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(54) MAGNETICALLY ACTING LOCK AND KEY

(71) We, LOWE AND 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:

From one aspect, the present invention relates to a lock intended for operation by a key with which there is associated a magnetic field.

There are known locks of this kind which include a plurality of channels and a plurality of magnetic elements disposed in respective ones of the channels for movement there along, the magnetic elements preventing operation of the lock when the key is absent and the magnetic elements being moved, when the proper key is applied to the lock, by the magnetic field of the key along the channels into predetermined releasing positions such that they no longer prevent operation of the lock.

By a 'magnetic element' we mean an element which is subjected to a substantial force when placed in a magnetic field. The magnetic element may comprise a permanent magnet or be formed of a ferro-magnetic material which is not permanently magnetised.

According to a first aspect of the invention, there is provided a lock comprising an operating member, a further member, a channel defined by the operating member and the further member collectively, a magnetic element and abutment surfaces at opposite sides of the channel, wherein the operating member and further member are arranged for relative movement, the magnetic element is disposed in the channel and is movable along the channel by a magnetic field, the abutment surfaces face in opposite directions in which the relative movement of the operating member and

further member can occur, the abutment surfaces are formed on the operating member and on the further member respectively, the abutment surfaces are engageable concurrently with the magnetic element except when the magnetic element occupies a predetermined releasing position in the channel whereby relative movement of said members to operate the lock is prevented by engagement of the magnetic element with the abutment surfaces except when the magnetic element occupies its releasing position, the magnetic element is formed as a roller having a peripheral surface and opposite end surfaces and the roller is arranged with its longitudinal axis transverse to the length of its channel, whereby the roller can roll along its channel on its peripheral surface, and the end surfaces of the roller are presented towards the abutment surfaces, whereby engagement between the abutment surfaces and the roller occurs at the end surfaces of the roller.

The abutment surfaces and the end surfaces of the magnetic element are preferably all flat. The magnetic element may be hollow or have recesses at its ends. Thus, the flat end surfaces of the magnetic element may be annular.

In the preferred construction, the operating member is formed with an internal keyway for receiving a key, the operating member is rotatable about an axis when the magnetic element is in its releasing position, the channel extends circumferentially of the axis around the operating member, the abutment surfaces face along the axis and constraining means other than the magnetic element is provided for constraining the operating member against movement along the axis throughout operation of the lock.

There may be a plurality of channels defined collectively by the operating member and further member, there being in each channel a respective magnetic element which is formed as a roller and is arranged in the

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manner hereinbefore defined.

According to a second aspect of the invention there is provided, in combination, a lock according to the first aspect of the invention and a key which comprises a magnetised region for the or each magnetic element of the lock, wherein each magnetised region of the key includes a pair of magnetic poles of like polarity disposed at diametrically opposite positions with respect to an axis of the key.

By the expression 'a magnetised region' we mean a region with which there is associated a permanent magnetic field.

The invention also includes a vehicle anti-theft device comprising a lock in accordance with the first aspect of the invention.

The invention will now be described by way of example with reference to the accompanying drawings wherein:-

Figure 1 shows a lock and a key for operation thereof, the lock being shown in longitudinal cross section and the key being present in a key-receiving member of the lock;

Figure 2 shows a cross section on the line II-II of Figure 1.

Figure 3 shows a fragmentary cross section on the line III-III of Figure 1;

Figure 4 shows diagrammatically a modification of the lock and key shown in Figure 1;

Figure 5 shows a cross section on the line V-V of Figure 4;

Figure 6 shows a cross section of a vehicle anti-theft device comprising a lock in accordance with the invention;

Figure 7 shows a cross section on the line VII-VII of Figure 6;

Figure 8 shows an alternative form of key which may be used in combination with the locks of Figures 1, 4 and 6, parts of the key being shown disassembled from one another, and Figure 9 shows diagrammatically a further example of a lock in accordance with the invention.

The lock shown in Figure 1 comprises a body 10 which, when the lock is in use, is normally disposed in a housing of a device to be controlled by the lock. From one end of the body, called herein the inner end, there projects a driving member 11 which, when the correct key 12 is applied to the lock, can be rotated about a longitudinal axis 13 of the lock to release or operate the associated device. As shown in Figure 1, a driven member 14 of the device may be received on the driving member 11, keyed thereto and retained thereon by a circlip 15.

The associated device may be a bolt or latch for a door or drawer, in which case the driven member 14 may be in the form of a crank for moving the bolt or latch. Alternatively, the lock could be incorporated in a vehicle anti-theft device, in which case the driven member 14 may be a cam arranged for moving a bolt of the device substantially in

the manner hereinafter described with reference to Figure 6.

The driven member 11 is integral with or rigidly secured to a key-receiving member of the lock which is in the form of a barrel 16. The barrel is rotatable about the axis 13 during operation of the lock and is constrained at all times against axial movement relative to the body 10. An outer end face of the barrel is presented towards and engageable with a radially projecting flange 17 on the body 10, which flange defines an opening 18 in the body for receiving the key 12. An axially inwardly facing shoulder on the barrel abuts a ring 19 which is in sliding contact with an annular closure member 20. The closure member is secured in the inner end of the body 10 by a screw thread and prevents axially inward movement of the ring 19. The ring is keyed to the barrel. It will be seen that the driving member 11 projects through the central opening of the closure member 20 and is freely rotatable therein.

Also disposed within the body 10, there is an obstructing member 21 for obstructing rotation of the barrel 16 when the proper key is absent therefrom. The obstructing member is in the form of a sleeve and, for convenience of manufacture and assembly, is formed in three parts, 22, 23 and 24, each of which is a sleeve. The sleeve 22 forms the axially inner end of the obstructing member, the sleeve 24 forms the axially outer end of the obstructing member and the sleeve 23 forms the middle of the obstructing member. The middle sleeve 23 has a smaller diameter portion which is received within a larger diameter portion of the sleeve 22 and a larger diameter portion within which a smaller diameter portion of the sleeve 24 is received. The barrel 16 is formed at one side with a longitudinally extending spline 25 which is received in aligned, axially extending grooves formed in the radially inwardly presented faces of the sleeves 22, 23 and 24. This spline therefore constrains the obstructing member to rotate with the barrel but permits axial movement of the obstructing member relative to the barrel.

From the axially outwardly presented face of the sleeve 24 there projects a cam formation 26. When the key is absent from the lock and the obstructing member is in the outer position shown in Figure 1, this cam formation is received in a corresponding recess 27 formed in a rearwardly presented internal face of the body 10. Whilst the cam formation is situated in this recess, rotation of the sleeve 24 and therefore of the other sleeves and of the barrel 16 is prevented. The obstructing member 21 is urged in the outward axial direction by a spring 28 so that the cam formation 26 remains in the recess 27 whenever the rotational position of the sleeve 24 is such that the formation 26 is in alignment with the recess 27. The shape of the cam formation 26

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is such that it can be driven out of the recess 27 by rotation of the sleeve 24, provided that axial movement of the sleeve 24 relative to the body 10 and therefore relative to the barrel 16 is permitted.

In the absence of the proper key, each one of the sleeves 22, 23 and 24 is constrained against axial movement relative to the barrel 16 by respective magnetic locking elements 29, 30 and 31. Other parts of the lock are formed of non-magnetic materials. Accordingly, the elements 29, 30 and 31 can be controlled by a suitably magnetised key. When the proper key is inserted into a keyway of the barrel 16, the elements 29, 30 and 31 are moved into releasing positions such that the sleeves 22, 23 and 24 are freed for axial movement relative to the barrel.

In the radially outwardly presented face of the barrel 16, there are formed three circumferentially extending grooves 32. These grooves do not extend completely around the axis 13 but subtend an angle of approximately 300° thereat. Each of the grooves 32 lies radially inwardly of a corresponding one of the sleeves 22, 23 and 24. Each sleeve is formed in its radially inner face with an arcuate recess 33, the position of which along the axis 13 is the same as that of the corresponding groove 32 when the parts are in the position shown in Figures 1 and 2. The axial extent of each recess 33 is the same as that of each groove 32. Each recess 33, together with a part of its corresponding groove 32, forms a channel in which a corresponding one of the locking elements 29, 30 and 31 is received. The locking elements are adapted to roll along their respective channels and are preferably in the form of hollow cylindrical rollers. The axial extent of each locking element is only slightly less than that of the corresponding groove 32, so that the locking elements can move freely along their respective channels but are constrained against axial movement relative to the barrel 16.

The recess 33 of each of the sleeves 22, 23 and 24 is bounded at its axially outermost side by a wall 34 in which there is formed at least one notch 35. The notch is of sufficient size to accommodate that part of the transverse cross-section of the associated locking element which projects from the groove 32. Accordingly, if each locking element is aligned axially with the notch 35 of its corresponding sleeve, the sleeve can move axially relative to the barrel in the inward direction so that the locking element enters the notch. If one locking element is not completely aligned with its notch, axial movement of the associated sleeve and therefore of the obstructing member as a whole relative to the barrel is prevented.

The locking elements 29, 30 and 31 preferably present for engagement with the walls 34 of the associated sleeves 22, 23 and 24 and

for engagement with the walls of the grooves 32 flat end faces. With this arrangement, even a small degree of overlap between the end face of the locking element and the wall of the associated sleeve will prevent axial movement of the obstructing member. Furthermore, the locking elements will not readily deform the associated sleeves even under high axial pressures.

When the key is absent from the lock, each of the locking elements 29, 30 and 31 will occupy a locking position which will normally be the lowest position that locking element can reach by movement along its channel. In its locking position, each locking element is engaged between the barrel 16 and an associated one of the sleeves 22, 23 and 24 in such a manner as to prevent axial movement of the sleeve from the position shown in Figure 1. When the key is withdrawn, the locking elements are moved to their locking positions by gravity.

The key 12 is adapted to so control the locking elements 29, 30 and 31 that, when the key is applied to the lock, each of these elements is moved from its locking position into and is held in its releasing position, in which the locking element is aligned with the corresponding notch 35. The key has three magnetised regions, each comprising a permanently magnetised element, 36, 37 and 38 of approximately annular form. The magnetised elements (magnets) are carried on a stem 39 of the key which extends through the central openings. Each magnet has a pair of pole faces, these being presented in opposite directions along the key so that its unlike poles are spaced apart longitudinally of the key and of the axis 13. Adjacent to each pole face there is a magnetic conductor 40, the conductors also being of approximately annular form and carried on the stem 39.

It is the respective forms of the conductors 40 which determines the positions to which the locking elements 29, 30 and 31 are moved by the key. In the particular example illustrated in Figure 1, there is one conductor 40 for each pole face of each magnet and adjacent conductors associated with different magnets are spaced apart by shield elements 41. These shield elements have a low magnetic permeability and shield the conductors associated with one magnet from the field associated with an adjacent magnet. When the key is fully inserted into the barrel 16, the two conductors 40 associated with the magnet 36 are substantially in alignment with opposite end portions of the locking element 29. The conductors associated with the magnets 37 and 38 have a similar relationship to the locking elements 30 and 31 respectively.

The shape of the magnetic conductors 40 is such, relative to the paths along which the locking elements 29, 30 and 31 move between

their locking and releasing positions that the distance between each locking element and the associated conductors varies as the locking element moves along its channel and is a minimum at the releasing position. In the particular example shown, each locking element is free to move along a path which forms an arc of a circle centered on the axis 13. As viewed in a direction along the key, the conductors 40 have non-circular profiles as shown in Figure 2. One part of the periphery of each conductor (corresponding to the releasing position of the associated locking element) is situated at least as far from the axis 13 as are all other parts of the periphery and further from the axis than most of the periphery. In the example illustrated in Figure 5, two parts of the periphery which are separated angularly about the axis 13 by 180° , are situated further from the axis than all other parts of the periphery. This enables the locking elements to be set in their releasing positions when the key is inserted into the barrel in either one of two alternative angular positions which differ by 180° about the axis 13.

The cross section of the stem 39 is non-circular and the central opening of each conductor 40 has a corresponding shape, so that the conductors cannot turn relative to the stem. For convenience of illustration, the particular example illustrated in Figures 2 and 3 is such that the locking elements 29, 30 and 31 are in axial alignment with one another when in their releasing positions. Accordingly, all of the magnetic conductors 40 are identical. Different samples of the lock would be produced with different releasing positions of the locking elements, the shape of the sleeves 22, 23 and 24 and of the conductors 40 being modified accordingly.

The use of two magnetic conductors 40 in association with each of the locking elements 29, 30 and 31 as shown in Figure 1, is preferred in a case where the locking elements are fairly long. The use of two conductors in this manner provides better control over the locking element with regard to the maintenance of a parallel relationship between the axis of the locking element and the axis 13 than would be likely to be established by the use of a single conductor in association with a long locking element.

As shown in Figure 2, in the particular example illustrated in Figures 1, 2 and 3, the notch 35 of each of the sleeves 22, 23 and 24 is situated half way along the recess 33. In different samples of the lock, the notch may be situated away from the middle of the recess 33 so that locks having the recesses 33 similarly positioned cannot be operated by the same key, the key being required to correspond to the positions of the notches 35. A number of locking elements greater than 3

may be provided in the lock, the number of sleeves in the obstructing member being increased accordingly.

To enable torque to be transmitted from the key 12 to the barrel 16, the key is provided with a pair of radial projections 42 which project from a part of the key lying between the stem 39 and a handle portion of the key (not shown). When the key is inserted into the lock, these projections pass through diametrically opposite notches in the flange 17 and engage in recesses 44 in the barrel 16. These recesses are open at their outer ends, but are closed at their inner ends so that axially inwardly directed force can also be transmitted from the key to the barrel by the projections 42.

When the key is inserted into the lock, each of the locking elements 29, 30 and 31 is moved to its releasing position. This frees the obstructing member 21 for axial movement relative to the barrel 16. The key can then be rotated to rotate the barrel and obstructing member about the axis 13. During an initial part of such rotation, the cam formation 26 drives the obstructing member 21 axially inwardly until the cam formation is completely withdrawn from the recess 27. Further rotation can then take place without any axial movement occurring. Until the key is returned to the initial position by reverse rotation, the key is retained in the lock as the projections 42 are situated axially inwardly of the flange 17 and would engage this flange if an attempt is made to withdraw the key.

If required, each of the sleeves 22, 23 and 24 may be formed with more than one notch 35. This would enable the lock to be operated by at least two different keys, one of which could be a master key for operating a suite of locks.

If, whilst the key is absent from the lock, an attempt is made to move the barrel 16 by means of some other instrument inserted into the lock, the application of torque to the barrel will, through the action of the cam formation 26, result in the application to the obstructing member 21 of an axially inwardly directed force. This will establish pressure contact between, on the one hand the locking elements 29, 30 and 31 and, on the other hand, the walls 34 of the corresponding sleeves 22, 23 and 24 and the barrel 16. Such contact pressure will establish sufficient friction to prevent subsequent movement of the locking elements to their releasing positions until the application of torque to the barrel is discontinued. Similarly, any application of an axially directed force to the barrel 16 will establish contact pressure with the locking elements and prevent movement of the locking elements to their releasing positions.

When torque is applied to the barrel 16 by means other than the correct key, the locking

elements 29, 30 and 31 are not required to withstand the entire force applied to the barrel. Friction between the cam projection 26 and the body 10 is such that, when axial movement of the obstructing member 21 is prevented, the major part of any torque applied to the barrel is resisted by cooperation between the cam projection and the body. The cam projection can be made sufficiently large to ensure that unauthorised rotation of the barrel 16 is prevented and the sleeve 24, including the cam projection, can be formed of a strong material, for example steel.

In the particular example of lock illustrated in Figures 2 and 3, the locking elements 29, 30 and 31 are formed of a magnetic material but are not permanently magnetised. These elements are therefore urged to the positions along their respective paths of movement at which the density of the magnetic flux established by the key is greatest, irrespective of the polarity of each magnetised region of the key. If required, each locking element could be permanently magnetised, in which case only a key having an appropriate polarity of each magnetised region would be capable of operating the lock. It is intended that the key should be assembled with the magnets 36, 37 and 38 in an unmagnetised condition and that the key should then be treated to permanently magnetise these magnets with the required polarities. The magnets 36, 37 and 38 may be formed of a sintered ferrite. The magnetic conductors 40 are formed of a magnetic steel, preferably one having high carbon content.

A plurality of different locks may be arranged so that they can be operated by a single key. Such key would have one or more magnetic conductors of such a form that there are a plurality of positions around the axis of the key and at the same distance from that axis at which the strength of the magnetic field is greater than at other positions. The locks would be arranged to provide different paths of movement for their locking elements, each path corresponding to a respective one of the maximum field strength positions of the key.

As shown in Figure 2, the profile of each magnet of the key is non-circular. However, for convenience of production and assembly of the lock, we prefer to provide circular magnets so that different keys will differ only in respect of the shapes of the magnetic conductors. In Figures 4 and 5 there is illustrated a modification of the lock and key combination of Figure 1 whereof the key has magnets with a circular profile. In Figure 4 parts corresponding to those already described with reference to Figures 1 to 3 are indicated by like reference numerals with the prefix 1 and the preceding description is deemed to apply, except for the differences

hereinafter mentioned.

In the key 112 shown in Figure 4, each magnetic conductor 140 modifies the field of two magnets 150. These two magnets lie on opposite sides of the conductor and present towards the conductor like magnetic poles. The key of Figure 4 comprises only a single conductor to control each one of the locking elements 129, 130 and 131 and these locking elements are short, as compared with the locking elements shown in Figure 1.

The cam formation 126 on the sleeve 124 of the lock of Figure 4 is a female formation and a complementary male cam formation 127 is provided on the flange 117 of the body.

As shown in Figure 5 the profile of each magnetic conductor 140 is non-circular. However, the conductor overlaps with almost the whole of the pole face (end face) of each adjacent magnet 150. At two diametrically opposite positions 151 and 152, the periphery of the conductor is spaced from the axis 13 by a distance greater than the radius of the magnets 150. Only one of these positions, depending upon which way up the key is inserted, lies adjacent to the path along which the corresponding locking element 129, 130 and 131 can move. Since this particular part of the profile of the conductor is closer to the path than is any other part of the profile, the locking element will be attracted to a position in which it lies on the diameter through the parts 151 and 152 of the conductor. This is the releasing position of the locking element, in which it is aligned with the notch 135 of the corresponding sleeve. In different keys intended to operate different samples of lock, the profile of the conductors would have an angular relation to the key stem in accordance with the different releasing positions of the locking elements.

The barrel 116 is provided with only one recess to receive a projection 142 of the key. This recess is defined between two axially projecting pegs 153 (one of which is shown) on the barrel. If excessive torque is applied to either of these pegs, for example by an attempt to force the lock without the proper key, the peg will shear off the barrel. At a position diametrically opposite to that of the recess 144, there is provided on the barrel a radial projection 154 which can engage with an abutment on the body 110 to limit rotation of the barrel relative to the body.

In Figures 6 and 7 there is illustrated a vehicle anti-theft device incorporating a further example of a lock in accordance with the present invention.

The anti-theft device comprises a housing 201 which, when the device is fitted to a motor vehicle, is rigidly clamped (by means not shown) to the stationary outer part of a steering column of the vehicle. In the housing there is mounted a bolt 202 which is slidable between a projected, locking position shown

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in Figure 6, in which a nose of the bolt engages in a groove formed in a collar secured to a rotatable shaft of the steering column, and a releasing position in which the nose is withdrawn from the collar. For urging the bolt towards its locking position there is provided a spring 203.

For displacing the bolt 202 from its locking position to its releasing position, there is provided a cam 204 rotatably mounted in an opening in a wall 205 of the housing. A portion of the cam remote from the bolt 202 projects beyond the wall 205 to cooperate with an electrical switch (not shown) which controls ignition and other electrical circuits of the vehicle when the anti-theft device is in use. Such switch is received in a chamber 206 of the housing.

The lock 207 is disposed within the housing 201 with its axis 213 perpendicular to the path of travel of the bolt 202 and with the body 210 of the lock partly projecting from the housing 201 through an opening at the end thereof opposite to the chamber 206. The body is permanently secured in the housing. A driving member 211 of the lock is coupled by a spindle 208 with the cam 204, the axis 213 of the lock coinciding with the axis of rotation of the cam.

Within the body 210 of the lock there is provided a barrel 216, near to the axially outer end of which there is formed a passageway 249 which extends radially from the periphery of the barrel to a keyway thereof. This passageway contains a key-detecting element 250, the length of which is somewhat longer than that of the passageway so that, when the key 212 is present in the keyway, the key detecting element is constrained to occupy the position shown in Figure 6 in which it projects radially from the barrel. The key detecting element can withdraw into the barrel only when the key is removed therefrom.

Also disposed within the body 210 there is an obstructing member 218 which is formed in two parts. Each of these parts extends along the entire length of the obstructing member and the parts lie on opposite sides of the axis 213. The obstructing member has a cam formation 226 which cooperates with a complimentary formation on the barrel 216 to ensure that the barrel can rotate about the axis 13 relative to the obstructing member only when axially inward displacement of the obstructing member from the position shown in Figure 6 is permitted. The obstructing member is urged in the axially outward direction by a spring 251 which is disposed around the spindle 248 and acts between the obstructing member and the cam 204. An upper part of the obstructing member carries a bolt-retaining element 252 which, when the obstructing member is in the first position shown in Figure 6, is held by the obstructing

member clear of the path of travel of the bolt 202. The retaining element can move in the axially outward direction relative to the obstructing member against the action of a spring 253. The upper part of the obstructing member is disposed in an internal spline formed in the body 210 and thereby constrains the obstructing member against rotation about the axis 213.

There is also carried by the obstructing member 218 retaining means for retaining the obstructing member in its second axial position relative to the barrel 216 when the obstructing member has once moved axially into that second position. This retaining means is in the form of a spring loaded plunger 256 which is guided for radial movement relative to the obstructing member and is urged radially inwardly towards the barrel. The barrel is formed with a peripheral groove 257 which is aligned with the plunger 256 only when the obstructing member is in its second position. At one end of the groove 257 there is a ramp leading up from the groove onto the surface of the barrel 216 so that the plunger 256 can be expelled from the groove when the barrel is rotated into its locking position.

For holding the obstructing member 218 in its second position whilst the barrel 216 is in its locking position until the key 212 has been withdrawn, there is formed on the obstructing member 218 an abutment 258 which cooperates with the projecting portion of the key detecting element 250. When the barrel is in its locking position and the obstructing member is in its first position, the projecting portion of the key detecting element 250 occupies a recess 259 in the obstructing member at the axially inner side of the abutment 258. Rotation of the key in the clockwise direction moves the key detecting element out of the recess 259 and clear of the abutment 258, moves the obstructing member 218 axially towards its second position and withdraws the bolt 202 from its locking position.

As the bolt is withdrawn from its locking position, the retaining element 252 bears against an axially outwardly facing surface of the bolt and the obstructing member 218 therefore moves axially inwardly relative to the retaining element. When the bolt reaches its releasing position, the retaining element moves axially inwardly to a position beneath a shoulder 260 on the bolt and therefore prevents the bolt returning to its locking position. Continued rotation of the key closes switch contacts of the switch disposed in the chamber 206.

When the key is rotated in the reverse direction to immobilise the vehicle, the switch contacts are opened. The cam 204 is rotated out of engagement with the bolt 202 so that the latter is held in its releasing position only

by the retaining element 252. Before the plunger 256 is expelled from the groove 257, the key detecting element 250 moves into overlapping relation with the abutment 258 and therefore prevents movement of the obstructing member 218 in the axially outward direction until the key is withdrawn.

When the key 212 is withdrawn, which can be done only when the barrel 213 is in its locking position, the action of corresponding cam faces on the abutment 258 and the key detecting element 250 drives the latter radially inwardly to clear the abutment and so free the obstructing member 218 for movement to its first position under the action of its spring. This withdraws the retaining element 252 from the bolt so that the latter is freed for movement into its locking position.

Axial movement of the obstructing member 218 is controlled by an assembly of sleeves 226, which assembly just fits between flanges 219 and 220 which project radially inwardly at opposite ends of the obstructing member. When the key is absent, the sleeves are constrained against axial movement relative to the barrel 216 by locking elements 227. When the correct key is inserted into a keyway of the barrel, the sleeves are freed for axial movement.

Each locking element 227 is disposed in a channel formed by a peripheral groove in the barrel 216 and a recess in an associated one of the sleeves 226, the arrangement being similar to that of the locking elements and channels hereinbefore described with reference to Figure 1. Each of the sleeves 226 also has a notch 232 similar to the notches 35 described with reference to Figure 1. The key 212 is adapted to move each locking element into alignment with the notch of the associated sleeve 226, thereby freeing the sleeves for axially inward movement.

Each of the locking elements 227 comprises a permanent magnet which is preferably contained in a casing of stronger, non-magnetic material. Each locking element is formed as a roller so that it can move easily along its channel. It will be noted that the locking elements of all of the embodiments of the invention which are shown in the accompanying drawings have flat end faces for contact with the sides of their respective channels. Each locking element is thus well adapted to support against any pressure exerted by an adjacent locking element on a part of the lock which lies between the two locking elements. It will be understood that the channels are generally so arranged that, when the locking elements are all in their locking positions, they will be in axial alignment with one another. To forcibly rotate the barrel of one of the locks whilst the locking elements are in their locking positions would involve

shearing of each one of the associated sleeves and the locking elements themselves provide support against such shearing. In the particular embodiment illustrated in Figure 6, further support for the sleeves is provided by the flanges 219 and 220.

The key 212 for operating the lock shown in Figure 6 comprises a number of magnetised regions equal to the number of locking elements 227 (three in the particular case illustrated). Each magnetised region of the key is constituted by a respective permanent magnet 233 having a central opening. The magnets are carried on a stem 234 of the key which extends through the central opening. The magnets are separated from one another by shield elements 235, also carried on the stem 234. The magnetic field associated with each magnet 233 is directed around the periphery of the key so that any magnetic body adjacent to the periphery of one of these magnets is subjected to a force which tends to move the magnetic body around the periphery of the magnet to a pole position on the circumference of the magnet. The shield elements 235 prevent the field of one of the magnets 233 controlling the position of a magnetic body which is adjacent to the periphery of another of the magnets.

That portion of the key 212 which includes the magnets 233 and the shield elements 235 has a non-circular cross section and the keyway in the barrel 216 has a complementary cross section so that the key can be inserted into the keyway only in a single, predetermined angular relation to the barrel. The pole positions of the magnets 233 are so arranged that, when the key is fully inserted, they each lie on the same diameter of the barrel as the, or one of the releasing positions of the corresponding locking element 227.

Adjacent to its axially outer end, the barrel 216 is formed with a recess to receive a radial projection 238 of the key, whereby torque can be transmitted from the key to the barrel. The sleeves 226 are constrained to rotate with the barrel by an axially extending rib 240 which projects radially from the barrel and engages in a keyway which extends through all of the sleeves 226.

It will be appreciated that the non-circular cross section of the keyway increases the difficulty of picking the lock without applying to the barrel 216 any torque. The application of such torque tends to move the obstructing member 218 and the sleeves 226 axially and thereby establishes pressure contact between the locking elements 227 on the one hand and the barrel and sleeves on the other hand. This substantially prevents movement of the locking elements into their releasing positions.

The length of each of the channels in which the locking elements are contained is preferably such that each locking element can move

along a path which subtends at the axis 213 an angle of at least 60°. The length of each channel is such that each locking element is constrained to a region sufficiently near to the pole position of the corresponding magnet 233, when the key is inserted, that the magnetic field of the key will be able to move the locking element into its releasing position without difficulty. The releasing position of each locking element is preferably intermediate the ends of its channel, rather than at one end of its channel.

In Figure 8, there is illustrated an alternative form of key which may be combined with the lock shown in Figure 1, with the lock shown in Figure 4 or with the device shown in Figure 6. The key of Figure 8 comprises a magnetised body 60 of cylindrical form which has a central opening of non-circular cross section in which there is received a shank 61 having a corresponding cross section. On one end of the shank, there is provided a handle portion 62 which can be grasped by a user. Between the body 60 and the handle portion 62, there is on the shank a pair of radial projections 63 which transmit torque to a barrel of the lock. The body 60 is covered by a sheath 64 which is conveniently formed as a moulding of a plastics material. A pin 65 extends through the sheath and through an aperture in the free end of the shank 61 to retain the body 60 and the sheath 64 on the shank.

The body 60 is formed of a material which can be permanently magnetised. A sintered ferrite, for example barium ferrite, is a suitable material for the body 60. After this body has been formed, it is magnetised in such a manner as to produce spot magnetic poles on the circumferential face of the body. Such poles can be produced by electro-magnetic probes in a known manner, the position of the probes being selected according to the required positions of the spot poles in the key. Thus, spot poles can be produced at various positions corresponding to the releasing positions of the magnetic elements of the lock with which the key is to operate.

Preferably, the body 60 is provided with a plurality of pairs of magnetic poles, each pair comprising a north pole and a south pole which are spaced apart along the key by a distance corresponding approximately to the length of a magnetic element of the lock which the key is to operate. At least one pair of poles is provided for each magnetic element, but we prefer to provide for each magnetic element two pairs of poles, these pairs being situated at diametrically opposite positions on the body 60 so that the key can be inserted into the lock in a selected one of two alternative positions which differ by 180° about the axis of the lock.

A further example of a lock in accordance with the invention is shown diagrammatically

in Figure 9. Certain parts shown in Figure 9 correspond to parts already described with reference to Figure 1, 2 and 3 and such corresponding parts are indicated by like reference numerals with the prefix 3. Except for the differences hereafter mentioned, the preceding description is deemed to apply to such corresponding parts.

The driven member 314 of the lock shown in Figure 7 is not permanently keyed to the driving member 311 which, in this example, is an integral part of the barrel 316. The driven member 314 is constrained against movement along the axis 313 by the body 310. When the proper key is present in the barrel 316, the barrel can move along the axis 313 between an outer position shown in Figure 7, in which it can rotate relative to the driven member 314, and an inner position in which the driving member engages in recesses 366 in the driven member to cause the latter to rotate with the barrel.

When the key is absent, movement of the barrel 316 along the axis 313 is prevented by an obstructing member 321 which, for convenience of manufacture, is formed as three separate sleeves 322, 323 and 324. Magnetic elements 329, 330 and 331 act between the obstructing member 321 and the barrel 316 to prevent relative axial movement unless the magnetic elements are first moved about the axis 313 to releasing positions. The obstructing member 321 is urged axially inwardly relative to the barrel 316 by a spring 328.

The obstructing member is caused to rotate with the barrel by a key portion 325 of the barrel.

When the correct key is inserted into the barrel 316, the magnetic elements 329, 330 and 331 are moved along their respective channels to releasing positions in which they are aligned with notches in the sleeves 321, 322 and 323. The barrel can then be pushed axially inwardly so that the driving member 311 engages in the recesses 366. The barrel is then turned by means of the key to rotate the driven member 314. When the key is withdrawn, the spring 328 moves the barrel axially outwardly relative to the obstructing member 321. Since the magnetic elements 329, 330 and 331 are ingrooves in the barrel, they are withdrawn from the notches in the sleeves 322, 323 and 324 and so permitted to move to locking positions under the influence of gravity.

The magnetic elements of all of the examples of locks hereinbefore described are in the form of rollers and these can be solid, hollow or recessed at their ends, provided that a flat surface is provided at each end for cooperation with the barrel and the obstructing member respectively.

Attention is drawn to specification No. 28810/78 (Serial No. 1572092) which is

divided from this specification.

WHAT WE CLAIM IS:

1. A lock comprising an operating member, a further member, a channel defined by the operating member and the further member collectively, a magnetic element and abutment surfaces at opposite sides of the channel, wherein the operating member and further member are arranged for relative movement, the magnetic element is disposed in the channel and is movable along the channel by a magnetic field, the abutment surfaces face in opposite directions in which the relative movement of the operating member and further member can occur, the abutment surfaces are formed on the operating member and on the further member respectively, the abutment surfaces are engageable concurrently with the magnetic element except when the magnetic element occupies a predetermined releasing position in the channel whereby relative movement of said members to operate the lock is prevented by engagement of the magnetic element with the abutment surfaces except when the magnetic element occupies its releasing position, the magnetic element is formed as a roller having a peripheral surface and opposite end surfaces and the roller is arranged with its longitudinal axis transverse to the length of its channel, whereby the roller can roll along its channel on its peripheral surface, and the end surfaces of the roller are presented towards the abutment surfaces, whereby engagement between the abutment surfaces and the roller occurs at the end surfaces of the roller.
2. A lock according to claim 1 wherein the abutment surfaces are flat.
3. A lock according to claim 1 further comprising an internal keyway for receiving a key.
4. A lock according to any preceding claim wherein the operating member is rotatable, when the magnetic element is in its releasing position, about an axis, said channel extends circumferentially of the axis around the operating member, said abutment surfaces face along the axis and constraining means other than the magnetic element is provided for constraining the operating member against movement along the axis throughout operation of the lock.
5. A lock according to claim 4 wherein the further member is arranged for movement along the axis when the magnetic element is in the releasing position and means is provided for displacing the further member axially relative to the operating member when the operating member is rotated and for preventing rotation of the operating member when axial displacement of the further member is prevented by the magnetic element.
6. A lock according to any preceding

claim wherein a formation in the operating member which constitutes a part of the channel is longer than a corresponding formation in the further member.

7. A lock according to any one of claims 4, 5 and 6 wherein the channel extends sufficiently far around the axis for the path along which the magnetic element moves between opposite ends of its channel to subtend at the axis an angle of at least 60°.

8. A lock according to claim 7 wherein the channel subtends at the axis an angle less than 360°.

9. A lock according to claim 5 or any of claims 6, 7 and 8 as appendant thereto wherein the further member is in the form of a sleeve and surrounds the operating member.

10. A lock according to claim 4 as appendant to claim 3 wherein the magnetic element is constrained at all times against movement relative to the operating member along the axis.

11. A lock according to any preceding claim wherein the end faces of the magnetic element are flat.

12. A lock according to any preceding claim wherein the magnetic element is hollow.

13. A lock according to claim 12 wherein the magnetic element comprises a hollow body of magnetic material.

14. A lock according to any preceding claim wherein said channel extends in opposite directions from the releasing position of the magnetic element.

15. A lock according to any preceding claim comprising means through which torque is transmitted from the key to the operating member, said means being adapted to fail to transmit a torque which is sufficiently large to turn the operating member when the magnetic element is not in its releasing position.

16. A lock according to any preceding claim comprising a plurality of channels defined collectively by the operating member and further member, there being in each channel a respective magnetic element which is formed as a roller.

17. In combination, a lock according to any preceding claim and a key which comprises a magnetised region for the or each magnetic element of the lock, wherein each magnetised region of the key includes a pair of magnetic poles of like polarity disposed at diametrically opposite positions with respect to an axis of the key.

18. A lock substantially as hereinbefore described with reference to and as shown in Figures 1, 2 and 3 of the accompanying drawings or substantially as herein described with reference to and as shown in Figures 4 and 5 of the accompanying drawings.

19. An anti-theft device substantially as herein described with reference to and as



divided from this specification.

WHAT WE CLAIM IS:

1. A lock comprising an operating member, a further member, a channel defined by the operating member and the further member collectively, a magnetic element and abutment surfaces at opposite sides of the channel, wherein the operating member and further member are arranged for relative movement, the magnetic element is disposed in the channel and is movable along the channel by a magnetic field, the abutment surfaces face in opposite directions in which the relative movement of the operating member and further member can occur, the abutment surfaces are formed on the operating member and on the further member respectively, the abutment surfaces are engageable concurrently with the magnetic element except when the magnetic element occupies a predetermined releasing position in the channel whereby relative movement of said members to operate the lock is prevented by engagement of the magnetic element with the abutment surfaces except when the magnetic element occupies its releasing position, the magnetic element is formed as a roller having a peripheral surface and opposite end surfaces and the roller is arranged with its longitudinal axis transverse to the length of its channel, whereby the roller can roll along its channel on its peripheral surface, and the end surfaces of the roller are presented towards the abutment surfaces, whereby engagement between the abutment surfaces and the roller occurs at the end surfaces of the roller.

2. A lock according to claim 1 wherein the abutment surfaces are flat.

3. A lock according to claim 1 further comprising an internal keyway for receiving a key.

4. A lock according to any preceding claim wherein the operating member is rotatable, when the magnetic element is in its releasing position, about an axis, said channel extends circumferentially of the axis around the operating member, said abutment surfaces face along the axis and constraining means other than the magnetic element is provided for constraining the operating member against movement along the axis throughout operation of the lock.

5. A lock according to claim 4 wherein the further member is arranged for movement along the axis when the magnetic element is in the releasing position and means is provided for displacing the further member axially relative to the operating member when the operating member is rotated and for preventing rotation of the operating member when axial displacement of the further member is prevented by the magnetic element.

6. A lock according to any preceding

claim wherein a formation in the operating member which constitutes a part of the channel is longer than a corresponding formation in the further member.

7. A lock according to any one of claims 4, 5 and 6 wherein the channel extends sufficiently far around the axis for the path along which the magnetic element moves between opposite ends of its channel to subtend at the axis an angle of at least 60°.

8. A lock according to claim 7 wherein the channel subtends at the axis an angle less than 360°.

9. A lock according to claim 5 or any of claims 6, 7 and 8 as appendant thereto wherein the further member is in the form of a sleeve and surrounds the operating member.

10. A lock according to claim 4 as appendant to claim 3 wherein the magnetic element is constrained at all times against movement relative to the operating member along the axis.

11. A lock according to any preceding claim wherein the end faces of the magnetic element are flat.

12. A lock according to any preceding claim wherein the magnetic element is hollow.

13. A lock according to claim 12 wherein the magnetic element comprises a hollow body of magnetic material.

14. A lock according to any preceding claim wherein said channel extends in opposite directions from the releasing position of the magnetic element.

15. A lock according to any preceding claim comprising means through which torque is transmitted from the key to the operating member, said means being adapted to fail to transmit a torque which is sufficiently large to turn the operating member when the magnetic element is not in its releasing position.

16. A lock according to any preceding claim comprising a plurality of channels defined collectively by the operating member and further member, there being in each channel a respective magnetic element which is formed as a roller.

17. In combination, a lock according to any preceding claim and a key which comprises a magnetised region for the or each magnetic element of the lock, wherein each magnetised region of the key includes a pair of magnetic poles of like polarity disposed at diametrically opposite positions with respect to an axis of the key.

18. A lock substantially as hereinbefore described with reference to and as shown in Figures 1, 2 and 3 of the accompanying drawings or substantially as herein described with reference to and as shown in Figures 4 and 5 of the accompanying drawings.

19. An anti-theft device substantially as herein described with reference to and as

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shown in Figures 6 and 7 of the accompanying drawings.

20. A lock substantially as herein described with reference to and as shown in Figure 9 of the accompanying drawings.

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