

PATENT SPECIFICATION

(11)

1 588 811

(21) Application No. 39886/77

(22) Filed 24 Sept. 1977 (19)

(23) Complete Specification filed 30 May 1978

(44) Complete Specification published 29 April 1981

(51) INT. CL.³ E05B 47/00

(52) Index at acceptance

E2A LW

H1P 3

(72) Inventor LESLIE VICTOR HERRIOTT



1 588 811

(54) LOCK AND MAGNETIC KEY FOR OPERATING SAME

(71) We, LOWE & FLETCHER LIMITED, a British Company of Fryers Road, Leamore, Walsall, West Midlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a lock and key wherein there is associated with the key a magnetic field and the lock comprises one or more magnetic elements which can be moved by magnetic action of the key to respective releasing positions in which they permit operation of the lock.

According to the invention there is provided a combination comprising a key with which there is associated a magnetic field and a lock which is operable by the key, the lock comprising a magnetic element which is movable by the magnetic action of the key along a path defined by the lock into a releasing position, the lock defining opposite ends of the path, wherein the key comprises a body of magnetised material which, when the key is applied to the lock, lies adjacent to said path and extends along more than half of the length of the path, the magnetic field of the key has, adjacent to opposite ends of said path, a differential coefficient of the flux density with respect to distance along the path which is sufficient to move said element from either end of the path, the releasing position lies between the ends of the path and the flux density increases along the path from the ends thereof to a maximum value at the releasing position.

Preferably, the magnetised body of the key extends along the path substantially from one end thereof to the other end.

The distance between said path and said magnetised body of the key may be at least approximately constant along the entire length of the path.

In the preferred arrangement, the path is curved and extends around a central axis of the key and the path subtends at that axis an angle exceeding 45°. The angle sub-

tended by the path at the axis of the key is preferably at least 90°.

Also in the preferred arrangement, the magnetised body of the key is cylindrical, the magnetic element is a rolling element and the diameter of the magnetic element is within the range one-half to one-sixth of the diameter of the key body.

The lock may define a plurality of paths which are spaced apart long the axis of the key, when applied to the lock, there being a respective magnetic element movable along each of said paths, the paths extending transversely of the axis of the key and said magnetised body of the key having respective parts which lie adjacent to said paths and are integral with one another.

The magnetised body of the key preferably has on its surface a magnetic pole which, when the key is applied to the lock, lies adjacent to said path, the pole occupying an elongate area of the surface of the body with the length of the area extending along the path.

The magnetised body of the key may be elongate with the width of the surface area occupied by the magnetic pole extending longitudinally of the body and the length of the surface area occupied by the magnetic pole extending in a direction transverse to a longitudinal axis of the body.

The invention will now be described, by way of example, with reference to the accompanying drawing wherein:—

Figure 1 shows a side elevation of a lock, certain parts being broken away to reveal internal parts of the lock,

Figure 2 shows a cross section on the line II—II of Figure 1 of the lock, together with a key applied thereto,

Figure 3 illustrates diagrammatically the key and means for magnetising the key, and

Figure 4 is a graphical representation of a part of a magnetic field of the key.

The lock comprises a hollow body 1 which, when the lock is in use, would be fitted in a housing of an associated device (not shown) which is to be controlled by the lock. The

50

55

60

65

70

75

80

85

90

95

interior of the body is generally cylindrical and is partly closed at one end by a flange 2 defining a non-circular aperture 3 at the end of the body. Within the body there are disposed three sleeves 4, 5 and 6 respectively which are rotatable relative to the body about a longitudinal axis 7 thereof. The sleeves abut one another and overlap somewhat in the axial direction, a smaller diameter portion of the sleeve 4 being received within the sleeve 5 and a smaller diameter portion of the sleeve 5 being received within the housing 6.

The lock further comprises a barrel 8 which extends from the aperture 3 of the body through the sleeves 4, 5 and 6 and protrudes from the opposite end of the body. There is formed in the barrel an elongate slot for receiving a key (shown in Figures 2 and 3). Between each of the sleeves 4, 5 and 6 and the barrel 8, there is formed a respective channel which extends around the axis 7. The channels may, as shown in Figure 2, extend completely around the axis. Alternatively, the channels may extend a part of the way around the axis. Each channel is formed partly in the barrel 8 and partly in the associated sleeve. The part of the channel which is formed in the barrel constitutes a circumferential groove 9 in the barrel. Thus, this part of the channel is bounded by axially facing abutment surfaces 10 and 11 at opposite sides of the groove and by a radially outwardly facing surface 12 at the bottom of the groove. The part of each channel which is formed in the associated sleeve is constituted by an annular or arcuate recess in the associated sleeve and is defined by a single axially facing abutment surface 13 and a radially inwardly facing surface 14 on the sleeve.

In each of the channels defined between the sleeves 4, 5 and 6 and the barrel 8, there are provided two locking elements which are formed of a magnetic material, for example mild steel. The locking elements are adapted to roll along the channels and are preferably in the form of cylindrical rollers. The rollers which run in the channel associated with the sleeve 4 are indicated in Figure 2 by the reference numerals 15 and 29. Each roller is arranged with its longitudinal axis parallel to the axis 7 and has a diameter only slightly less than the distance between the surface 12 at the bottom of the groove and the surface 14 of the sleeve. Thus, approximately one half of the roller occupies the groove 9 and the other half of the roller occupies the recess in the sleeve. Parts of the lock other than the rollers are formed of non-magnetic material.

The barrel 8 includes a part 23 which protrudes from the body 1 and is adapted, for example by the radially projecting lugs shown in the drawing, drivingly to engage the associated device. When the key is present in the key slot of the barrel, the barrel can

be rotated to operate the associated device. When the key is absent, rotation of the barrel is prevented by a cam mechanism. The cam mechanism is arranged to displace the sleeves 4, 5 and 6 axially when the barrel is rotated but, in the absence of the key, axial displacement of the sleeves is prevented by the magnetic locking elements.

The barrel 8 is constrained against axial movement relative to the body 1. The length of each magnetic locking element is slightly less than the distance between the opposite sides of the groove in the barrel containing that element (the sides 10 and 11 of the groove 9 in the case of the rollers 15 and 29). Accordingly, the rollers are constrained against axial displacement relative to the barrel and the body and, when one end surface of the roller 15 faces towards the surface 13 of the sleeve, the roller prevents axial displacement of the sleeve in a first direction relative to the barrel. The other rollers similarly obstruct axial displacement of the sleeve in the absence of the key from the barrel.

In the side surface 13 of the recess of each of the sleeves 4, 5 and 6, there are formed two openings 16, each having a sufficient size to accommodate that part of a respective one of the rollers which protrudes from the groove 9. Thus, if each roller is moved along its channel into a releasing position in which it is aligned with a respective one of the openings 16, the associated sleeve can move in the first axial direction.

Each roller is constrained to move around the axis 7 along a respective path, opposite ends of which are defined by abutments 30 which are spaced apart around the axis, project into the recess in the associated sleeve and are fixed with respect to that sleeve. The abutments are so arranged that the releasing position of each roller is spaced from the ends of the path along which it can move. It will be noted that each path is of arcuate form with its centre of curvature on the axis 7 so that the distance between the path and the axis is uniform along the length of the path. The length of each path is a plurality of times the diameter of the rollers 15 and 29. The length of each path may be at least four times the diameter of the rollers.

The respective paths along which the rollers 15 and 29 and the other rollers in the lock can move preferably subtend at the axis 7 angles exceeding 45°. The angles subtended by different ones of the paths may differ from each other. Preferably, each path subtends at the axis an angle of at least 90°.

The cam mechanism for causing axial displacement of the sleeves 4, 5 and 6 in the first direction when the barrel 8 is rotated from the single rotary position in which the key can be inserted and withdrawn, called herein the key-insertion position, is situated

within the body 1 and adjacent to the end thereof remote from the aperture 3. This first cam mechanism comprises a ring 17 which is constrained to rotate with the barrel 8 by a spline on the ring engaged in an axially extending groove 8a formed in the barrel. The ring 17 has an axially projecting cam formation 18. The first cam mechanism comprises a further ring 10 which lies at the side of the ring 17 remote from the aperture 3 and has a recess 20 complementary to the cam formation 18 and in which that cam formation is received when the key is absent from the lock. The ring 19 is constrained (by means not shown) against rotation relative to the body 1.

Axial displacement of the ring 19 relative to the barrel 8 in a direction away from the aperture 3 is prevented by a circlip 22 engaged in a peripheral groove formed in the part 23 of the barrel which protrudes from the body 1. Accordingly, when the barrel is rotated relative to the body, the ring 17 is positively displaced relative to the barrel in the first axial direction and, since the ring 17 abuts the sleeve 6, each of the sleeves 4, 5 and 6 also is positively displaced in the same direction. This can occur only when all of the rollers are aligned with their respective openings 16.

A second cam mechanism is provided for positively displacing the sleeves 4, 5 and 6 relative to the barrel in a second axial direction when the barrel 8 is returned to its key-insertion position. The second mechanism is situated adjacent to the aperture 3 and comprises a bush 25 and a ring 24 which is keyed to the barrel 8 by a spline on the ring engaging in the groove 8a. A portion of the bush 25 extends into the aperture 3 and has a complementary non-circular shape, so that the bush is constrained against rotation relative to the body 1. At its opposite end, the bush is provided with an axially projecting cam formation 26 which co-operates with a corresponding axially projecting cam formation 27 on the ring 24. When the barrel is in the key-insertion position, the cam formations 26 and 27 co-operate with each other to maintain the ring 24 and bush 25 apart.

When the barrel is rotated from the key-insertion position in either direction, the cam formations 26 and 27 permit the ring 24 and bush 25 to move towards each other. Conversely when the barrel is rotated towards its key-insertion position, the cam formations 26 and 27 move the ring 24 and bush 25 positively apart. Since a shoulder 28 on the bush abuts the flange 2 on the body, this causes displacement of the ring 24 in the second axial direction. The ring 24 abuts the sleeve 4 so that the sleeves 4, 5 and 6 are caused to move in the second axial direction with the ring 24.

The clearances between various components of the lock are sufficient to ensure

that a small degree of rotation of the ring 24 can occur before positive axial displacement of that ring occurs, and avoid jamming of the cam formation 27 on the cam formation 26. The sleeves 4, 5 and 6 are constrained to rotate with the barrel by respective splines on the sleeves which engage in the groove 8a.

The key for operating the lock comprises an elongate body 31 of substantially cylindrical shape. On one end of the key body, there is secured a handle 32 of moulded plastics material. The handle may have a metal core. Adjacent to the handle, there projects radially from the body 31 a lug 33 to engage in a complementary recess (not shown) formed in the barrel to enable torque to be transmitted to the barrel when the key is applied to the lock. There is formed in the bush 25 an opening to admit the key to the key slot of the barrel, this opening including a notch through which the lug 33 passes. The key can be applied to and withdrawn from the lock only when the lug 33 is in alignment with this notch.

The end of the key body 31 which is remote from the handle 32 may be chamfered and the key body may be enclosed in a sleeve of non-magnetic material. The key body is formed of a material which can be permanently magnetised. A sintered isotropic ferrite is a suitable material.

When the key is applied to the lock, a longitudinal axis of the key body 31 coincides with the axis 7 of the lock. Since the key body is cylindrical, respective parts of that body which are integral with each other lie adjacent to respective ones of the paths along which the rollers of the lock move. Furthermore, each such part of the body extends along the entire length of the corresponding path. The provision of a cylindrical body of magnetisable material is convenient in the manufacture of a number of keys, each with a different magnetic field pattern. However, it would be within the scope of the invention to provide a non-cylindrical key body. Such key body would include respective parts lying adjacent to the paths along which the rollers move, each such part extending along at least one half of the length of the corresponding path. The distance between each path and the surface of the corresponding part of the key is preferably uniform along the length of the path or along such part of the length as lies adjacent to a corresponding part of the key.

The key may be magnetised by means of a magnetising head as indicated diagrammatically in Figure 3. This magnetising head comprises a pole piece having three integral, parallel limbs 34, 35 and 36 of soft iron. Around the central limb 35 there is an electrically conductive winding 37. This winding may lie between free end portions of the limbs. At the free ends of the limbs of

the pole piece there are formed arcuate end faces having the same radius of curvature as the peripheral surface of the key body 31. The pole piece is supported adjacent to the key with the end face of the central limb 35 overlying a position on the key body which corresponds to the path along which one roller of the lock moves, or to a mid-portion of the path, and with the centre of the end face overlying a point on the surface of the key body which corresponds to the releasing position of the roller which moves along that path. A current is then passed through the winding 37. This establishes on the surface of the key body 31 a magnetic pole which occupies an elongate area corresponding approximately to the end face of the limb 35. Around this elongate pole, there is a region of opposite polarity.

A magnetic pole corresponding to the path along which one of the rollers moves is indicated in Figure 3 by the reference numeral 38. An opposite magnetic pole which surrounds the pole 38 is indicated by the reference numeral 39. Between these poles there is a narrow region without significant magnetic polarity. The pole 38 is substantially rectangular, the length of the pole extending around the axis of the key body and the width of the pole extending along the axis. The magnetic flux density has a maximum value at a position along the pole 38 which corresponds to the releasing position of the corresponding roller and decreases gradually towards opposite ends of the pole.

In Figure 4, there is shown a typical curve obtained by plotting magnetic flux density against angular coordinate about the axis of the key body at a position along the key body corresponding to the groove 9 of one of the sleeves 4, 5 and 6. Also in Figure 4 there is represented above the curve the paths along which the two rollers associated with this groove can move. It will be seen that the flux density reaches maxima at respective positions along the roller paths which lie between the ends thereof and decreases from those maxima towards the ends of the paths. Along the entire length of each path, except at the releasing position, the flux density is changing at a rate represented in Figure 4 by the slope of the curve. With the exceptions of the releasing positions and parts of the curves which lie outside the roller paths, the rate of change of flux density with distance along the paths is always sufficient to move the rollers along the paths towards their releasing positions.

It will be appreciated that the distance which a roller can move along its path is less than the length of that path, because the roller has a finite size. The angle through which the centre of a roller can move about the axis 7 is equal to the difference between the

angle subtended at the axis by the path pertaining to that roller and the angle subtended by the roller itself at the axis. Thus, in a typical case where the path pertaining to a roller subtends at the axis an angle of 140° , and the releasing position of the roller is spaced from the ends of the path by a distance greater than the diameter of the roller, the magnetic action of the key is required to move the centre of the roller about the axis 7 through an angle of not more than 70° . At positions spaced from the releasing position of the roller by an angle greater than 70° , the rate of change of flux density with distance measured longitudinally of the path may fall to a value which is too small to effect movement of the roller. Although in the example illustrated in Figure 4, the flux density does not reach a minimum value within either of the roller paths, this is not essential to satisfactory operation and the flux density may reach a minimum value within, but close to, an end of a roller path.

The magnetic flux density typically has a value of 0.5 Kilogauss at the releasing positions.

In the particular example of lock and key illustrated, the diameter of each roller is approximately one half the diameter of the magnetised body 31 of the key. In a case where the overall diameter of the lock body must be limited to a prescribed value, we believe an arrangement with locking elements having a diameter of approximately one third the diameter of the key body represents the best compromise between reliable operation and adequate security. The diameter of the magnetic elements may be within the range one half to one sixth of the diameter of the key body.

WHAT WE CLAIM IS:—

1. A combination comprising a key with which there is associated a magnetic field and a lock which is operable by the key, the lock comprising a magnetic element which is movable by the magnetic action of the key along a path defined by the lock into a releasing position; the lock defining opposite ends of the path, wherein the key comprises a body of magnetised material which, when the key is applied to the lock, lies adjacent to said path and extends along more than half of the length of the path, the magnetic field of the key has, adjacent to opposite ends of said path, a differential coefficient of the flux density with respect to distance along the path which is sufficient to move said element from either end of the path, the releasing position lies between the ends of the path and the flux density increases along the path from the ends thereof to a maximum value at the releasing position.

2. The combination according to Claim 1 wherein the magnetised body of the key

the pole piece there are formed arcuate end faces having the same radius of curvature as the peripheral surface of the key body 31. The pole piece is supported adjacent to the key with the end face of the central limb 35 overlying a position on the key body which corresponds to the path along which one roller of the lock moves, or to a mid-portion of the path, and with the centre of the end face overlying a point on the surface of the key body which corresponds to the releasing position of the roller which moves along that path. A current is then passed through the winding 37. This establishes on the surface of the key body 31 a magnetic pole which occupies an elongate area corresponding approximately to the end face of the limb 35. Around this elongate pole, there is a region of opposite polarity.

A magnetic pole corresponding to the path along which one of the rollers moves is indicated in Figure 3 by the reference numeral 38. An opposite magnetic pole which surrounds the pole 38 is indicated by the reference numeral 39. Between these poles there is a narrow region without significant magnetic polarity. The pole 38 is substantially rectangular, the length of the pole extending around the axis of the key body and the width of the pole extending along the axis. The magnetic flux density has a maximum value at a position along the pole 38 which corresponds to the releasing position of the corresponding roller and decreases gradually towards opposite ends of the pole.

In Figure 4, there is shown a typical curve obtained by plotting magnetic flux density against angular coordinate about the axis of the key body at a position along the key body corresponding to the groove 9 of one of the sleeves 4, 5 and 6. Also in Figure 4 there is represented above the curve the paths along which the two rollers associated with this groove can move. It will be seen that the flux density reaches maxima at respective positions along the roller paths which lie between the ends thereof and decreases from those maxima towards the ends of the paths. Along the entire length of each path, except at the releasing position, the flux density is changing at a rate represented in Figure 4 by the slope of the curve. With the exceptions of the releasing positions and parts of the curves which lie outside the roller paths, the rate of change of flux density with distance along the paths is always sufficient to move the rollers along the paths towards their releasing positions.

It will be appreciated that the distance which a roller can move along its path is less than the length of that path, because the roller has a finite size. The angle through which the centre of a roller can move about the axis 7 is equal to the difference between the

angle subtended at the axis by the path pertaining to that roller and the angle subtended by the roller itself at the axis. Thus, in a typical case where the path pertaining to a roller subtends at the axis an angle of 140° , and the releasing position of the roller is spaced from the ends of the path by a distance greater than the diameter of the roller, the magnetic action of the key is required to move the centre of the roller about the axis 7 through an angle of not more than 70° . At positions spaced from the releasing position of the roller by an angle greater than 70° , the rate of change of flux density with distance measured longitudinally of the path may fall to a value which is too small to effect movement of the roller. Although in the example illustrated in Figure 4, the flux density does not reach a minimum value within either of the roller paths, this is not essential to satisfactory operation and the flux density may reach a minimum value within, but close to, an end of a roller path.

The magnetic flux density typically has a value of 0.5 Kilogauss at the releasing positions.

In the particular example of lock and key illustrated, the diameter of each roller is approximately one half the diameter of the magnetised body 31 of the key. In a case where the overall diameter of the lock body must be limited to a prescribed value, we believe an arrangement with locking elements having a diameter of approximately one third the diameter of the key body represents the best compromise between reliable operation and adequate security. The diameter of the magnetic elements may be within the range one half to one sixth of the diameter of the key body.

WHAT WE CLAIM IS:—

1. A combination comprising a key with which there is associated a magnetic field and a lock which is operable by the key, the lock comprising a magnetic element which is movable by the magnetic action of the key along a path defined by the lock into a releasing position, the lock defining opposite ends of the path, wherein the key comprises a body of magnetised material which, when the key is applied to the lock, lies adjacent to said path and extends along more than half of the length of the path, the magnetic field of the key has, adjacent to opposite ends of said path, a differential coefficient of the flux density with respect to distance along the path which is sufficient to move said element from either end of the path, the releasing position lies between the ends of the path and the flux density increases along the path from the ends thereof to a maximum value at the releasing position.

2. The combination according to Claim 1 wherein the magnetised body of the key



extends along the path substantially from one end thereof to the other end.

3. A combination according to Claim 1 or Claim 2 wherein the distance between the path and the magnetised body of the key is at least approximately constant along the path.

4. A combination according to any preceding claim wherein the length of the path is at least four times the corresponding dimension of the magnetic element.

5. A combination according to any preceding claim wherein the path is curved and extends around a central axis of the key and the path subtends at that axis an angle exceeding 45° .

6. A combination according to Claim 5 wherein the angle subtended by the path at the axis of the key is at least 90° .

7. A combination according to Claim 5 or claim 6 wherein the magnetised body of the key is cylindrical, the magnetic element is a rolling element and the diameter of the magnetic element is within the range one half to one sixth of the diameter of the key body.

8. A combination according to any preceding claim wherein the magnetised body of the key has on its surface a magnetic pole which, when the key is applied to the lock, lies adjacent to said path, the pole occupying an elongate area of the surface of the body with the length of the area extending along the path.

9. A combination according to Claim 8

wherein the magnetised body of the key is elongate, the width of the magnetic pole extends along the body and the length of the magnetic pole extends in a direction transverse to the length of the body.

10. A combination according to any preceding claim wherein the lock defines a plurality of paths which are spaced apart, there is a respective magnetic element movable along each of said paths and the magnetised body of the key has respective parts which lie adjacent to the parts and are integral with one another.

11. A combination according to Claim 10 wherein said paths are spaced apart in a direction transverse to the length of each path.

12. A lock and key substantially as herein described with reference to and as shown in the accompanying drawings.

FORRESTER, KETLEY & CO.,
Chartered Patent Agents,
Rutland House,
148, Edmund Street,
Birmingham, B3 2LD,
also at
Forrester House,
52, Bounds Green Road,
London, N11 2EY.
and
Scottish Provident Building,
29, St. Vincent Place,
Glasgow, G1 2DT.
Agents for the Applicants.