the box, the wheel being rotatable through the medium of the operating knob and shaft. Box **21** has a back plate **23** and fixed thereto is a hollow post **24** into which the inner end of the shaft **17** telescopes, the post being adapted to support a plurality of rotatable members **25** which are retained thereon by means of a resilient snap ring or retainer **26** adapted to seat within a groove formed in the post adjacent the free end thereof. The rotatable members **25** are maintained in spaced relation on the post by using washers which are connected to remain fixed to the post and serve to prevent the transmission of rotation of one of the rotatable members to the adjacent rotatable member except through the "pin and fly" connection between the rotatable members, neither the washers nor the "pin and fly" connections being shown, but readily understood by those skilled in the art.

A "pin and fly" connection also exists between the primary drive wheel **22** and the rotatable member **25** nearest thereto, whereby said rotatable member may be rotated

by turning the operating knob **19**. Because of the "pin and fly" connections between the rotatable members **25**, the rotation of the first such members is transmitted to the next member and so on through the several members arranged on the post. Thus, by proper manipulation or turning of the operating knob, according to the combination or "setting" of the rotatable members **25**, these members are brought into a predetermined relationship which permits releasing of the lock mechanism and the unlocking of the safe or container.

Ordinarily, each of the rotatable members **25** is made in two parts, an inner part **28** rotatably mounted on the post and an outer part **29** carried by said inner part, the outer periphery of the inner part and the inner periphery of the outer part being suitably serrated for intermeshing connection to each other, thereby providing for the outer part to be slipped off and set with respect to the inner part, suitable indicia being provided whereby any desired setting may be made. The outer part **29** constitutes a tumbler or tumbler wheel and has formed in the outer periphery thereof a notched opening or gate **31**, the setting or combination of the openings or gates being determined by setting each outer part **29** with respect to its inner part **28**, as hereinbefore described. When the tumbler openings or gates have been rotated into alignment by proper manipulation of the operating knob according to the combination or setting of the terminal, the fence end of the lock bolt (not shown) can move into the aligned openings to permit releasing of the lock mechanism by turning of the operating knob **19**. The hereinbefore described parts of the lock, and the operation thereof, should be readily understood by those skilled in the art and further description thereof appears unnecessary.

In the application of this invention to the conventional lock hereinbefore described, firstly, the outer part **29**, in which is formed the tumbler opening or gate, is made of a material having low X-ray absorption characteristics; that is, a low density material such as nylon, Teflon, Bakelite, etc. Secondly, the box **21** is contained in a housing **32** made of material having high X-ray absorption characteristics; that is, a high density shield material, such as lead or the like, a suitable bore or opening **33** being provided therein for passage of the operating shaft **17** therethrough. Thirdly, the box is flanked on all six sides by layers of material **34** having high X-ray scattering characteristics and disposed exteriorly of the shield material.

The X-ray scatter material may take several forms, such as, a plain steel plate, a plate with drilled holes, or a layer of steel balls. Fig. 4 shows a steel plate **35** drilled with holes **36**, the holes being ¼ inch in diameter and spaced ½ inch on centers with the maximum number of holes possible being drilled in the plate, the thickness thereof being ¼ inch. Fig. 5 illustrates X-ray scatter material in the form of a layer of steel balls **37**, preferably ¼ inch in diameter, such layer of balls being adapted to be contained in the shield housing **32**, parts of which are suitably hollowed out to receive the balls, the balls being held in place by means of plates secured to the housing, or by being molded in a matrix of plastic **38**, as illustrated in Figs. 2 and 3.

In one of the tests of the invention, a combination lock was fitted with three ¼ inch nylon tumbers, with the appropriate notched openings or gates therein. Placed on all six sides of the lock was ½ inch lead shield material and ¼ inch diameter steel balls. Thus, the radiation path extended through the three ¼ inch nylon tumblers, the total of 1 inch of lead and two layers of ¼ inch diameter steel balls. The lock, thus protected, was placed on a file drawer and a radiograph was taken employing a radioactive source. In the radiograph, although various parts of the lock were visible, the notched openings or gates in the tumblers were undefined and lost. Such locks are considered fully protected against entry by radiographic methods or means.

In the event future technological developments make it possible to detect the tumbler openings, each tumbler could also be provided with several dummy gates which would have therein a thin web of material to prevent the fence of the lock from entering therein. Extreme difficulty will therefore be encountered in determining the true tumbler gates or openings, thereby concealing the proper settings thereof for protection of the lock against advanced radiographic methods and means.

Consideration of all the factors effecting the protection of combination locks from radiographic comprise has lead to the selection of low density tumbler material because of the difficult detection problem presented thereby, the use of lead shielding for limiting the selection of radition sources to those with high energy, and the employment of efficient scattering material for scattering the radiation rays. Presently, the optimum protective system is considered to consist of nylon tumblers, a ½ inch of lead on each side, and a layer of ¼ inch diameter steel balls outside the lead. With this system, as much as 0.7 inch of nylon can be utilized in the lock without being detected radiographically.

From the foregoing, it should be apparent that there has been provided a combination lock which is fully pro- against compromise by radiographic means or methods and that such protected lock represents an embodiment of the present invention.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A lock protected agains radiographic compromise, comprising a lock including tumblers made of a low density material, a casing for said tumblers, a housing contacting said casing for shielding said tumblers, said housing being of a high-density, X-ray absorbing material, and layers of material contacting said housing and having the capability of scattering penetrating X-ray radiation impinging thereon.

2. A lock protected against radiographic compomise, comprising a lock including tumblers made of a low density material, a housing surrounding said tumblers for shielding the same, said housing being of a high density material, and layers of material flanking said tumblers and having the capability of scattering penetrating radiation impinging thereon, said layers of material being metal plates having holes uniformly formed therein.

3. A lock protected against radiographic compromise, comprising a lock including tumblers made of a low density material, a housing surrounding said tumblers for shielding the same, said housing being of a high desnity material, and layers of material flanking said tumblers and having the capability of scattering penetrating radiation impinging thereon, said low density material being nylon, said high density material being lead, and said layers of material each being a layer of one-quarter inch diameter steel balls.

4. A lock protected against radiographic compromise, said lock comprising a housing made of material having high X-ray penetrating radiation absorption characteristics and formed with an internal chamber, said housing having exterior portions thereof flanking said chamber and hollowed out for providing shallow cavities therein, X-ray penerating radiation scattering material disposed in each of said cavities, lock tumbler and casing means contained in said chamber, said casing means being in contact with said housing, and said tumbler means being made of a material having low X-ray penetrating radiation absorption characteristics.

5. A lock as defined in claim 4, the material of said housing being lead and the thickness thereof between said

chamber and said scattering material being at least one-half inch.

6. A lock protected against radiographic compromise, said lock comprising a housing made of material having high penetrating radiation absorption characteristics and formed with an internal chamber, said housing having exterior portions thereof flanking said chamber and hollowed out for providing shallow cavities therein, penetrating radiation scattering material disposed in each of said cavities, and lock tumbler means contained in said chamber, said tumbler means being made of a material having low penetrating radiation absorption characteristics, said scattering material including a layer of one-quarter inch steel balls.

7. A lock as defined in claim 4, said last-named material being nylon.

8. A lock protected against radiographic compromise



and comprising tumbler means made of nylon, a casing for said tumbler means, a housing made of lead contacting said casing, and layers of X-ray scattering material flanking said tumbler means and secured to said housing.

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