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(54) **Electrical fuse device with locking mechanism**

(57) An electrical fuse device having a primary fuse, a secondary fuse and a connecting device operable to bring the second fuse in-circuit in response to a failure of the primary fuse, wherein a holder for the primary fuse is provided on a removable part of the device. A locking mechanism is co-operable with the connecting device and with the removable part of the device such that, in response to removal of the removable part, the locking mechanism prevents the connecting device from being operated to disconnect the secondary fuse.

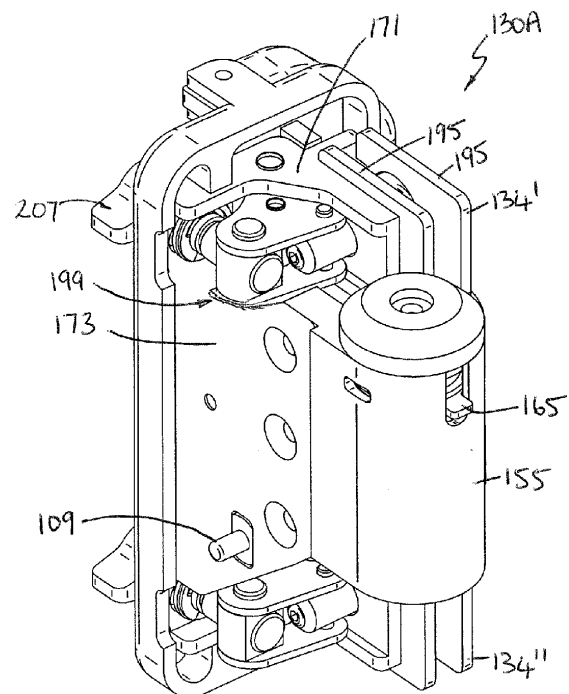


FIG. 10A

## Description

### Field of the Invention

**[0001]** The present invention relates to an electrical fuse device.

### Background to the Invention

**[0002]** An electricity supply system typically comprises an electricity generator, a plurality of transformers and a plurality of consumer outlets, the aforesaid being interconnected by a network of electricity supply lines. The electricity supply network usually comprises a transmission network, for carrying electricity between the generator and a first set of transformers; a distribution network, for carrying electricity between the first set of transformers and a second set of transformers; and a mains network, for supplying electricity to the consumers. By way of example, the transmission network may carry high voltage (HV) signals of 66kV or above. The distribution network usually carries medium voltage (MV) signals of 11kV or 22kV. The mains network usually carries low voltage (LV) signals which are, for example, 240V in the United Kingdom and 110V in the USA.

**[0003]** The electricity supply can be disrupted by a fault in a supply line or in the equipment connected to a supply line. A fault can cause widespread disruption of the electricity supply and, accordingly, the management of faults is an important aspect of the operation of an electricity supply system.

**[0004]** Typically, a fault causes one or more fuses in the supply line to blow thereby causing an outage in the supply to consumers. Electricity providers can be heavily penalised for outages, the penalty level usually depending on the duration of the outage. It is known to provide automatic circuit reclosers at various locations in a network instead of fuses. A typical recloser comprises a normally closed circuit breaker which opens upon detection of a fault. Reclosers may be configured to close again after a predetermined period of time. If the fault is a permanent fault, then the recloser will open again but if the fault is intermittent, it remains closed until the next time a fault is detected. Reclosers are therefore useful in the management of intermittent faults. However, reclosers tend to be relatively large and expensive and this places a practical limitation on their use.

**[0005]** It would be desirable, therefore, to provide a relatively small and inexpensive device for managing faults, especially intermittent faults, in an electricity supply network. Such a device is disclosed in European patent application EP 1912241.

**[0006]** It would be desirable to improve on the device of EP 1912241.

### Summary of the Invention

**[0007]** A first aspect of the invention provides an elec-

trical fuse device comprising first and second main electrical contacts between which a primary fuse is electrically connectable; means for receiving a secondary fuse such that one end of said second fuse is electrically connected to said first main contact; means for selectably connecting the other end of said secondary fuse to said second main contact; means for detecting a failure of said primary fuse, and causing said connecting means to connect said other end of said secondary fuse to said second main contact in response to a detected failure of the primary fuse, and wherein a holder for said primary fuse is provided on a removable part of said device, characterised in that the fuse device further includes a locking mechanism that is co-operable with said connecting means and with said removable part of the device such that, in response to removal of said removable part, said locking mechanism prevents said connecting means from being operated to disconnect said other end of said secondary fuse from said second main contact.

**[0008]** Other preferred features of the invention are recited in the claims appended hereto.

**[0009]** In preferred embodiments, the device is adapted for use in place of a conventional fuse in an electrical circuit. The device automatically restores electrical supply to a circuit after a fault condition. Advantageously, the device permits a blown fuse to be replaced without interrupting the electrical supply to the circuit. In a typical use, the device is installed in an electrical distribution panel in place of a conventional fuse.

**[0010]** In preferred embodiments, an actuator is provided for actuating said connecting means into a closed state in which said other end of the secondary fuse is connected in use to said second main contact, and wherein said actuator is carried by a removable part of the device. The actuator is thus removable from and insertable into its working position in the device by respectively removing and replacing said removable part of the device.

**[0011]** Preferably, a carrier for said primary fuse is provided on a removable part of the device. In preferred embodiments, said actuator and said primary fuse carrier are both provided on the same removable part of the device. The, or each, removable part of the device is preferably adapted to be clipped or plugged into the device, conveniently by a manual pulling action.

**[0012]** Preferably, said actuator is adapted to be primed for actuation, preferably manually primed, when removed from the device.

**[0013]** In preferred embodiments, said connecting means comprises a movable contact cooperable with first and second, preferably fixed, contacts, said movable contact being movable between an open state in which said first and second preferably fixed contacts are electrically isolated from one another, and a closed state in which said first and second preferably fixed contacts are electrically connected to one another. Typically, one of said preferably fixed contacts being connected in use to said other end of said secondary fuse, the other of said

preferably fixed contacts being connected to said second main contact.

**[0014]** The actuator, when inserted into the device, is arranged to actuate said movable contact into its closed state. The movable contact is typically carried by a support including a strike plate, the actuator including a deployable, preferably linearly deployable, actuating member arranged to act on said strike plate.

**[0015]** In some embodiments, said selectively connecting means also includes means for actuating said movable contact between the open and closed states, or at least from said open state to said closed state. The actuation means preferably includes a spring, or other resilient biasing means, arranged to act directly or indirectly on said movable contact. Preferably, the spring, or other resilient biasing means, is held under tension when said movable contact is in the open state and, when released, causes the movable contact to adopt the closed state.

**[0016]** The movable contact is preferably movable substantially linearly. The actuation means may comprise a line or rod connected to the movable contact and arranged to pull the movable contact from the open state to the closed state. The actuation means may include a pivotable or rotatable lever mechanism acted upon by said spring, or other resilient biasing means, and acting on said movable contact, for example via said line or rod.

**[0017]** Said detecting means may comprise a voltage monitor arranged to monitor the voltage across the first fuse or main contacts.

**[0018]** A second aspect of the invention provides an electrical fuse device comprising first and second main electrical contacts between which a primary fuse is electrically connectable; means for receiving a secondary fuse such that one end of said second fuse is electrically connected to said first main contact; means for selectively connecting the other end of said secondary fuse to said second main contact; means for detecting a failure of said primary fuse, and causing said connecting means to connect said other end of said secondary fuse to said second main contact in response to a detected failure of the primary fuse, and wherein a holder for said primary fuse is provided on a removable part of said device, characterised in that the device further includes a status indicating mechanism that is co-operable with said connecting means and with said removable part of the device such that the mechanism presents a first status indicator when said connecting means does not connect said other end of said secondary fuse to said second main contact and, in response to removal of said removable part after said connecting means has been operated to connect said other end of said secondary fuse to said second main contact, presents a second status indicator.

**[0019]** Preferably, said status indicating mechanism comprises at least two displayable surfaces and is operable, preferably mechanically operable, to display one or other of said at least two displayable surfaces.

**[0020]** The connecting means may comprise a movable contact that is co-operable with first and second con-

tacts, said movable contact being movable between an open state in which said first and second contacts are electrically isolated from one another, and a closed state in which said first and second contacts are electrically connected to one another, said status indicating mechanism being coupled to said movable contact such that movement of said movable contact into said closed state causes said status indicating mechanism to be operated from a first state to a second state.

**[0021]** In preferred embodiments, said status indicating mechanism is coupled to said removable part of the device such that removal of said removable part causes said status indicating mechanism to be operated from said second state to a third state. Preferably, when said status indicating mechanism is in said third state it is arranged to present said second status indicator.

**[0022]** Preferably, when said status indicating mechanism is in said first or second states it is arranged to present said first status indicator.

**[0023]** Preferably, when said status indicating mechanism is in said first state it is arranged to present said first status indicator and when it is in said second state it is arranged to present a third status indicator.

**[0024]** Typically, said status indicating mechanism is arranged to expose one or other of said at least two displayable surfaces in a window provided in the body of the device.

**[0025]** In preferred embodiments, said at least two displayable surfaces are provided on an assembly that is movable with respect to the window so that a respective one of said at least two displayable surfaces is exposed by the window depending on the position of the assembly with respect to the window.

**[0026]** Conveniently, at least one of said at least two displayable surfaces are provided on a portion of said assembly that is movable with respect to the assembly.

**[0027]** Optionally, the coupling between the status indicating mechanism and the movable contact effects said movement of the assembly, and wherein said assembly is moved to expose a respective one of said at least two displayable surfaces depending on whether said status indicating mechanism is in its first state or its second state.

**[0028]** In typical embodiments, said device further includes a mechanism, preferably comprising a lever, for operating said movable contact at least out of its closed state, said status indicating mechanism being coupled to said operating mechanism such that movement of the operating mechanism causes a corresponding movement of the assembly.

**[0029]** Preferably, said movable portion of said assembly is coupled to the removable part of the device when the status indicating mechanism is in its second state such that removal of the removable part of the device effects movement of said movable portion with respect to said assembly. More preferably, said movable portion of the assembly is not coupled to the removable part of the device when the status indicating mechanism is in its

third state.

**[0030]** Typically, when said status indicating mechanism is in its second state one of said displayable surfaces provided on said movable portion is exposed by said window and wherein said movement of the movable portion caused by removal of said removable part causes another of said displayable surfaces provided on said movable portion to be exposed by said window.

**[0031]** Other advantageous aspects of the invention will become apparent to those ordinarily skilled in the art upon review of the following description of a specific embodiment and with reference to the accompanying drawings.

**[0032]** In preferred embodiments, the removable part of the device is removable such that, when removed, it is completely separate from the rest of the device. Alternatively, the removable part may be removable such that, when removed, one or both ends of the holder is separated from the respective electrical contact on the rest of the device, and that correspondingly one or both ends of the primary fuse, when present, are not connected to the contacts. This can be achieved for example by coupling the removable part to the rest of the device for movement between an installed and a removed position. The coupling may for example be pivotable and/or slidable.

**[0033]** It will be understood that the word "supply" as used herein may embrace electricity supply, power supply and voltage supply, as appropriate.

#### Brief Description of the Drawings

**[0034]** A specific embodiment of the invention is now described by way of example and with reference to the accompanying drawings in which like numerals are used to indicate like parts and in which:

Figure 1 is a schematic view of a conventional electricity supply network in the form of an open ring network;

Figures 2A and 2B are circuit diagrams illustrating how a fuse device embodying the invention may operate;

Figures 3A and 3B are perspective views of a preferred fuse device, shown in a disassembled state, embodying aspects of the invention;

Figure 4A and 4B shows the device of Figures 3A and 3B in an assembled state;

Figure 5 shows the device of Figures 4A and 4B in the assembled state with part of its housing removed;

Figures 6A to 6C are respective perspective views of part of the device of Figures 3 and 4, illustrating a locking mechanism embodying one aspect of the invention;

Figures 7A to 7D are respective perspective views of part of the device of Figures 3 and 4, illustrating a status indicating mechanism embodying another aspect of the invention, the status indicating mechanism being shown in a first state;

Figures 8A to 8D are respective perspective views of part of the device of Figures 3 and 4, illustrating the status indicating mechanism shown in a second state;

Figures 9A to 9D are respective perspective views of part of the device of Figures 3 and 4, illustrating the status indicating mechanism shown in a third state;

Figure 10A is a perspective view of a removable part of the device of Figures 3 and 4, including a clamping mechanism embodying a further aspect of the invention;

Figure 10B is a perspective view of the clamping mechanism shown in Figure 10A, together with a fuse; and

Figure 10C is a perspective view of the clamping mechanism shown in Figures 10A and 10B;

#### Detailed Description of the Drawings

**[0035]** With reference to Figure 1 of the drawings, there is shown, generally indicated as 10, a conventional electricity supply network. The network 10 may form part of a larger electricity network, or system (not shown). In Figure 1, the network 10 takes the form of an open ring network by way of example only. The network 10 is of the type that may for example be used in a mains supply network and may include supply lines that are located underground.

**[0036]** The network 10 comprises a plurality of electrical supply lines including an open ring line 14 to which a plurality of feeder lines 16 are connected. The network 10 is connectable to an electricity supply which, in the present example, is provided by electrical substations or distribution units 18. Each end of open ring line 14 is connectable to a respective substation or distribution box 18 via a respective isolating device 12 which may, in a conventional network, take the form of a fuse or an automatic circuit recloser. The distribution units 18 may include one or more transformers (not shown) for transforming the electrical supply voltage to a level suitable for the network 10. The particular nature of the units 18 depends on which part of the supply system is being implemented by the network 10. The ring line 14 includes a normally open switch 20, which provides a normally open point (NOP) in the ring line 14. The electricity supply is usually a three phase supply but this is not described herein for reasons of clarity and since it is not instrumental

in understanding the invention.

**[0037]** The network 10 may comprise, or form part of, a transmission network, a distribution network or a mains network and may be arranged to carry high voltage (HV), medium voltage (MV) or low voltage (LV) signals. In the present example, it is assumed that the network 10 is arranged for carrying MV (e.g. 11kV or 22kV) or LV (e.g. 110V or 240V) signals. In the case where network 10 comprises an MV network, the network 10 typically comprises a distribution network and substations 18 are typically supplied by an electricity generator, for example a power station (not shown), via an HV transmission network (not shown). For an MV network, the feeders 16 normally supply electricity to further networks, or network portions, or to distribution substations, distribution transformers, or even large consumers, such as factories (not shown). In the case where network 10 comprises an LV network, the network 10 normally comprises a mains network and substations 18 are normally supplied by a distribution network (not shown). For an LV network, the feeders 16 normally supply electricity directly to domestic or commercial consumers.

**[0038]** A fault occurring in the line 14 or feeders 16 causes the isolating devices 12 to blow (in the case of a fuse) or to open (in the case of a recloser) thereby isolating the network 10 (or at least a portion of it) from the substation units 18. Where the fault is intermittent, a conventional fuse can be replaced manually by an engineer but this is time consuming and tends to prolong the outage caused by the fault. The use of a recloser overcomes this problem but reclosers are relatively expensive and tend to be too large to fit into local distribution boxes.

**[0039]** Fuse devices embodying the invention are suitable for use in networks of the type described above. Figures 2A and 2B show circuit diagrams illustrating the typical operation of a fuse device 30 embodying the invention. In Figure 2A, the circuit between main contacts 38, 40 is normally made via a first, or primary, fuse 34. The device 30 include a second fuse 36, which is normally out-of-circuit but which may be brought in-circuit to make a circuit between the contacts 38, 40 depending on the state of a switching mechanism 62. The device 30 also includes, or is associated with, a controller 60 for causing the switch 62 to operate (close in this example) to bring the second fuse 36 in-circuit in response to detecting that the first fuse 34 has failed. The detection may involve monitoring the voltage across the first fuse 34 or across the main contacts 38, 40 - the rupturing of fuse 34 may be detected by an increase in the voltage across it (typically an increase to supply line voltage). It is preferred to introduce a delay (typically of between 10 and 60 seconds) between detecting that the fuse 34 is blown and causing the switch 62 to activate. This allows time for an intermittent fault to disappear while keeping the outage period relatively short. The controller 60 may comprise microprocessor, microcontroller, PLC or other programmable device (not shown) for controlling the operation of the switch 62. The controller may monitor the output of

the voltage monitor, determine when the fuse 34 is blown and, after an appropriate delay, cause the switch 62 to close.

**[0040]** In use, the device 30 is incorporated into an electricity supply line, for example as component 12 in Figure 1, or other electrical circuit, such that the main contacts 38, 40 are included in the electrical path of the circuit.

**[0041]** The contact of the switching mechanism 62 connecting to fuse 36 must be capable of carrying fault current, but is only required to be load make or break. The contact connecting to fuse 36 (e.g. the contacts 42, 44, 46) should be capable of carrying fault current and be able to make onto fault current, but will only be required to be load break.

**[0042]** Referring now to Figures 3 to 5 in particular, there is shown, generally indicated as 130, a preferred fuse device embodying the invention. The fuse device 130 is suitable for use in the circuit of Figures 2A and 2B. The device 130 comprises a housing 132 which houses a first, or primary, fuse 134 and a secondary fuse 136. In Figures 3A and 3B, the device 130 is shown in two separable parts, namely a first part 130A including the primary fuse 134 and a second part 130B including the secondary fuse 136. The second part 130B is typically, in use, fixed to a terminal 131, e.g. in an electricity distribution box, as shown in Figure 3A. The primary fuse 134 is connectable between first and second main electrical contacts or terminals 138, 140 in order to make an electrical connection between the main contacts 138, 140 when the fuse 134 is intact. The contacts 138, 140 are in use connected to an electrical circuit such that the fuse 134 forms part of the circuit. The secondary fuse 136 has a first end 137 or terminal connected (at least electrically) to the first main contact 138. The second end 139 or terminal of the second fuse 136 is connectable (at least electrically) to the second main contact 140 depending on the position or state of a movable contact 142 (see Figure 5).

**[0043]** The contact 142 forms part of a switch device 143. The switch device 143 also includes fixed contacts 144, 146 which are cooperable with the movable contact 142 to make or break an electrical circuit and, in particular, to make or break the electrical connection between the second end 139 of the fuse 136 and the second main contact 140. In the preferred embodiment, the contacts 144, 146 are spaced-apart and arranged to receive the movable contact 142 therebetween such that the movable contact 142 makes an electrical connection between the fixed contacts 144, 146. Optionally, the movable contact 142 is wedge-shaped such that its leading end (in the direction of movement towards the fixed contacts) is narrower in transverse cross-section than its trailing end. The gap between the fixed contacts 144, 146 is correspondingly wedge-shaped. The contact 142 and gap may take any other suitable shape and, typically, are substantially rectangular in transverse cross-section.

**[0044]** In the preferred embodiment, the movable con-

tact 142 is carried by a support or carriage 147. The carriage 147 is movable between a first (open) state (as shown in Figure 3B) in which the contact 142 is isolated, or spaced apart from, the fixed contacts 144, 146, and a second (closed) state (as shown in Figure 5) in which the contact 142 is located between and is in contact with the contacts 144, 146. Conveniently, the carriage 147 is slidable between its first and second states by any convenient sliding mechanism. For example a slot may be provided in which a corresponding projection (not visible) on the carriage is slidably located. A second projection may be provided on the other side of the carriage 147 for sliding engagement with a second slot (not shown) provided adjacent the other side of the carriage 147.

**[0045]** The switch 143 further includes means for actuating the switch 143 at least from its open state into its closed state. The actuating means comprises an actuator 155 having a deployable member, conveniently in the form of a rod 157 (shown in dashed outline in Figure 3A), that is deployable, preferably linearly deployable, between a retracted state and an extended state, or partially extended state. Operation of the actuator 155 into the extended state drives the contact 142 between the contacts 144, 146. A preferred arrangement is such that, when the carriage 147 is in the open state and the rod 157 is retracted, the rod 157 abuts, or substantially abuts, against the carriage 147 so that, when actuated, the rod 157 pushes against the carriage 147 rather than impacts upon it before pushing.

**[0046]** The actuator 155 may take any suitable form and may be operated by any suitable means, e.g. it may be pneumatically, hydraulically, electrically and/or mechanically powered. In the illustrated embodiment, the actuator 155 includes resilient biasing means in the form of a spring (not visible but typically located inside the body of the actuator 155) arranged to urge the rod 157 into its extended state. The actuator 155 preferably also includes means, e.g. a latch, for maintaining the rod 157 in its extended state. The actuator 155 is co-operable with activation means, for example in the form of a latch mechanism 161, arranged to hold the actuator 155 in the retracted state, and, when activated, to cause the rod 157 to adopt the extended state. In the illustrated embodiment, the latch mechanism 161 includes an activating member in the preferred form of cradle 163 in which the actuator 155 may be removably received. The cradle 163 is cooperable with an operating member in the preferred form of trigger 165 on the actuator 155, and is movable to operate the trigger 165 thereby causing the rod 157 to be extended. The cradle 163 may be operated by any suitable means, for example an electro-mechanical actuator (not shown) coupled to the cradle by a linkage or other suitable means. By way of example, the trigger 165 may be coupled to one or more retaining members (not visible), e.g. ball bearings, which pass through the body of the actuator and hold the internal biasing means in its primed state until the trigger 165 is operated whereupon the internal biasing means is re-

leased to drive the rod 157.

**[0047]** The device 130 also includes means for opening the switch 143, i.e. returning the movable actuator to its first state. The switch opening mechanism may take any suitable form and may be operated by any suitable means, e.g. it may be pneumatically, hydraulically, electrically and/or mechanically powered. In the illustrated embodiment, a manual switch operating mechanism 175 is provided, in the convenient form of a lever, for this purpose.

**[0048]** The device 130 includes, or is cooperable with, a controller (not shown) for detecting the failure of the primary fuse 134 and, upon such detection, causing the switch 143 to close. The controller may be the same or similar to the controller 60 described above and, typically, monitors the voltage across and/or current in the primary fuse. The device 130 may also include a communications module (not shown) for communication, typically wireless communication, of its condition to a remote monitoring station (not shown).

**[0049]** The first part 130A of the device 130 is removable from the second part 130B. In the preferred embodiment, the first part 130A includes not only the primary fuse 134, but also the actuator 155. It will be seen from Figures 3A and 10A that the first part 130A includes part of the housing 132, a carrier or holder 171 for the primary fuse 134 and a carrier or holder 173 for the actuator 155. The holder 173 for the actuator 155 may take any suitable form.

**[0050]** The second part 130B of the device defines a station 186 for receiving the actuator 155, and typically also its holder 173, when the two parts 130A, 130B are assembled together. In the station 186, the actuator 155 is positioned such that the rod 157 can act directly or indirectly on the movable contact 142 without being fixed thereto. In the preferred embodiment, the carriage 147 defines part of the station 186 and includes a base that provides an abutment/striking surface 188 on which the rod 157 acts. There is no fixed connection between the actuator 155 and the carriage 147 and so the actuator 155 can readily be removed. Means for activating the actuator 155 are preferably provided in the station 186 and are adapted to releasably couple with the actuator 155 when the actuator is in the station 186. In the illustrated embodiment, the releasable coupling is provided by the cradle 163.

**[0051]** Hence, the contacts 138, 140 on the second part 130B of the device 130 are removably connectable to respective ends of the fuse 134 (or the fuse holder 171). The cradle 163 and carriage 147 are adapted to removably receive the actuator 155 (and/or its holder 173). The preferred arrangement is such that the first part 130A may be removed from the second part 130B by a manual pulling action, and reassembled with the second part 130B by a push fit action. One or more screws or other fasteners may be provided to secure the first part 130A to the second part 130B.

**[0052]** More generally, the preferred arrangement is

such that the removable part 130A may be engaged and disengaged with the rest of the device 130B by a manual pulling action, preferably in a lateral direction as indicated in the drawings. To this end, there is preferably provided a male and female fit between the two parts 130A, 130B. In particular, there is a male/female fit between the primary fuse (and/or its holder) and the main contacts 138, 140, and a male/female fit between the actuator 155 and its station 186. The fit between at least some of the respective parts may be a releasable friction or interference fit.

**[0053]** During normal operation, the switch 143 is held in the open position and all of the electrical current flowing through the device 130 is carried by the primary fuse 134. If a fault occurs on the circuit in which the fuse device 130 is installed, the primary fuse 134 ruptures, interrupting the current and isolating the electrical supply to the circuit. The device 130 detects this condition and automatically closes the switch 143 (typically under suitable defined conditions) to bring the secondary fuse 136 into the circuit, thus restoring the electrical supply. Where a communications module is provided, the device 130 can communicate its status to a remote location permitting appropriate remedial action to be initiated.

**[0054]** While the secondary fuse 136 is in circuit and carrying the load, the part 130A of the device 130 can be removed from the device. This permits the primary fuse 134 to be replaced without interrupting the current flow in the circuit. Moreover, since the actuator 155 is also removed, it can be re-primed for future activation. Being able to prime the actuator 155, and replace the fuse 134, while removed from the device 130 is advantageous since these acts may be performed manually by a single person - some regulations require that such acts can only be performed using a tool and in the presence of a second individual if the relevant components are part of a device that is still connected to the electricity supply.

**[0055]** Once the primary fuse 134 has been replaced, part 130A can then be refitted to part 130B. The switch 143 may then be opened to restore the device 130 to its initial condition and without interrupting the electrical supply to the circuit (since the new primary fuse and the secondary fuse will be in-circuit and in parallel with one another until the switch 143 is opened).

**[0056]** If the electrical fault persists after the primary fuse 134 has blown and the secondary fuse 136 is in circuit, then the secondary fuse 136 will also blow and the circuit will remain isolated until manual intervention can replace both fuses and repair the fault on the circuit. The preferred device 130 is also capable of reporting this condition to a remote location as above.

**[0057]** Optionally, the device 30, 130 may be fitted with visual indications to show which fuse is in circuit, optionally, and how much electrical current is being carried.

**[0058]** Advantageously, one aspect of the invention provides a locking mechanism that prevents the secondary fuse 136 from being removed from the fuse circuit until after the primary fuse 134 has been replaced (or at

least until after the removable part 130A has been replaced). In the preferred embodiment, this is achieved by locking, preferably mechanically locking, the switch 143 in its closed state until the removable part 130A has been replaced. Not only does this prevent the secondary fuse 136 from being taken out of the fuse circuit (which would otherwise result in an interruption of the electricity supply), but it also means that the physical characteristics of the switch 143 need not be such that it is capable of breaking under load and/or fault conditions.

**[0059]** Figures 6A to 6C illustrate the preferred embodiment of the locking mechanism. In Figures 6A to 6C, only those parts of the device 130 that are helpful in understanding the locking mechanism and its operation are shown. The locking mechanism is indicated generally as 101 and comprises a lock member 103 that is movably mounted on the second part 130B of the device 130. In particular, the lock member 103 is movable with respect to the movable part of the switch 143, in this case the carriage 147. The lock member 103 is movable between a non-locking state (as shown in Figures 6A and 6B), in which it does not interfere with the movement of the movable contact 142 between its open and closed states, and a locking state (not illustrated), in which it prevents the movable contact 142 from being moved out of its closed state. Optionally, in a second mode of use, the lock member 103 (or alternatively another lock member - not illustrated) is arranged to interact with the movable contact such that, in its locking state it prevents the movable contact from moving into its closed state. The preferred arrangement is such that, in said second mode of use, the lock member 103 (or other lock member) prevents the movable contact from moving into its closed state when the first part 130A is removed, but allows the movable contact to move into its closed state when the first part 130A is fitted.

**[0060]** Conveniently, the locking member 103 is actuated between its locking and non-locking states by relative movement between the first and second parts 130A and 130B as the device 130 is assembled and disassembled. In particular, the arrangement is such that the locking member 103 adopts the non-locking state when the first and second parts 130A, 130B are assembled together, and the locking state when they are apart. Preferably, means for resiliently biasing the locking member 103 into its locking state are provided. For example, the biasing means may take the form of a spring 105, which in the illustrated embodiment is connected between the locking member 103 and the body of the second part 130B of the device 130. The action of the first part 130A of the device 130 on the locking member 103 when the parts 130A, 130B are assembled serves to hold the locking member 103 in its non-locking state against the bias of the spring 105.

**[0061]** In the preferred embodiment, the locking member 103 includes a portion 107 for engaging with a corresponding portion 109 of the first part 130A of the device 130. The portion 107 conveniently takes the form of a

free end of the locking member 103, but may take any other suitable form. The corresponding portion 109 of the first part 130A preferably takes the form of a projection. A suitable projection 109 is shown in Figure 10A, the projection 109 extending laterally from the first part 130A with respect to the direction of movement of the first part 130A when being brought together with the second part 130B. When the parts 130A, 130B are brought together, the respective portions 107, 109 engage with one another and the movement of the first part 130A drives the locking member 103 into its non-locking state. When the first part 130A is removed from the second part 130B, the locking member 103 adopts its locking state under the action of the spring 105.

**[0062]** Preferably, a channel 111 for receiving the projection 109 is provided in the second part 130B, the locking member 103 being arranged such that its engaging portion 107 sits in the channel 11 for engagement with the projection 109. This arrangement helps to allow the first and second parts 130A, 130B to maintain a close fit when assembled.

**[0063]** In the preferred embodiment, the locking member 103 includes another portion 113 for engaging with the movable part of the switch 143. The portion 113 conveniently takes the form of a projection (visible in figure 6C). A corresponding engagement portion 115 is provided in the moveable part of the switch. In this example, the engagement portion 115 takes the form of a recess provided in the carriage 147. When the locking member 103 is in its locking state, the projection 113 is seated in the recess 115 and so prevents movement of the carriage 147 in a vertical direction as viewed in the drawings. The engagement portions 113, 115 can take any other suitable form, typically corresponding male and female members (either of which could be provided on the locking member 103.) Optionally, first and second engagement portions 115, 115' (shown as recesses in Figure 6C) are provided in the carriage 147, spaced apart from one another in a vertical direction. The arrangement is such that the portion 113 is engagable with one or other of the portions 115, 115' depending on whether the carriage 147 is up or down, i.e. on whether the switch mechanism 143 is open or closed. Hence, the locking member 103 is able to lock the movable contact either in its closed position or its open position when the first part 130A of the device 130 is removed.

**[0064]** The locking member 103 may take any suitable form, conveniently a bar as shown in the drawings. In the illustrated embodiment, it is coupled to the second part 130B of the device 130 such that it is capable of reciprocating movement between its locking and non-locking states. This may be achieved by one or more pin-and-slot mechanisms 117. Alternatively, the locking member 103 may be arranged for pivoting movement with respect to the body of the second part 130B.

**[0065]** In the preferred embodiment, the body of the second part 130B of the device 130 includes a wall 119 that supports various components of the device 130 in-

cluding the locking mechanism 101. In the illustrated embodiment, the locking mechanism 101 and carriage 147 are located on opposite sides of the wall 119, an aperture being provided in the wall 119 to allow the projection 113 to project through.

**[0066]** The switch operating mechanism 175 is carried by the wall 119. It preferably takes the form of a lever and so is pivotable with respect to the wall 119. The lever 175 is coupled to the movable part of the switch 143 so that it may actuate the movable part of the switch 143 at least from its closed state into its open state. The coupling is preferably such that the lever 175 cannot move the switch 143 from the open state to the closed state (see the coupling of Figures 7 to 9 where the lever can only act on the switch from below). In the preferred embodiment, the carriage 147 has a projection 121 that rides in a slot 123 formed in the wall 119. Typically, the slot 123 is shaped and orientated such that it causes the carriage 147, and therefore the contact 142, to move substantially linearly as the switch 143 opens and closes. A second projection 125 extends from the carriage 147 through the slot 123. The lever 175 is coupled to the second projection 125 to effect movement of the carriage 147. The lever 175 could alternatively be coupled to the first projection 121, in which case the second projection 125 could be omitted. The lever 175 may be resiliently biased, e.g. by a spring 127, to assist opening the switch 143.

**[0067]** Referring now to Figures 7 to 9, there is described a status indicating mechanism embodying a further aspect of the invention. In Figures 7 to 9, only those parts of the device 130 that are helpful in understanding the status indicating mechanism and its operation are shown. The status indicating mechanism, which is generally indicated as 151, is arranged to present to a user a respective one of at least two indicators depending on the status of the device 130. In the preferred embodiment, the respective valid indicator is presented at a window 153 (see Figures 3 and 4) that is provided in the second part 130B of the device 130 and is visible to the user. The indicators are preferably mechanical in nature, for example flags, rather than electrically powered indicators. In the illustrated embodiment, each indicator comprises a displayable surface 159, 159', 159" that carries a status-identifying marking, preferably a respective different status-identifying marking. Depending on the status of the device 130, one or other of the displayable surfaces 159, 159', 159" is exposed by the window 153 so that the user can determine the status of the device from the displayed marking.

**[0068]** In the present example, three different status-identifying markings are supported by the indicators, although in alternative embodiments two or more than three may be supported. For the purposes of illustration only, it is assumed that each status-identifying marking is a respective colour - white, amber or red in the present example.

**[0069]** It is noted that in alternative embodiments, some of the indicators may carry the same marking. For

example, in the case where only two different markings are used, surfaces 159, 159' may each carry the same marking (e.g. coloured white), while surface 159" carries the other marking (e.g. red).

**[0070]** In the preferred embodiment, the purpose of the status indicating mechanism 151 is to indicate to a user whether or not the first part 130A has been removed and replaced after the device 130 has been activated to bring the secondary fuse into circuit (i.e. after the switch 143 has been closed automatically in response to a fault). This allows the user to decide whether to open the switch 143 manually using the lever 175 or to remove the first part 130A and replace the primary fuse 134.

**[0071]** Figures 7A to 7D show the device 130 in a first state of use and the status indicating mechanism in a corresponding first state. This is the normal operating state of the device 130 where the primary fuse 134 is in-circuit and the switch 143 is open. The lever 175 adopts a corresponding state and the user can determine from the corresponding position of the exposed end 177 of the lever 175 that the switch 143 is open. In this state, the status-indicating mechanism 151 is arranged to display a first display surface 159 in the window 153. In this example, the display surface 159 carries a first status-indicating marking, e.g. a white flag.

**[0072]** Figures 8A to 8D show the device 130 in a second state of use and the status indicating mechanism in a corresponding second state. In this state, the switch 143 has been closed by the actuator 155 in response to the primary fuse 134 being blown. The secondary fuse 136 is now in-circuit and it is assumed that the first part 130A of the device 130 has not yet been removed to replace the primary fuse. Closure of the switch 143 causes the lever 175 to adopt a corresponding state and the user can determine from the corresponding position of the exposed end 177 of the lever 175 that the switch 143 is closed. In this state, the preferred status-indicating mechanism 151 is arranged to display a second display surface 159' in the window 153. In this embodiment, the second display surface 159' carries a different marking to the first marking, e.g. an amber flag. Alternatively, the second display surface 159' may carry the same marking as the first display surface 159, in which case a user can distinguish between the first and second states by the position of the lever 175.

**[0073]** Figures 9A to 9D show the device 130 in a third state of use and the status indicating mechanism in a corresponding third state. This state follows the second state. The switch 143 is still closed and the secondary fuse 136 is still in-circuit. However, now the first part 130A of the device 130 has been removed (and may or may not yet have been replaced). In this state, the preferred status-indicating mechanism 151 is arranged to display a third display surface 159" in the window 153. The third display surface 159" carries a different marking to the first and second display surfaces 159, 159', e.g. a red flag.

**[0074]** Hence, when the two parts 130A and 130B are

assembled, the indicator displayed in the window 153 allows the user to determine whether or not the first part 130A has been removed, or removed and replaced. In the present example, if the displayed flag is amber, the user knows not to open the switch 143 manually using the lever 175 since the primary fuse has not been replaced. However, if it is red, the user may assume that the primary fuse has been replaced and so may operate the lever 175 to open the switch 143 and so to remove the secondary fuse 136 from the circuit leaving only the new primary fuse 134 in-circuit. It is noted that in both of these scenarios the position of the end 177 of the lever 175 indicates that the switch 143 is closed and so this in itself does not allow the user to determine which state the fuse device 130 is in when the two parts 130A, 130B are assembled.

**[0075]** In the preferred embodiment, the action of manually opening the switch 143 when the device 130 and status indicating mechanism 151 are in the third state of use causes the device 130 and status indicating mechanism 151 to return to the first state shown in Figures 7A to 7D.

**[0076]** The preferred status indicating mechanism 151 is now described in more detail. The mechanism 151 is provided in the second part 130B of the device and comprises an assembly 167 that includes each of the display surfaces 159, 159', 159". The assembly 167 is movable with respect to the body of the second part 130B and is coupled to the lever 175 (or otherwise coupled to the movable part of the switch 143) such that it moves between a first position (Figure 7) and a second position (Figures 8 and 9) as the switch 143 is opened and closed. In the present example and as viewed in the drawings, the assembly 167 moves upwards as the switch is closed (because the part of the lever 175 to which it is coupled moves upwards) and downwards as the switch is opened (because the part of the lever 175 to which it is coupled moves downwards). Conveniently, the assembly 167 is coupled to the lever 175 by a pin-and-slot mechanism 179.

**[0077]** In the illustrated embodiment, the assembly 167 is coupled to the wall 119 (see Figure 6A) by means of at least one, but in the present example two, pin-and-slot mechanisms 169 that guide the movement of the assembly 167 as the switch 143 is opened and closed. In this example, the movement is substantially linear. In the drawings, the pins are shown as provided on the wall 119 while the corresponding slots are formed in the assembly, although the opposite arrangement could alternatively be adopted. It will be understood that any other suitable coupling may be used.

**[0078]** When the assembly 167 is in its first position (Figure 7), the first display surface 159 is aligned with the window 153 and so the marker carried by the display surface 159 is exposed by the window 153. This corresponds to the first state of the mechanism 151 described above. When the switch 143 is closed, the assembly 167 moves (upwardly in this example) such that the second

or third display surface 159', 159" is exposed by the window 153 (depending on the configuration of the assembly 167 as described in more detail hereinafter). If the switch 143 is closed while the assembly 167 is in its first state (white flag), then the second surface 159" is exposed by the window 153. This corresponds to Figure 8 and the second state of the mechanism 151 described above.

**[0079]** The assembly 167 includes an indicator-carrying portion 181 that is movable with respect to the assembly 167 between a first position (Figures 7 and 8) and a second position (Figure 9). The indicator-carrying portion 181 includes the second display surface 159' and the third display surface 159". The third display surface 159" is concealed (conveniently behind the first display surface 159) when the portion 181 is in its first position, but exposed when the portion is in its second position. The arrangement is such that, with the assembly 167 in its second position (Figures 8 and 9), the second display surface 159' is exposed by the window 153 when the portion 181 is in its first position (Figure 8), and the third display surface 159" is exposed by the window 153 when the portion 181 is in its second position (Figure 9). The movable indicator-carrying portion 181 conveniently takes the form of a leg or similar member located behind (with respect to the window 153) a portion of the assembly 167 that carries the first display surface 159 and is movable with respect thereto to expose or conceal the third display surface 159".

**[0080]** The indicator-carrying portion 181 may be coupled to the assembly 167 by any suitable means. In this embodiment, the portion 181 is coupled to a pin 183 that rides in a slot 185 formed in the main assembly 167.

**[0081]** The mechanism 151 also includes means for engaging with the first portion 130A of the device 130 as it is being removed from the second portion 130B, the engaging means being co-operable with the assembly 167 to actuate the indicator-carrying portion 181 from its first position to its second position as the first portion 130A is removed. As can best be seen from Figures 7C, 8C and 9C, the preferred engaging means comprises a lever 187 that is pivotable with respect to the assembly 167 and is coupled to the indicator-carrying portion 181, e.g. via pin 183, to actuate the portion 181 between its first and second positions depending on the angular position of the lever 187. With the mechanism 151 in its first state (Figure 7) the arrangement is such that the lever 187 lies in the path of the first part 130A of the device 130 such that, when the part 130A is removed, it engages with the lever 187 causing the lever 187 to pivot and so to actuate the indicator-carrying portion 181 from its first position to its second position. Conveniently, to this end the arrangement may be such that the lever 187 lies in the path of the projection 109, for example in the channel 111. Preferably, after the lever 187 has been moved by the first part 130A upon its removal, the lever 187 no longer lies in the path of the part 130A so that it does not interfere with the replacement of the part 130A and such that the portion 181 remains in its second position while the part

130A is replaced.

**[0082]** The lever 187 and/or any component that is movable with the lever 187, in particular the portion 181, is coupled to the part 130B such that relative movement between the assembly 167 and the part 130B resulting from switch lever 175 being operated to open the switch 143 causes the lever 187 to return to its initial position where it lies in the path of the projection 109. In the preferred embodiment, this also causes the portion 181 to return to its corresponding position. The coupling may take any suitable means, e.g. an abutment (not shown) may be provided in any suitable location on the part 130B of the device 130, e.g. on the wall 119, the abutment being positioned to lie in the path of the lever 187, or in the path of any component coupled to the lever 187, e.g. portion 181, as the assembly 167 is moved when the switch lever 175 is operated to open the switch 143. The arrangement may be such that movement of the assembly 167 causes the portion 181 to move back to its first position as a result of engagement between the abutment and the portion 181/lever 187.

**[0083]** Means for guiding movement of the lever 187 may be provided in the preferred form of a pin-and-slot mechanism. In the illustrated example, the slot 189 is formed in the assembly and the corresponding pin 191 extends from the lever 187, although the opposite arrangement could be used. Preferably means for resiliently biasing the lever 187 into one or both of its use positions is provided, for example in the form of a spring 193. The preferred arrangement is such that the biasing means 193 is arranged with respect to the pivot of the lever 187 to provide an over-centre mechanism that encourages the lever 187 to adopt one or other of its use positions depending on its angular position with respect to the assembly 167.

**[0084]** As described above, before the user replaces the first part 130A of the device after the switch 143 has been closed, he is supposed to prime the actuator 155 (which in the illustrated embodiment involves deactivating the latch (if present) that holds the rod 157 in its extended state and pushing the rod 157 into its retracted state) so that it is ready to actuate the movable contact 142 in response to the next detected failure. Should the user fail to prime the actuator 155 before replacing the part 130A, then the extended actuator prevents the movable contact 142 from moving upwards (as viewed in the drawings). Hence the user is unable to operate the lever 175 to open the switch 143. Accordingly, the status indicating mechanism 151 maintains its third state (displaying the red flag in this example), indicating to the user that action is required to return the fuse device 130 to its normal operating state (which in this case will cause the user to remove the part 130A, prime the actuator 155 and replace the part 130A).

**[0085]** Referring now to Figures 10A to 10C, there is described a fuse clamping mechanism embodying a further aspect of the invention. When the two parts 130A, 130B of the device are brought together, they must be

mechanically interconnected to prevent the first part 130A from falling off, and electrically connected so that the primary fuse 134 carried by the first part 130A makes an electrical connection between the contacts 138, 140 of the second part 130B. Conveniently, both the electrical and mechanical connection can be made at the respective locations where the contacts 138, 140 engage with the respective terminals 134', 134" of the fuse 134. For example, in the illustrated embodiment, each terminal 134', 134" comprises spaced apart conductive plates 195 that are shaped to define an open socket that fits over a fastener 197, typically comprising a pin, for securing the fuse 134 with respect to the first part 130A. The respective contact 138, 140 fits between the plates 195. The fit is typically a close contact or friction fit to provide both a mechanical and electrical connection between the contact 138, 140 and the fuse terminal 134', 134". However, in some instances (e.g. during installation or testing), it can be desirable to fit the first part 130A to the second part 130B without the presence of the fuse 134 or a dummy fuse. This can create a problem since, as described above, the terminals 134', 134" of the fuse 134 normally provide a key part of the mechanical connection between the first and second parts 130A, 130B.

**[0086]** To overcome this problem, the device 130 is provided with the clamping mechanism 199 associated with the fuse holder. The preferred clamping mechanism 199 comprises a body 201 that provides a surface 203 against which an object, in this case a fuse terminal or a contact 138, 140, can be clamped, and a movable clamping member 205 (of which pin 197 is part) that is co-operable with the surface 203 to clamp objects therebetween. The clamping member 205 is movable into and out of a clamping state by operation of an operating mechanism, in the convenient form of a screw 207, that is coupled to the clamping member 205. The screw 207 and clamping member are preferably coupled together by means of a linkage 209 that is movable with respect to the body 201. The arrangement is such that operation of the screw 207 causes the linkage to move, which in turn causes a corresponding movement of the clamping member 205.

**[0087]** In the preferred embodiment, the screw 207 must be accessible to a user and so extends from the exterior face 211 of device part 130A. However, because of the required orientation of the fuse 134, the required movement of the clamping member 205 is substantially perpendicular with the movement of the screw 207. It is preferred therefore that the linkage 209 is pivotable with respect to the body 201 so that movement of the screw 207 in a first axial direction causes a corresponding movement of the clamping member 205 in a second axial direction that is non-parallel and preferably substantially perpendicular with the first axial direction. For example, the body 201 may have first and second parts 213, 215 that are substantially perpendicular with one another, each receiving a respective one of the screw 207 and clamp 205. The screw 207 and clamp 205 are movable

in a respective axial direction with respect to the respective part 215, 213 and the linkage 209 is pivotably coupled to the body 201, conveniently at a location between the screw 207 and clamp 205. The linkage 209 is pivotable about an axis that is substantially perpendicular to the plane in which the screw 207 and clamp 205 move. Typically, the coupling between the screw 207 and the linkage 209 is a screw (threaded) coupling, while the coupling between the clamping member 205 and the linkage 207 is pivotable.

**[0088]** In use, even when the fuse 134 is not present, the screw 207 may be tightened by the user to draw the clamping member 205 towards the clamping surface 203 until the respective contact 138, 140 is clamped therebetween. Hence part 130A of the device 130 may be fitted to part 130B whether the primary fuse 134, or a dummy fuse, is present or not.

**[0089]** In order to facilitate fitting the part 130A to the part 130B irrespective of whether a fuse is present in part 130A or not, parts 130A and 130B are arranged to allow relative movement between the parts 130A and 130B when they are fitted together. In the illustrated embodiment, the relative movement is in a lateral direction (as viewed in Figures 3A and 3B), and more particularly in said second axial direction. When a fuse or dummy fuse is present, little or no relative movement between the parts 130A, 130B is required when tightening the clamp. However, in the absence of the fuse or dummy fuse, since the fuse contacts 138, 140 are in a fixed position, the first part 130A must move towards the contacts 138, 140 as the clamp is tightened, since the clamp is tightened further than would be the case if a fuse were present (so that the clamp may engage directly with the respective contact 138, 140).

**[0090]** In preferred embodiments, the removable part 130A of the device is removable such that, when removed, it is completely separate from the rest of the device 130B. Alternatively, the removable part may be removable such that, when removed, one or both ends of the holder is separated from the respective electrical contact on the rest of the device, and that correspondingly one or both ends of the primary fuse, when present, are not connected to the contacts. This can be achieved for example by coupling the removable part to the rest of the device for movement between an installed and a removed position. The coupling may for example be pivotable and/or slidable.

**[0091]** The invention is not limited to the embodiments described herein which may be modified or varied without departing from the scope of the invention.

## Claims

1. An electrical fuse device comprising first and second main electrical contacts between which a primary fuse is electrically connectable; means for receiving a secondary fuse such that one end of said second-

ary fuse is electrically connected to said first main contact; means for selectably connecting the other end of said secondary fuse to said second main contact; means for detecting a failure of said primary fuse, and causing said connecting means to connect said other end of said secondary fuse to said second main contact in response to a detected failure of the primary fuse, and wherein a holder for said primary fuse is provided on a removable part of said device, **characterised in that** the fuse device further includes a locking mechanism that is co-operable with said connecting means and with said removable part of the device such that, in response to removal of said removable part, said locking mechanism prevents said connecting means from being operated to disconnect said other end of said secondary fuse from said second main contact.

2. An electrical fuse device as claimed in claim 1, wherein the arrangement is such that said locking mechanism allows said connecting means to be operated to disconnect said other end of said secondary fuse from said second main contact in response to replacement of said removable part.
3. An electrical fuse device as claimed in claim 1 or 2, wherein the connecting means comprises a movable contact that is co-operable with first and second contacts, said movable contact being movable between an open state in which said first and second contacts are electrically isolated from one another, and a closed state in which said first and second contacts are electrically connected to one another, the locking mechanism comprising a lock member that is movable with respect to the movable contact into and out of a locking state in which it prevents the movable contact from being moved out of its closed state.
4. An electrical fuse device as claimed in claim 3, wherein the locking member is actuated into its locking state in response to movement of said removable part of the device with respect to the device as the removable part is removed.
5. An electrical fuse device as claimed in claim 3 or 4, the locking member is actuated out of its locking state in response to movement of said removable part of the device with respect to the device as the removable part is replaced.
6. An electrical fuse device as claimed in any one of claims 3 to 5, including means for resiliently biasing the locking member into its locking state.
7. An electrical fuse device as claimed in claim 6, wherein the removable part of the device, when fitted to the device, is arranged to hold the locking member in its non-locking state against the bias of the resilient

biasing means.

8. An electrical fuse device as claimed in any one of claims 3 to 8, wherein the locking member includes a portion for engaging with a corresponding portion of the removable part of the device to effect movement of said locking member into and out of its locking state in response to movement of said removable part.
9. An electrical fuse device as claimed in claim 8, wherein said portion of the removable part comprises a projection that extends laterally from the removable part with respect to the direction of movement of the removable part, and wherein a channel for receiving the projection is provided in the device, the locking member being arranged such that its engaging portion sits in the channel for engagement with the projection.
10. An electrical fuse device as claimed in any one of claims 3 to 9, wherein the locking member includes a portion for engaging directly or indirectly with the movable contact to prevent the movable contact from moving out of its closed state.
11. An electrical fuse device as claimed in any one of claims 3 to 10, wherein the locking member includes a portion for engaging directly or indirectly with the movable contact to prevent the movable contact from moving out of its open state.
12. An electrical fuse device as claimed in claim 10 or 11, wherein said contact-engaging portion comprises a projection, a corresponding a recess being provided in the movable contact or in a component mechanically connected to said movable contact.
13. An electrical fuse device as claimed in claim 12, wherein first and second recesses are provided in the movable contact or in a component mechanically connected to said movable contact, said first recess being engagable with the, or a respective, projection to prevent the movable contact from moving out of its closed state and said second recess being engagable with the, or a respective, projection to prevent the movable contact from moving out of its open state.
14. An electrical fuse device as claimed in any one of claims 3 to 13, wherein the locking member is coupled to the device such that is capable of reciprocating movement between its locking and non-locking states.

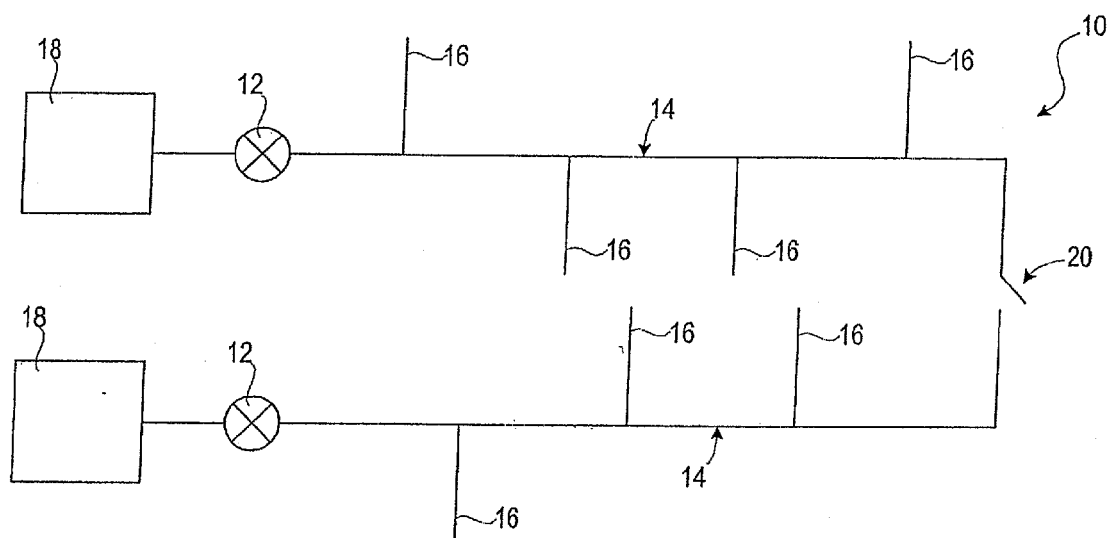
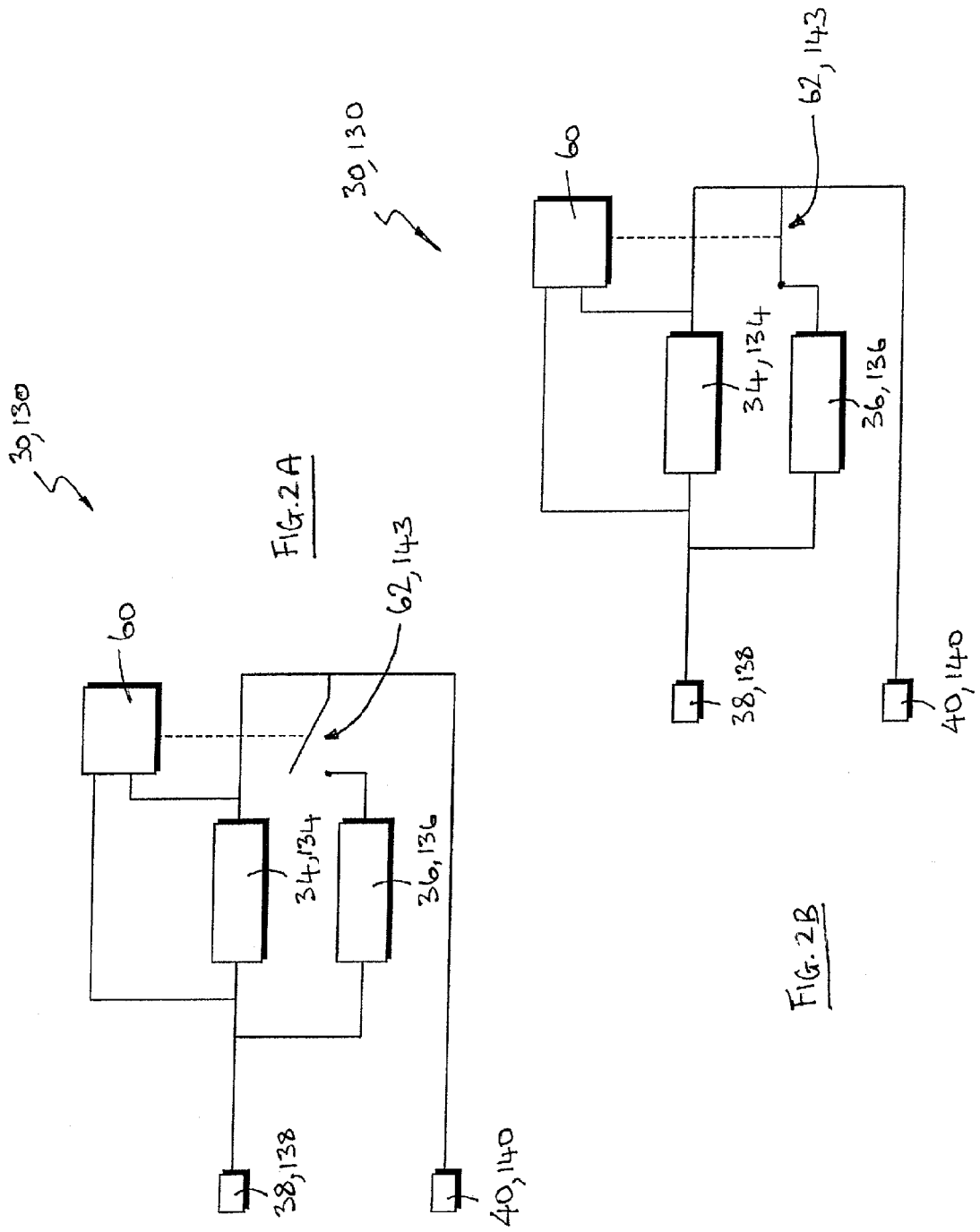
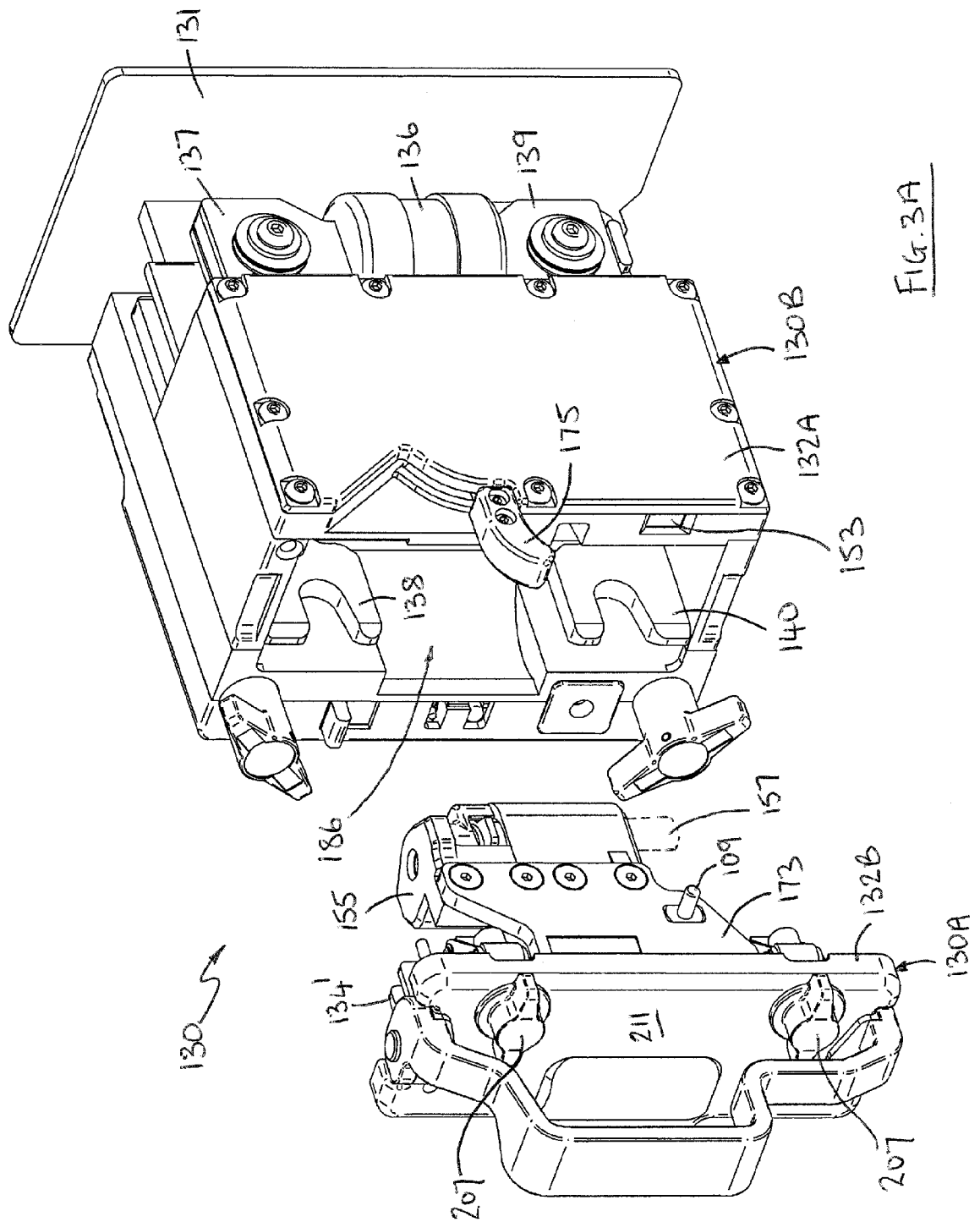


FIG. 1





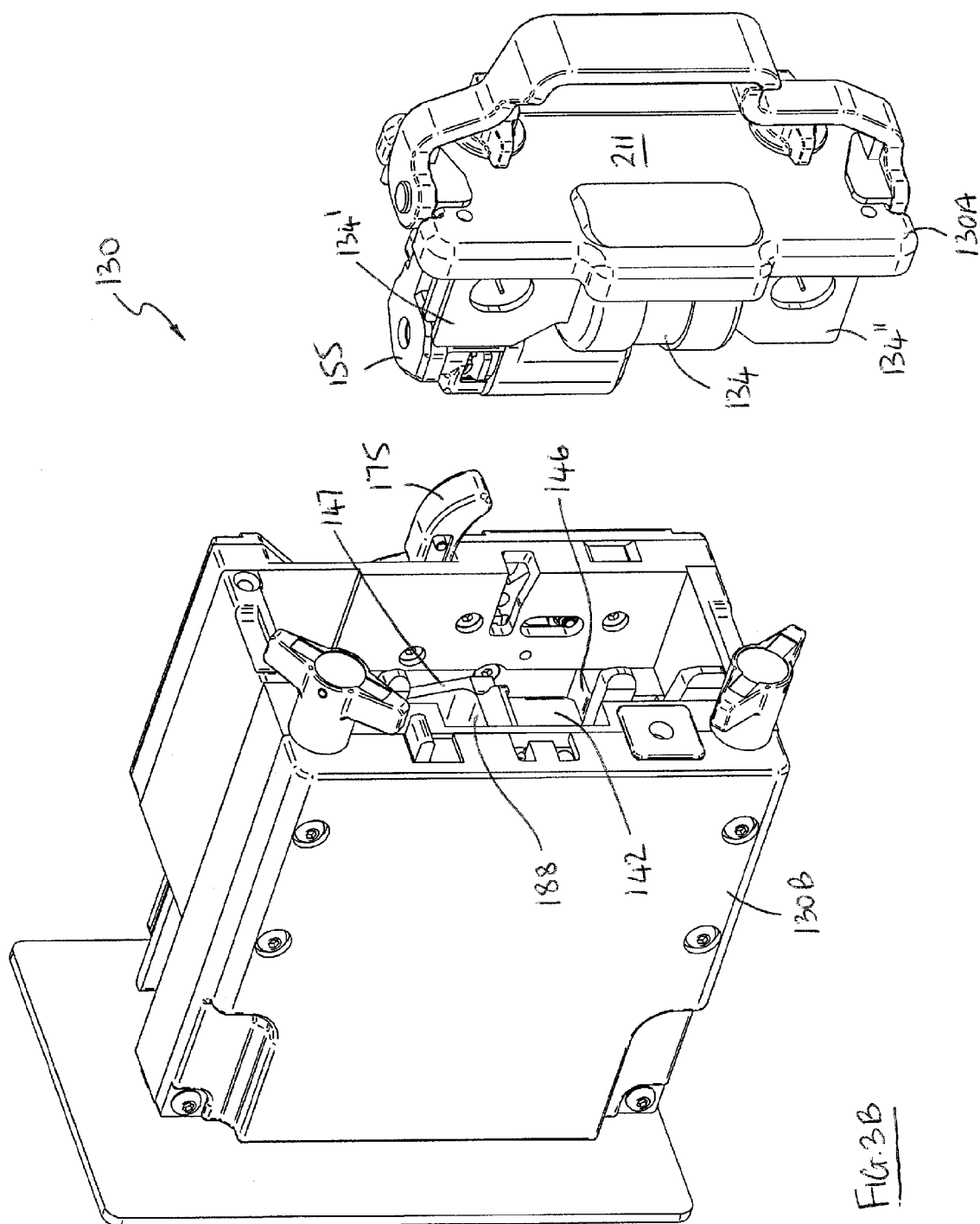


FIG. 3B

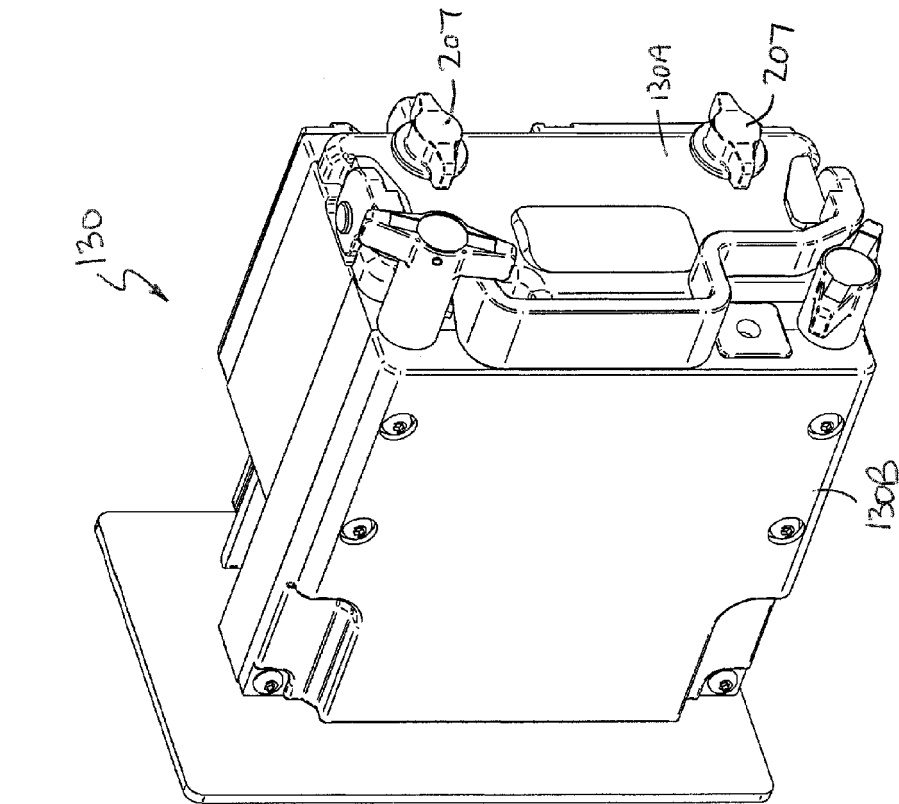


FIG. 4A

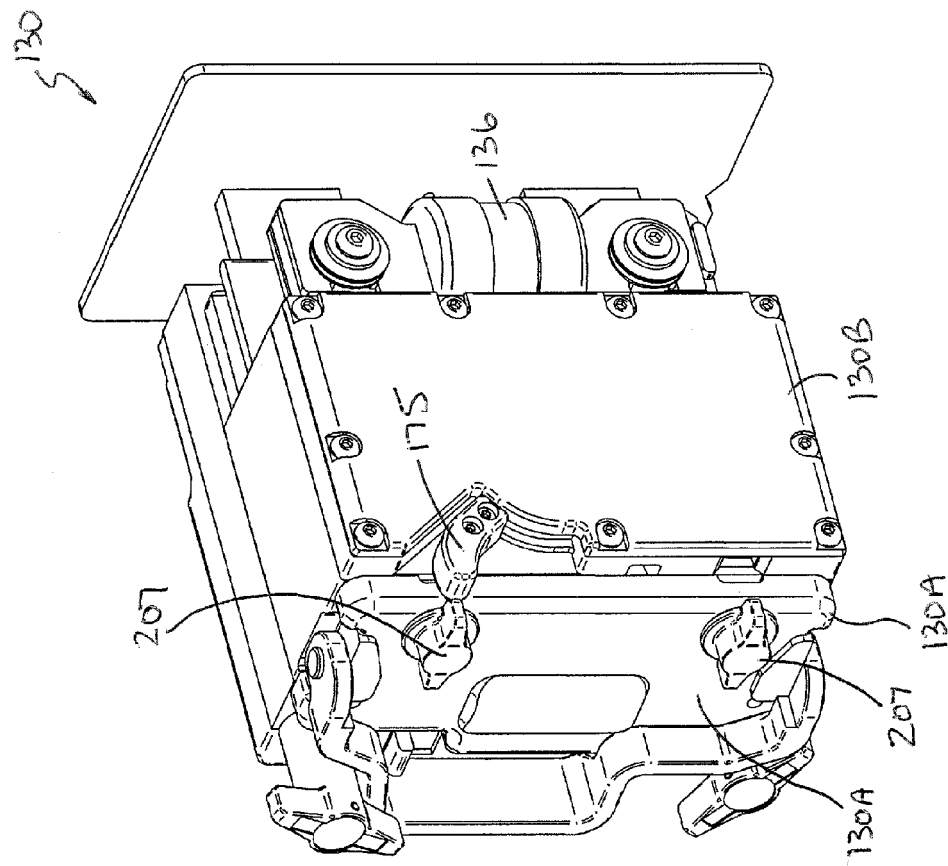


FIG. 4B

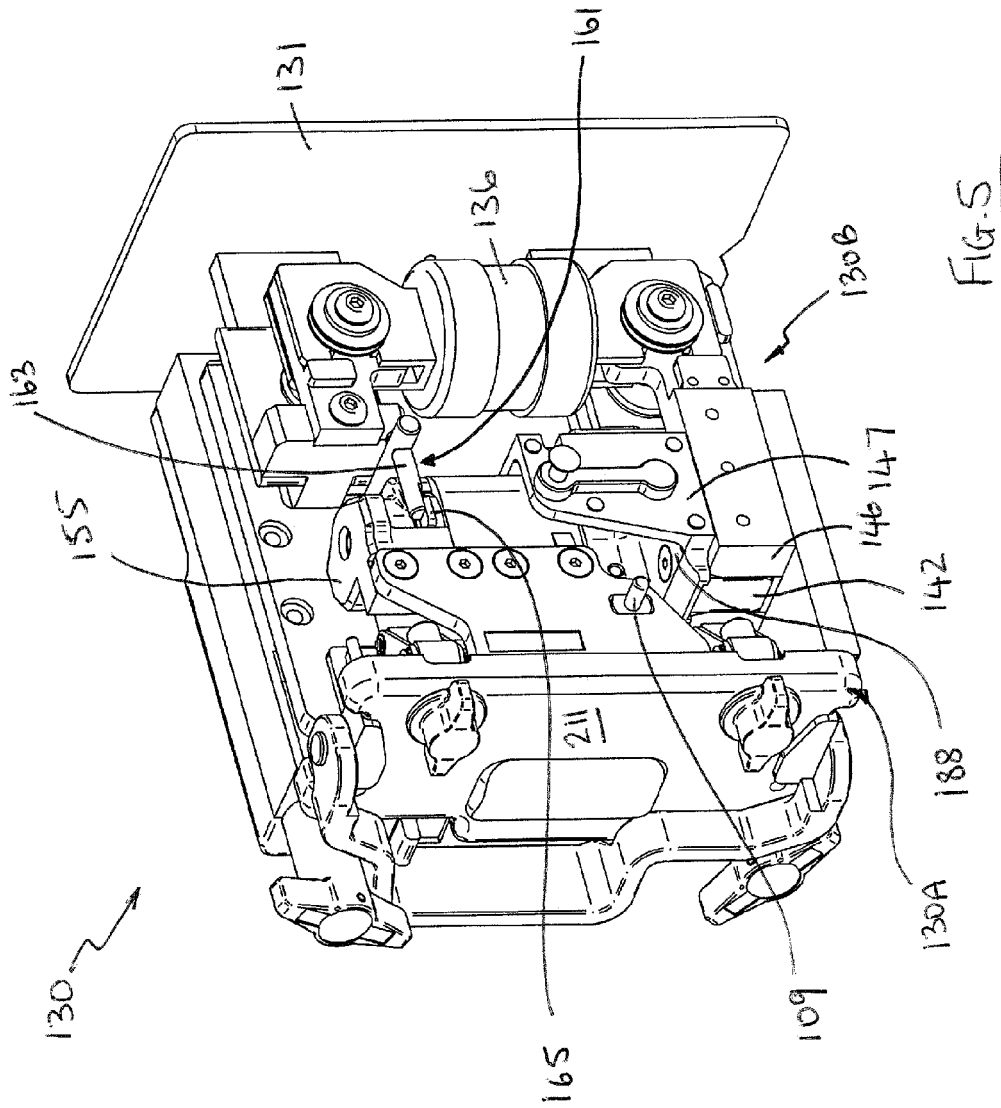
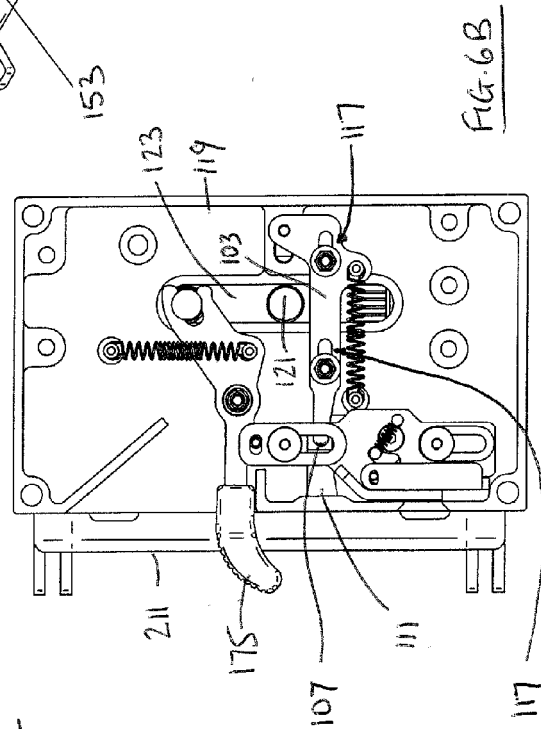
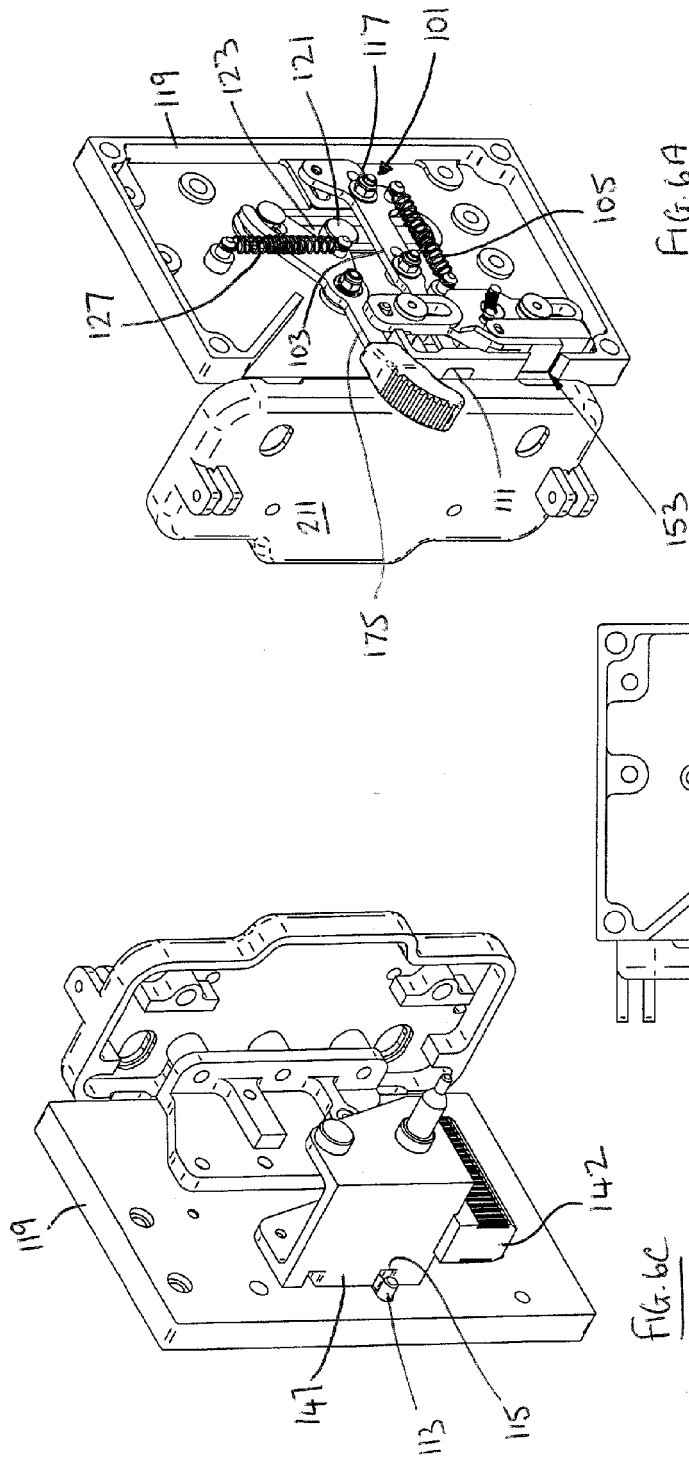
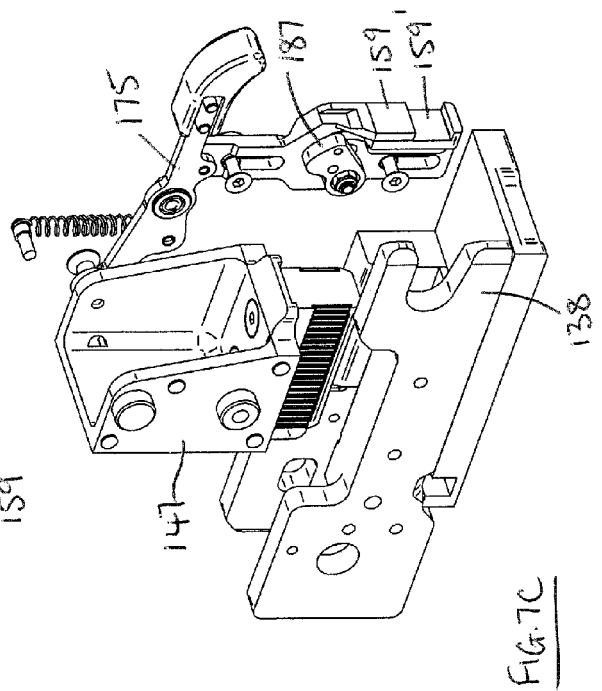
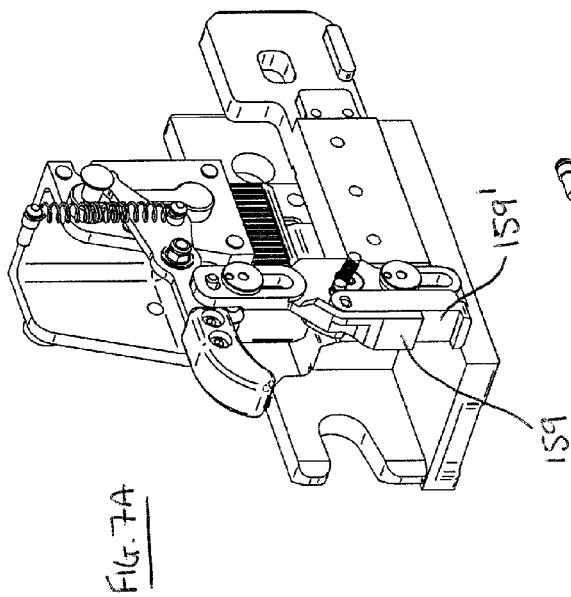
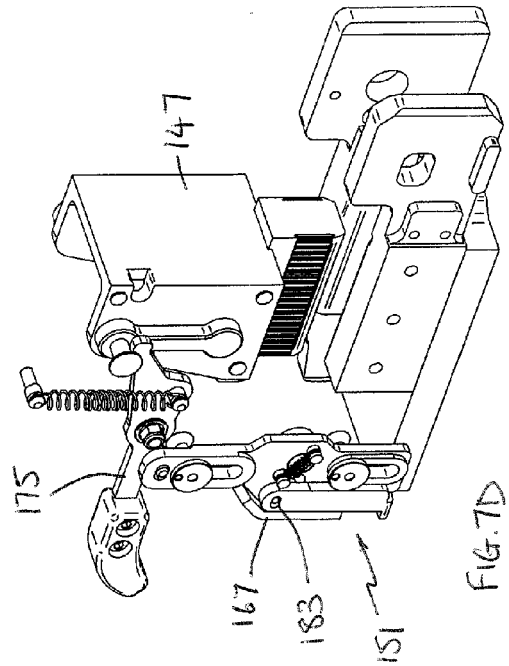
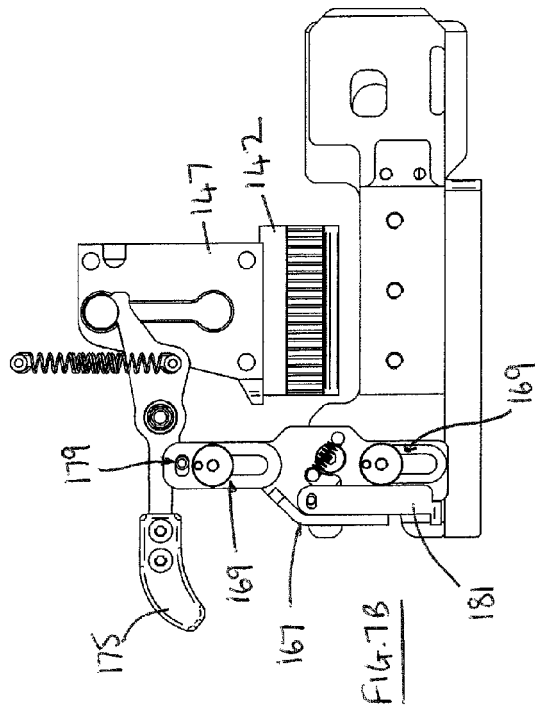
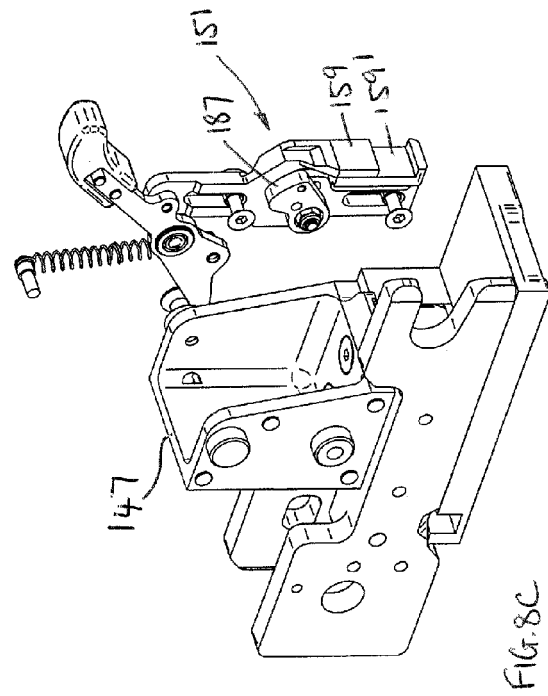
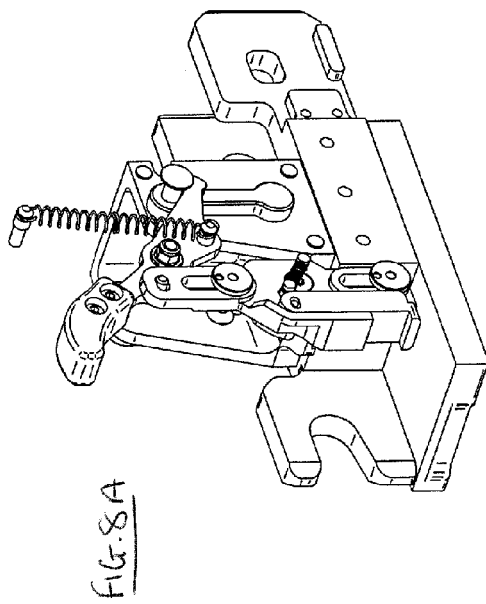
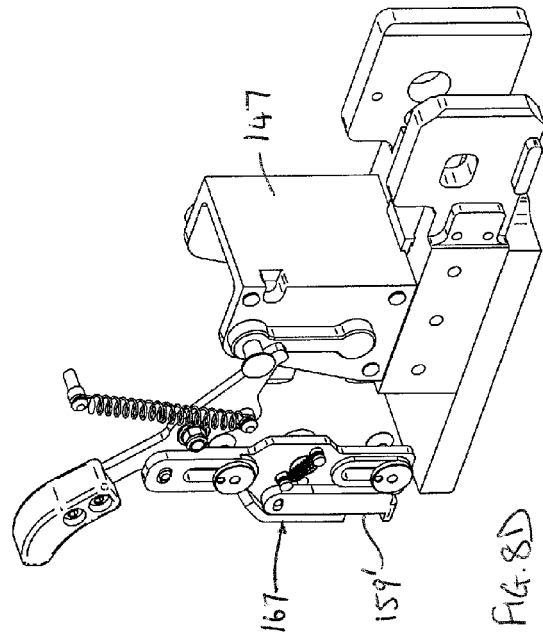
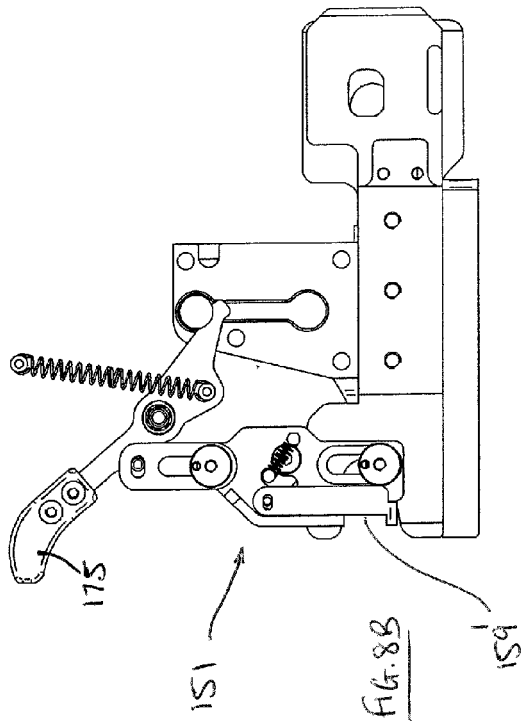
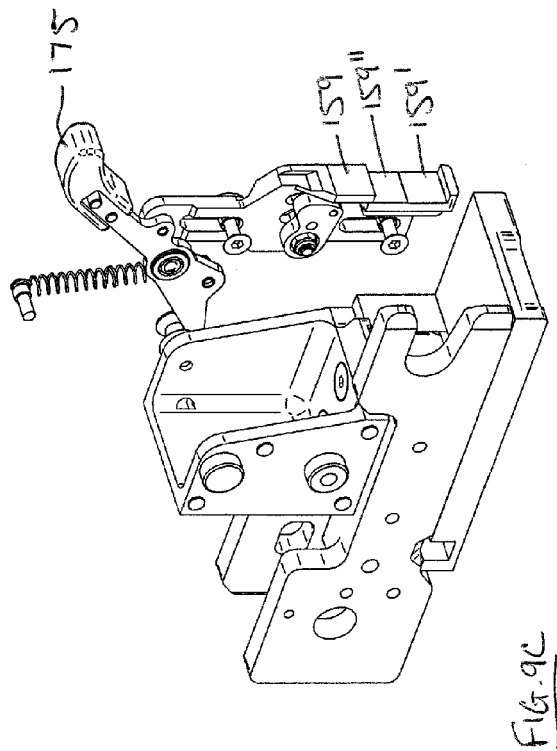
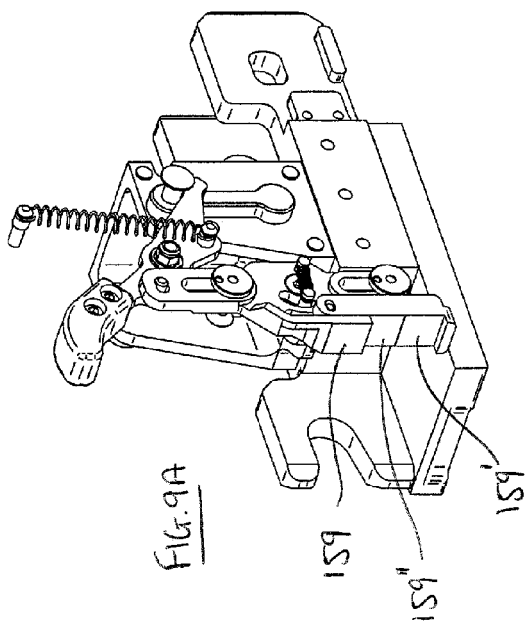
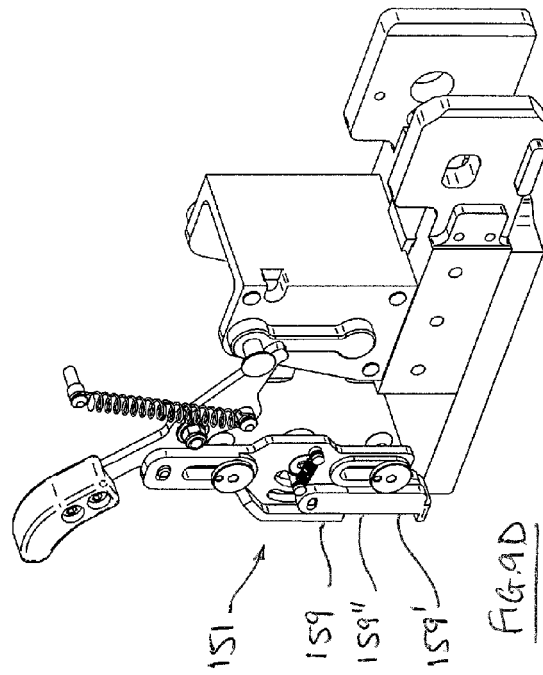
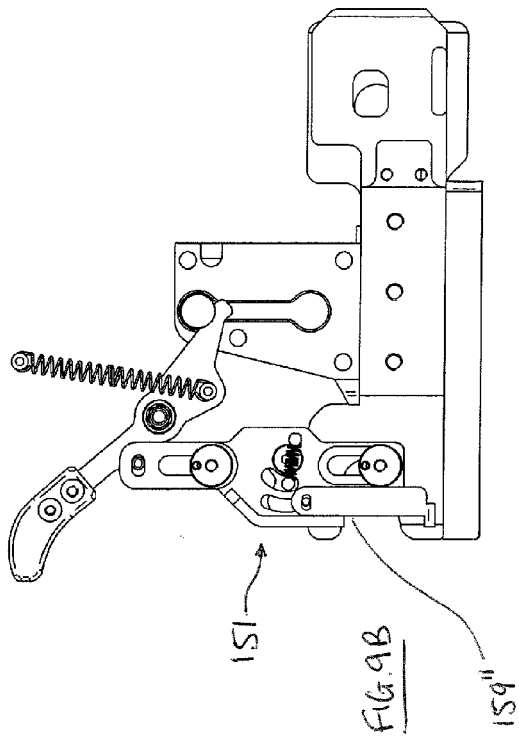


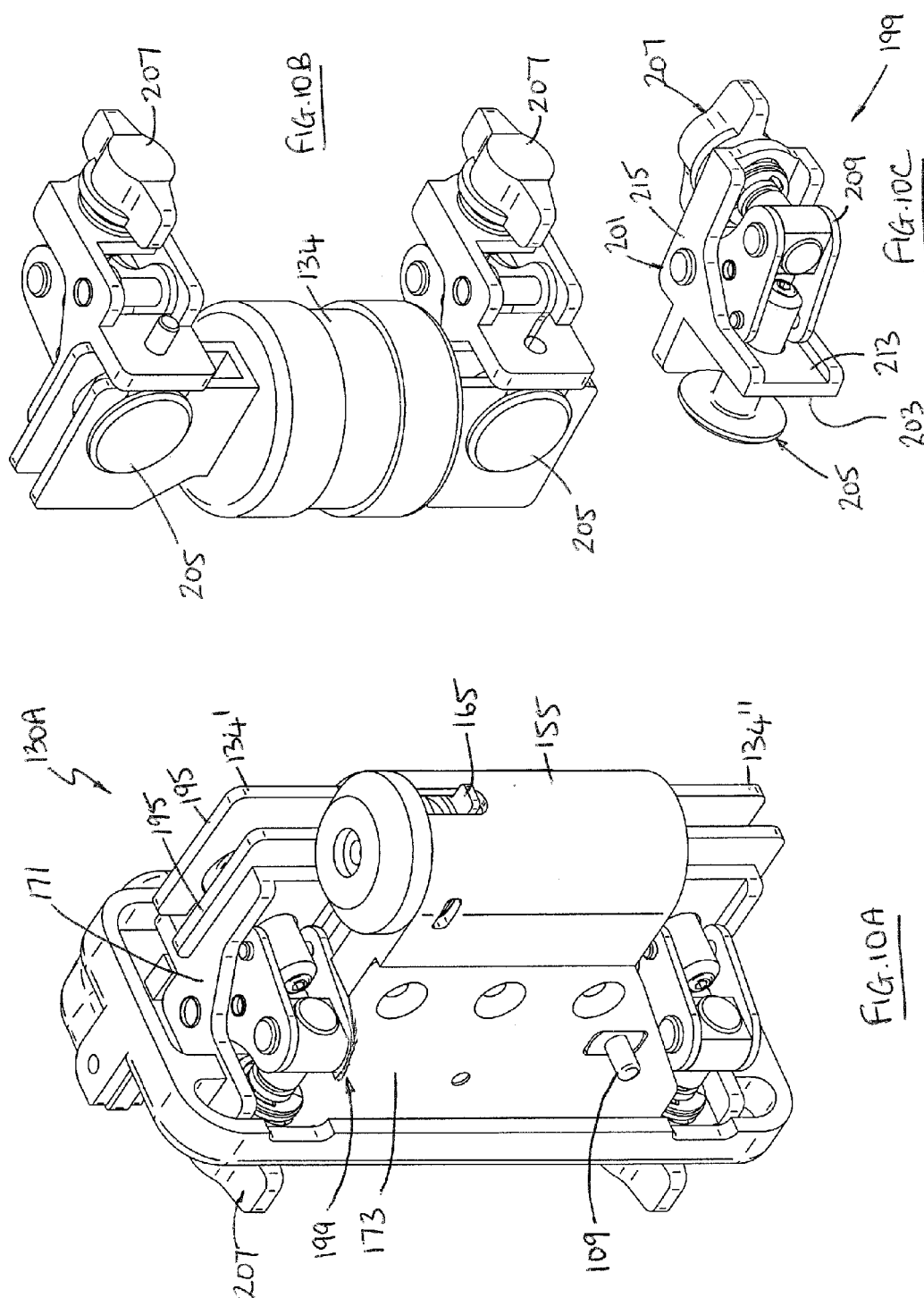
Fig. 5











**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- EP 1912241 A [0005] [0006]