

SPECIFICATION

Combination locks

5 This invention relates generally to combination locks, and more particularly to combination locks of the type employing dial-driven rotary elements, such as sleeves, that must be turned to a predetermined position to open the lock.

10 Because of their small size and relatively simple construction, combination locks of the type to which the invention pertains are particularly well adapted for use as locking mechanisms on luggage and the like. One type of prior combination lock, disclosed in
15 U.S. Patent No. 3,800,571 to Heine, issued April 2, 1974, and assigned to the same assignee as the present invention, employs a flat, spring-biased bolt pivoted along one edge and moved to a locked position by sleeves that are rotated about a common axis
20 by combination dials. Each sleeve has a bolt-engaging cam comprising a circular flange with a flat portion. When the dials are placed "on-combination," each cam is in its "unlocked" position, with all the flat portions of the cams aligned to
25 permit the flat bolt to move to an "unlocked" position, so that the lock may be opened. Turning any dial "off-combination" causes the corresponding cam to turn from its unlocked position to a "locked" position at which the circular flange engages the bolt
30 and moves it to a "locked" position, so that the lock may not be opened.

A typical lock of the type disclosed in the Heine patent employs dials with ten discrete combination number positions. To move a dial from one number
35 position to the next requires 36° of dial rotation. Thus, turning a dial from its on-combination position to a succeeding number position in either direction of rotation turns the corresponding cam 36° in either direction from its unlocked position. If the flat portion of the cam subtended 72° (twice 36°), the 36°
40 cam movement just described would cause a point on the circular flange of the cam to contact the bolt tangentially and would produce the same bolt travel regardless of the direction of rotation of the dial from
45 its on-combination position. Unfortunately, if such cams were employed in the typical lock, the amount of bolt travel would be insufficient to ensure reliable cooperation of the bolt with a hasp. In order to achieve additional bolt travel, it has been the practice
50 to employ cams with flat portions that subtend more than 72°. However, this construction has certain disadvantages. First, when a dial is turned in opposite directions from its on-combination position, the bolt travel is not the same. The difference in
55 bolt travel can result in insecure locking. Second, when a dial is one number position away from its on-combination position, the contact of the corresponding cam with the bolt is not tangential. Thus, pressure on the bolt may exert a torque on the cam
60 that moves the cam to its unlocked position. This may occur when the lock is subjected to shock forces, for example.

Sleeves of the type just described are also used in combination locks having a sliding mechanism,
65 rather than a pivoted bolt. For example, U.S. Patent

No. 3,416,338 to Gehrie, issued December 17, 1968, and assigned to the same assignee as the present invention, discloses a combination lock employing a bolt that slides in a direction parallel to the rotational
70 axis of the sleeves. U.S. Patent No. 3,405,544 to Gehrie, issued October 15, 1968, and assigned to the same assignee as the present invention, discloses a combination lock in which the sleeves slide relative to fixed abutments. U.S. Patent No. 3,543,545 to
75 Budzyn, issued December 1, 1970, and assigned to the same assignee as the present invention, discloses a combination lock in which a bolt slides in a direction perpendicular to the rotational axis of the sleeves. Such locks also may have problems due to
80 the construction of the sleeves and cooperable parts. For example, as will be discussed in detail later, pressure at the interface of a sleeve and a cooperable part may exert a torque that turns the sleeve to its unlocked position.

85 It is desirable, therefore, to provide combination locks which overcome the aforesaid difficulties, and it is to this end that the present invention is directed.

A primary object of the invention is to provide new and improved combination locks.

90 A further object of the invention is to provide a combination lock of the pivoting bolt type in which the bolt stroke is the same when a dial is turned either clockwise or counterclockwise from its on-combination position.

95 Another object of the invention is to provide a combination lock in which the force required to rotate the dials in opposite directions in the vicinity of their on-combination position is more uniform.

According to one aspect of the invention there is
100 provided a combination lock having a plurality of dials, each coupled to a corresponding rotary cam that must be turned by its respective dial to a predetermined position relative to a pivotal locking member in order for the locking member to assume
105 an unlocked position, characterised in that each cam has a circular periphery formed with a notch, and the pivotal member has a ridge portion for each notch, the locking member being positioned so that the ridge portions engage in the respective notches
110 when the cams each have said predetermined position, the notches and ridge portions defining cooperative camming formations for moving the locking member by a camming action from the unlocked position to a locked position when any one
115 of said cams is rotated from its predetermined position by an amount sufficient to disengage the ridge portion from the notch.

In another aspect, a combination lock in accordance with the invention may have a bolt moved by
120 dial-driven cams between an unlocked position and a locked position. Each cam has a notch into which a corresponding ridge portion of the bolt fits when the bolt is in the unlocked position.

These and other objects, advantages, features, and improved results provided by the invention will become apparent from the following detailed description and drawings of preferred embodiments of the invention.

125 Figures 1A-1C are diagrammatic views illustrating the cam-bolt arrangement employed in a conven-
130

tional combination lock of the pivoting bolt type;

Figures 2A-2C are similar diagrammatic views illustrating an improved cam-bolt arrangement provided by the present invention;

Figure 3 is a top plan view, partially broken away, illustrating a pivoting bolt combination lock made in accordance with the invention, the lock being illustrated in association with a hasp partially shown; Figure 4 is a vertical sectional view taken along line 4-4 of Figure 3;

Figure 5 is a vertical sectional view taken along line 5-5 of Figure 4, this view also illustrating a cover for the lock and valence members adapted to be mounted on luggage or the like to which the lock may be attached;

Figure 6 is a top plan view of a pivoting bolt in accordance with the invention;

Figure 7 is an end view of a dial and associated flanged sleeve which may be employed in the invention;

Figure 8 is a side elevation view of the sleeve of Figure 7;

Figure 9 is a plan view of a bracket that may be employed for supporting parts of the lock mechanism on a frame;

A first preferred embodiment of the invention is an improvement upon a prior combination lock of the type employing a pivoting bolt cooperable with cams that are turned by corresponding combination dials. Such a lock is disclosed in the Heine patent referred to earlier and incorporated herein by reference. The prior art bolt-cam arrangement is illustrated in Figures 1A-1C. Bolt 10 constituting a locking member is, in essence, a flat plate supported for pivotal movement at an edge 12 about an axis 14 (perpendicular to the plane of the drawing). Only one cam 16 is shown, but in the actual lock there may be three cams, for example, each driven by a corresponding dial (not shown in Figures 1A-1C). Each dial and its cam rotates about an axis 18 (perpendicular to the plane of the drawing). Each cam has a circular periphery 20 centered on axis 18 and has a chordal flat portion 22 that truncates the circular periphery.

Figure 1A illustrates the "unlocked" position of the cam and the bolt, where the flat portion 22 is juxtaposed with a mating flat surface of the bolt. It is assumed in Figure 1A that all of the cams are in their unlocked position and that the bolt is held against the flat portions of the cams by a spring (not shown here).

Each dial has ten combination indicia (numbers) equally spaced about its periphery. The peripheral position of the number displayed when a cam is in its unlocked position is designated in Figure 1A by reference numeral 24 (although the number is actually on the dial, not the cam). Each number position subtends 36° (angle a in Figure 1A), but the flat portion 22 subtends more than 72° (angle b is greater than 72°); with effects which will now be described.

When cam 16 is turned counterclockwise, as shown in Figure 1B, one number position away from its unlocked position, so that the number at succeeding position 24' is now displayed, the stroke of the free end of bolt 10 relative to reference line 26 (representing the unlocked position of the bolt in Figure

1A) is, for example, .097 inch. When, on the other hand, the cam is turned clockwise, as shown in Figure 1C, one number position away from its unlocked position, so that the number at succeeding position 24'' is displayed, the stroke of the free end of the bolt is only .085 inch. Although the theoretical difference in stroke is about .012 inch, in practice the difference can exceed .020 inch due to backlash, dial positioning error and tolerance build-up. The reduced bolt stroke with clockwise cam rotation results in limited engagement of the bolt with a hasp (to be described) and causes insecure locking. Furthermore, when the cam is in the positions illustrated in Figures 1B and 1C, the contact of the cam with the bolt is not tangential (the contact being at a "corner" of the flat portion) and pressure on the bolt toward the cam may produce a torque that will turn the cam to the unlocked position of Figure 1A. Thus, undesirable opening of the lock may occur in response to shock forces (dropping of a luggage case, for example). Also, the force required to turn a dial when its cam is near its unlocked position will vary considerably depending upon the direction of rotation, because the opposite corners of the flat portion of the cam contact the flat surface of the bolt at widely different distances from axis 14.

It is apparent from Figures 1A-1C that the unequal stroke of the bolt is the result of angle b being greater than twice angle a , that is, angle b is greater than 72° . With the same circular periphery, if the length of flat portion 22 were reduced (by using a shorter chord of the circle centered on axis 18) the flat portion could be made to subtend 72° , and the unequal bolt stroke could be eliminated. The contact of the bolt with the cam would then be tangential regardless of the direction of rotation of the cam from its unlocked position to a succeeding number position, and pressures exerted on the bolt would be directed at the center of rotation of the cam, producing no torque on the cam. Unfortunately, the problem of insecure engagement of the bolt with a hasp would not be solved by this technique, because the maximum theoretical bolt stroke would be reduced to .060 inch in the illustrative structure, and this stroke would not be sufficient to ensure reliable engagement with a hasp.

The present invention solves this problem by providing a structure in which the bolt travel is the same regardless of the direction in which a cam is turned from its unlocked position, in which the bolt stroke is adequate to ensure secure engagement with a hasp (being substantially the same as the maximum theoretical stroke in the prior art), and in which the contact between the bolt and a cam is tangential when the cam is one number position away from the unlocked position of the cam.

The remarkably improved structure of the invention is illustrated diagrammatically in Figures 2A-2C. As shown, a modified cam 16a still has a circular periphery 20, but instead of the flat portion 22 a V-notch portion 22a is employed (with an included angle preferably about 140°). Bolt 10a constituting a locking member, instead of being flat, has a central ridge portion 28 that mates with the V-notch 22a. The left end of bolt 10a in Figures 2A-2C may have a

configuration similar to the left end of bolt 10 in Figures 1A-1C, and the ridge portion 28 may be formed by shaping the central portion of bolt 10a into a configuration resembling a flat letter W. The right side of bolt 10a may be similar to the right side of bolt 10, but it is preferred to offset the right side upwardly (assuming orientation of the parts as in Figure 2A). The purpose of the offset is to provide the desired unlocked and locked positions of the free end of the bolt, for release and retention of a hasp. As will be seen hereinafter, the bolt and cam arrangement of the invention may be employed with other components that are presently employed in standard combination locks.

The cam and bolt positions illustrated in Figure 2A are the unlocked positions of these parts. Again, it is assumed that other cam employed in the lock have the position illustrated in Figure 2A and that the bolt is urged against the cams by a spring. As shown, ridge portion 28 has a shape that complements that of notch 22a.

With the above arrangement, it is apparent that the ridge formation 28, in each case, is defined by substantially planar converging camming surfaces which, in the unlocked condition of the bolt, as evidenced from Figure 2A, are disposed symmetrically with respect to a line passing through the centre of the cam and the junction of planes defining the converging surfaces. When the cam is turned in one or the other direction from the Figure 2A position, one or the other of the points on the cam defining the junctions of the notch 22a and the circular cam periphery 20 provides a cam formation which will move along the respective ridge surface of the bolt which provides a cooperative cam formation. Thus downward camming of the bolt is effected toward the Figure 2B or Figure 2C position.

When cam 16a is turned 36° counterclockwise (one number position) from the unlocked position of Figure 2A, as shown in Figure 2B, the crest of ridge portion 28 will rest on the circular periphery 20 of the cam, and when the cam is turned clockwise from the position of Figure 2A by the same amount, as shown in Figure 2C, the crest of ridge portion 18 will again rest on the circular periphery 20 of the cam. The notch subtends slightly less than 72° on the cam to ensure the conditions just described.

With the cam and bolt configuration of the invention, the bolt stroke achieved in Figure 2B is the same as that achieved in Figure 2C, for example .095 inch in the illustrative construction. This is substantially the same as the .097 inch maximum stroke achieved in Figure 1B, which is sufficient to ensure secure hasp engagement. The total stroke of the bolt is caused partially by the shape of the cam and partially by the shape of the bolt. Since the bolt contacts the circular periphery of the cam tangentially in both Figures 2B and 2C, any forces exerted upon the cam by the bolt are directed at axis 18 and cannot produce a torque to turn the cam to its unlocked position. Moreover, the force required to turn a dial in opposite directions in the vicinity of its on-combination position is more uniform than in the structure of Figures 1A-1C, producing better "feel".

It is now appropriate to describe an actual combi-

nation lock employing the bolt and cam arrangement of the invention as just described in connection with Figures 2A-2C. As shown in Figures 3-9, principal parts of the lock include combination dials A, sleeves B, a shaft C, a bolt D and a frame E.

Each dial A is supported on shaft C by a corresponding sleeve B. The dials have internal gear teeth 30 that mesh with external gear teeth 32 of the sleeves. The sleeves are held in successive abutting relationship by a coil compression spring 34 on the shaft, which urges the sleeves toward a collar 36 integral with the shaft. Opposite ends of the shaft may be supported upon brackets 38, one of which is shown in detail in Figure 9. Each bracket has a hole 40 into which the corresponding end of shaft C is inserted. Spring 34 is compressed between one of the brackets and an adjacent sleeve as shown in Figure 4.

Frame E may be generally U-shaped in cross-section, as shown in Figure 5, and each bracket 38 may have protrusions 42, 44, and 46 that enter corresponding slots in the adjacent walls of the frame. The frame may be supported on a valance member 48 (Figure 5) applied to an edge of part of a luggage case, for example, in a conventional manner. A mating valance member 50, applied to an edge of another part of the luggage case, may support a hasp 52 in a conventional manner, as indicated in Figures 3 and 5. The parts of the luggage case may be hingedly connected, and may be held closed, one upon the other, by engagement of hasp 52 with bolt D.

The bolt is supported along edge 12 for pivotal movement relative to the frame and the assembly of dials and sleeves. In the form shown, this is accomplished by providing lugs 54 at opposite ends of the bolt that are received in slots 56 of brackets 38. The slots are shaped to accommodate the pivotal movement of the bolt. Coil compression springs 58 adjacent to opposite ends of the bolt near edge 12 are positioned between the bolt and the frame to bias the bolt toward the sleeves. The bolt may have locating bosses 60 for the springs. A stop 61 limits movement of the bolt away from the sleeves.

As shown in Figures 3, 4 and 6, the bolt has a series of openings 62 freely receiving the dials A so that the bolt may engage sleeves B without interference from the dials. The dials may also protrude through corresponding openings 64 in a cover plate 66 (see Figure 5), where the combination indicia of the dials are displayed to the user. Each dial may have ten combination numbers equally spaced about its circumference, with successive numbers separated by indexing notches 68. The indexing notches cooperate with arms of a dial spring 70 as shown in Figure 5. In the form shown the dial spring has its base supported in a slot of the frame and has a resilient arm for each dial that enters the indexing notches of the dial. As shown, the indexing notches may be symmetrical V-shaped notches, but one notch, 68', may have a radial surface that engages the associated arm of the dial spring to stop rotation of the dial when the dial is rotated in a given direction (clockwise in Figure 5) to a particular rotational position. This feature permits rapid setting of all the

dials to a zero position, for example.

Each of the sleeves B has a flange forming the cam 16a described in connection with Figures 2A-2C. The flange has a circular periphery 20 with a V-notch 22a.

- 5 As shown in Figures 5 and 6, bolt D has a ridge 72 with portions that mate with corresponding notches 22a when the sleeves are turned to the rotational position of Figure 5. The bolt has latching lugs 74 adapted to engage corresponding lugs 76 (see Figure 3) of the hasp, but when the bolt is in the unlocked position of Figure 5, there is no engagement with the hasp. Lugs 76 of the hasp enter the frame E via slots 78 and are received in slots 80 of brackets 38 (see Figure 9) tapered to guide lugs 76 to a predetermined position when the parts of the luge-
15 cage case are closed.

When the bolt is in the full-line position of Figure 5, all of the dials are on-combination and the lock may be opened. If any dial is turned off-combination, the corresponding cam 16a will move the bolt to the phantom line (locked) position shown in Figure 5, positioning latching lugs 74 of the bolt for engagement with the corresponding lugs 76 of the hasp and preventing withdrawal of the hasp from the frame E.

- 25 The action of the cam and bolt assembly just described is precisely the same as described with reference to Figures 2A-2C, with all of the attendant advantages.

- Prior combination locks employing pivoting bolts in association with rotating sleeves having cams with flat portions (as in Figures 1A-1C) may employ a mechanism permitting the user to change the combination when the dials are on-combination. Such a mechanism has also been included in the foregoing embodiment of the invention and comprises a lever 82 (see Figure 4) mounted on shaft C and protruding through a slot 84 in the frame. By moving lever 82 to the left in Figure 4 against the bias of spring 34, the sleeves B may be moved to the left relative to the corresponding combination dials A to disengage the gear teeth 32 of the sleeves from the gear teeth 30 of the dials. If lever 82 is held in its leftward position (it may be so held by turning it slightly and engaging it with a branch of slot 84), the combination dials may be turned independently of the sleeves and set to a new combination. When lever 82 is returned to the position illustrated in Figure 4 (under the bias of spring 34) the sleeves will be reengaged with the dials and the lock will operate in its normal manner, but with a new combination.

- Prior combination locks also may employ a combination "finding" feature that permits the combination to be determined when the lock has been opened and the dials scrambled. For this purpose the frame has holes 85 for receiving a probe, and the sleeves have recesses 86 into which the probe may be inserted when the sleeves are turned to their unlocked position. Bolt D has recesses 88 (see Figure 6) for passing the probe.

- 60 As stated earlier, when sleeves having circular peripheries with flat portions are employed in conjunction with cooperable parts that slide relative to the sleeves (see, for example, Patent No. 3,416,338 to Gehrie referred to earlier and incorporated herein by reference), the combination lock may suffer from

certain problems that afflict combination locks having pivoting bolts. Fortunately, the bolt and sleeve configurations of the invention are highly efficacious in both types of locks.

70 CLAIMS

1. A combination lock having a plurality of dials, each coupled to a corresponding rotary cam that must be turned by its respective dial to a predetermined position relative to a pivotal locking member in order for the locking member to assume an unlocked position, characterised in that each cam has a circular periphery formed with a notch, and the pivotal locking member has a ridge portion for each notch, the locking member being positioned so that the ridge portions engage in the respective notches when the cams each have said predetermined position, the notches and ridge portions defining cooperative camming formations for moving the locking member by a camming action from the unlocked position to a locked position when any one of said cams is rotated from its predetermined position by an amount sufficient to disengage the flange portion from the notch.

2. A combination lock in accordance with claim 1, wherein each notch is generally V-shaped and the shape of each ridge portion complements the shape of the corresponding notch.

3. A combination lock according to claim 1 or 2, wherein each dial has a series of combination indicia spaced about its periphery with one indicium displayed when the peripheral portion of the corresponding cam has said predetermined position, and wherein the locking member contacts the circular periphery of any rotary element substantially tangentially when that cam is turned to display an indicium that succeeds said one indicium at either side thereof.

4. A combination lock according to claim 1, 2 or 3, wherein the cams comprise sleeves supported for rotation on a shaft and wherein each dial is supported on a corresponding sleeve for rotating that sleeve.

5. A combination lock according to claim 4, wherein each sleeve has a flange constituting the circular periphery and the notches are formed in the flanges respectively.

6. A combination lock according to any preceding claim wherein the locking member comprises a pivoting bolt.

7. A combination lock according to claim 6 wherein the bolt is supported along an edge thereof for pivotal movement about an axis parallel to the axis of the shaft and is resiliently biased toward the sleeves.

8. A combination lock according to claim 6 or 7 wherein the locking member is a bolt pivoted along one edge and the opposite edge portion of the bolt is offset towards the axis of said cams.

9. A combination lock according to any preceding claim, wherein a point of camming contact between said formations moves along one of a pair of substantially planar converging surfaces which, when the ridge portion is in engagement with the notch, are disposed symmetrically with respect to a line passing through the centre of the cam and the



dials to a zero position, for example.

Each of the sleeves B has a flange forming the cam 16a described in connection with Figures 2A-2C. The flange has a circular periphery 20 with a V-notch 22a.

5 As shown in Figures 5 and 6, bolt D has a ridge 72 with portions that mate with corresponding notches 22a when the sleeves are turned to the rotational position of Figure 5. The bolt has latching lugs 74 adapted to engage corresponding lugs 76 (see Figure 3) of the hasp, but when the bolt is in the
10 unlocked position of Figure 5, there is no engagement with the hasp. Lugs 76 of the hasp enter the frame E via slots 78 and are received in slots 80 of brackets 38 (see Figure 9) tapered to guide lugs 76 to a predetermined position when the parts of the luggage case are closed.

When the bolt is in the full-line position of Figure 5, all of the dials are on-combination and the lock may be opened. If any dial is turned off-combination, the
20 corresponding cam 16a will move the bolt to the phantom line (locked) position shown in Figure 5, positioning latching lugs 74 of the bolt for engagement with the corresponding lugs 76 of the hasp and preventing withdrawal of the hasp from the frame E.

25 The action of the cam and bolt assembly just described is precisely the same as described with reference to Figures 2A-2C, with all of the attendant advantages.

Prior combination locks employing pivoting bolts
30 in association with rotating sleeves having cams with flat portions (as in Figures 1A-1C) may employ a mechanism permitting the user to change the combination when the dials are on-combination. Such a mechanism has also been included in the foregoing embodiment of the invention and comprises a lever
35 82 (see Figure 4) mounted on shaft C and protruding through a slot 84 in the frame. By moving lever 82 to the left in Figure 4 against the bias of spring 34, the sleeves B may be moved to the left relative to the corresponding combination dials A to disengage the
40 gear teeth 32 of the sleeves from the gear teeth 30 of the dials. If lever 82 is held in its leftward position (it may be so held by turning it slightly and engaging it with a branch of slot 84), the combination dials may
45 be turned independently of the sleeves and set to a new combination. When lever 82 is returned to the position illustrated in Figure 4 (under the bias of spring 34) the sleeves will be reengaged with the dials and the lock will operate in its normal manner,
50 but with a new combination.

Prior combination locks also may employ a combination "finding" feature that permits the combination to be determined when the lock has been opened and the dials scrambled. For this purpose
55 the frame has holes 85 for receiving a probe, and the sleeves have recesses 86 into which the probe may be inserted when the sleeves are turned to their unlocked position. Bolt D has recesses 88 (see Figure 6) for passing the probe.

60 As stated earlier, when sleeves having circular peripheries with flat portions are employed in conjunction with cooperable parts that slide relative to the sleeves (see, for example, Patent No. 3,416,338 to Gehrie referred to earlier and incorporated herein
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1. A combination lock having a plurality of dials, each coupled to a corresponding rotary cam that must be turned by its respective dial to a predetermined position relative to a pivotal locking member
75 in order for the locking member to assume an unlocked position, characterised in that each cam has a circular periphery formed with a notch, and the pivotal locking member has a ridge portion for each notch, the locking member being positioned so that
80 the ridge portions engage in the respective notches when the cams each have said predetermined position, the notches and ridge portions defining cooperative camming formations for moving the locking member by a camming action from the
85 unlocked position to a locked position when any one of said cams is rotated from its predetermined position by an amount sufficient to disengage the flange portion from the notch.

2. A combination lock in accordance with claim 1, wherein each notch is generally V-shaped and the shape of each ridge portion complements the shape of the corresponding notch.

3. A combination lock according to claim 1 or 2, wherein each dial has a series of combination indicia
95 spaced about its periphery with one indicium displayed when the peripheral portion of the corresponding cam has said predetermined position, and wherein the locking member contacts the circular periphery of any rotary element substantially
100 tangentially when that cam is turned to display an indicium that succeeds said one indicium at either side thereof.

4. A combination lock according to claim 1, 2 or 3, wherein the cams comprise sleeves supported for rotation on a shaft and wherein each dial is supported on a corresponding sleeve for rotating that sleeve.

5. A combination lock according to claim 4, wherein each sleeve has a flange constituting the circular periphery and the notches are formed in the flanges respectively.

6. A combination lock according to any preceding claim wherein the locking member comprises a pivoting bolt.

7. A combination lock according to claim 6 wherein the bolt is supported along an edge thereof for pivotal movement about an axis parallel to the axis of the shaft and is resiliently biased toward the sleeves.

8. A combination lock according to claim 6 or 7 wherein the locking member is a bolt pivoted along one edge and the opposite edge portion of the bolt is offset towards the axis of said cams.

9. A combination lock according to any preceding claim, wherein a point of camming contact between said formations moves along one of a pair of substantially planar converging surfaces which, when the ridge portion is in engagement with the notch, are disposed symmetrically with respect to a
130 line passing through the centre of the cam and the



junction of planes defining the converging surfaces.

10. A combination lock having a pivotal bolt moved by dial-driven cams between an unlocked position and a locked position, characterised in that
- 5 each cam has a notch in which a corresponding ridge portion of the bolt engages when the bolt is in the unlocked position.

11. A combination lock according to claim 10, wherein the cams turn about the same rotational
- 10 axis and the bolt is supported adjacent to an edge thereof for pivotal movement about an axis parallel to the rotational axis of the cams, and wherein each cam has a periphery with its notch formed therein, the periphery being circular except for the notch.

12. A combination lock in accordance with claim 10, or 11 wherein the movement of the bolt from its unlocked position is the same when any cam is
- 15 turned so as to move the corresponding ridge portion out of its notch, irrespective of the direction of rotation of the cam.

13. A combination lock in accordance with any of claims 10 to 12, wherein the notches are substantially V-shaped and the shape of the ridge portions complements the shape of the notches.

14. A combination lock according to claim 6 wherein the bolt is of generally planar form supported along one edge for pivotal movement about an axis parallel to the axis of the shaft, and wherein the ridge portions are disposed between said one
- 20 edge and an opposite free edge of the bolt, the opposite free edge being formed to engage a hasp.

15. A combination lock according to claim 14, wherein a portion of the bolt at said opposite edge is offset towards the axis of the cams.

16. A combination lock substantially as hereinbefore described with reference to and as shown in
- 35 Figures 2a to 9 of the accompanying drawings.