May 2, 1961 E. F. GOETZ 2,982,827

INTERLOCKING MECHANISM

Filed Sept. 9, 1959 4 Sheets-Sheet 1

Fig. 1.

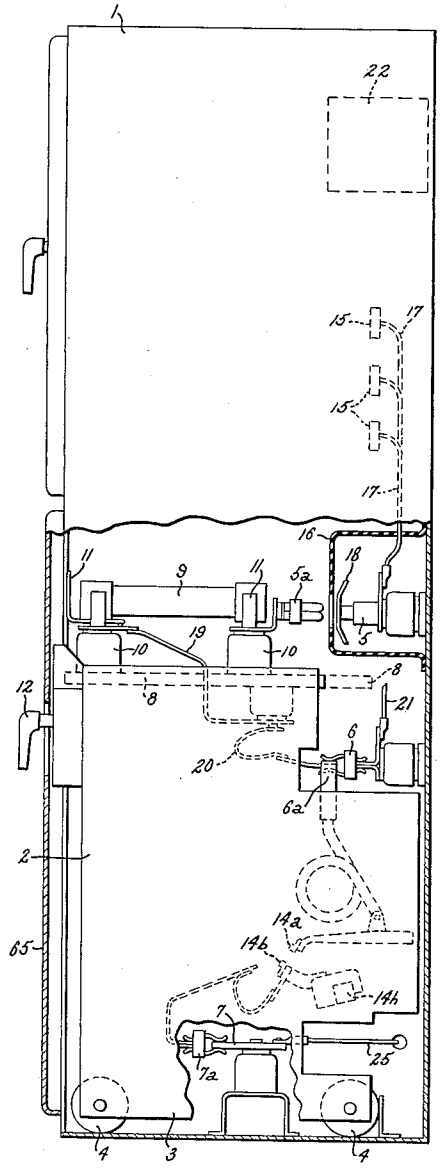
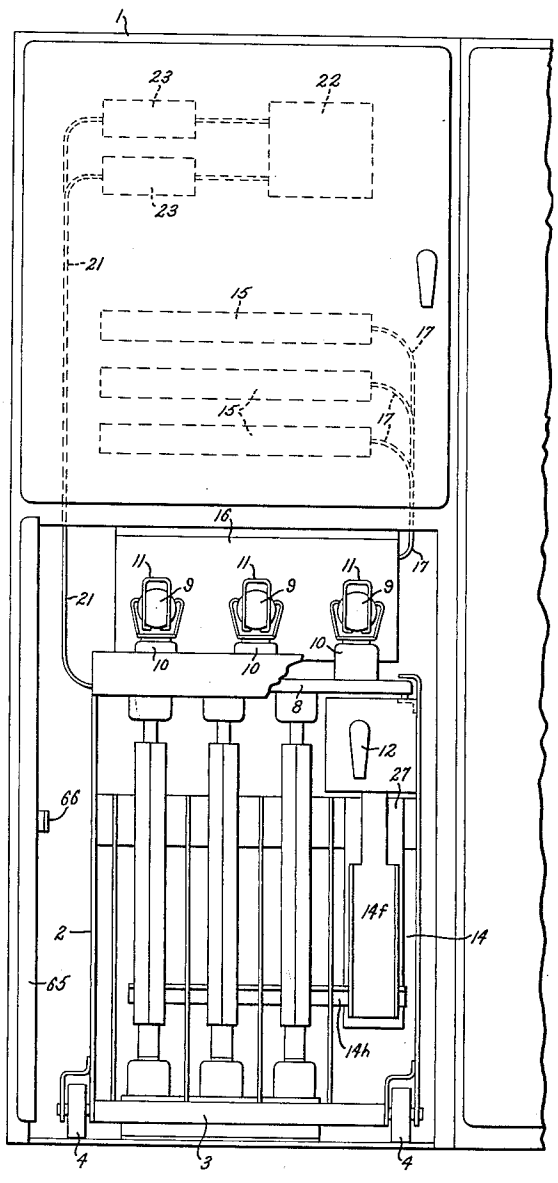


Fig. 2.



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INTERLOCKING MECHANISM

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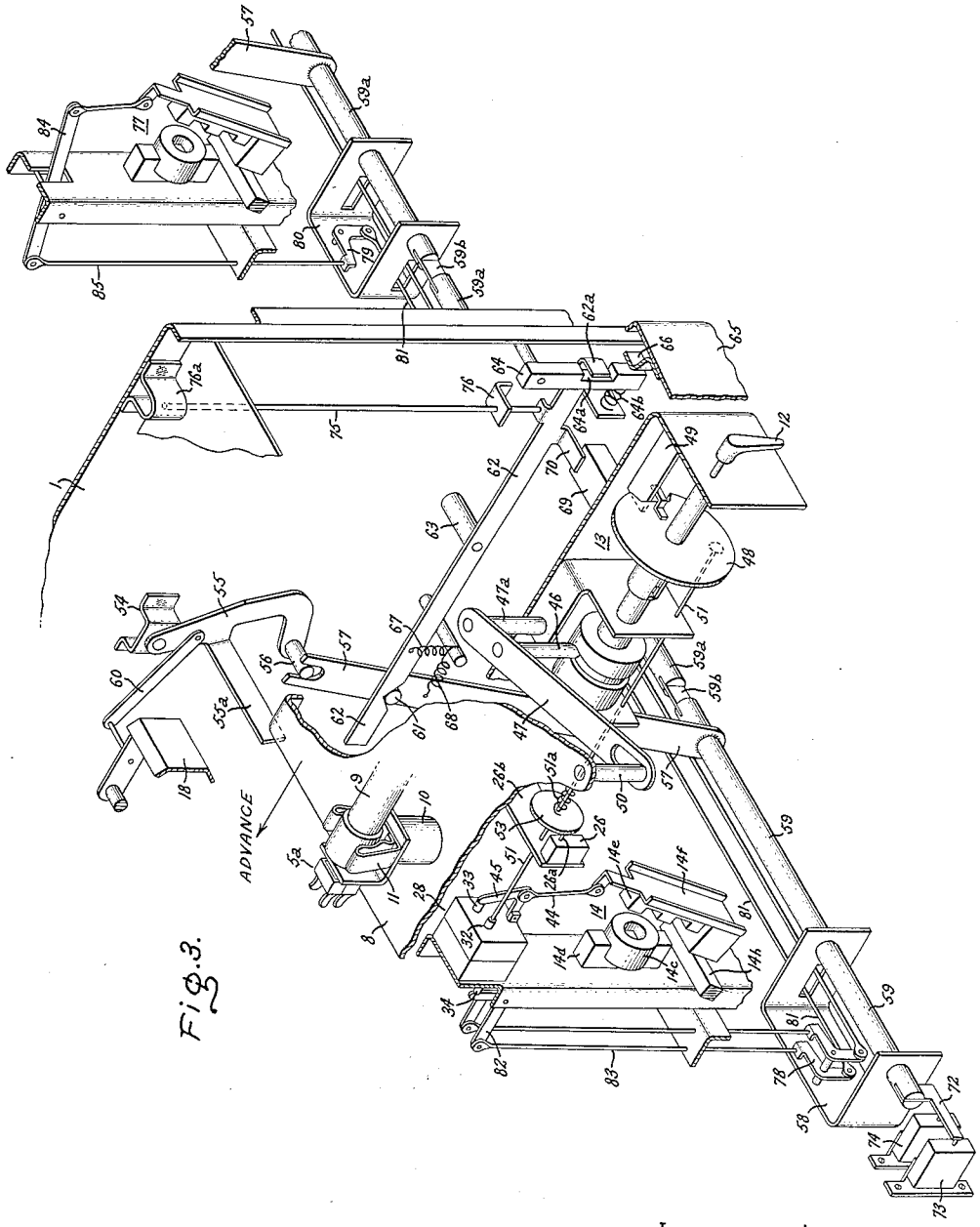

Fig. 3.

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INTERLOCKING MECHANISM

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Fig. 4.

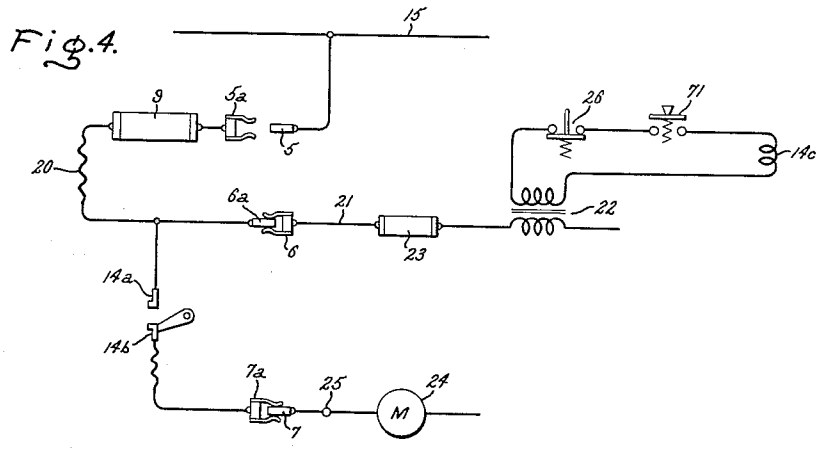


Fig. 6.

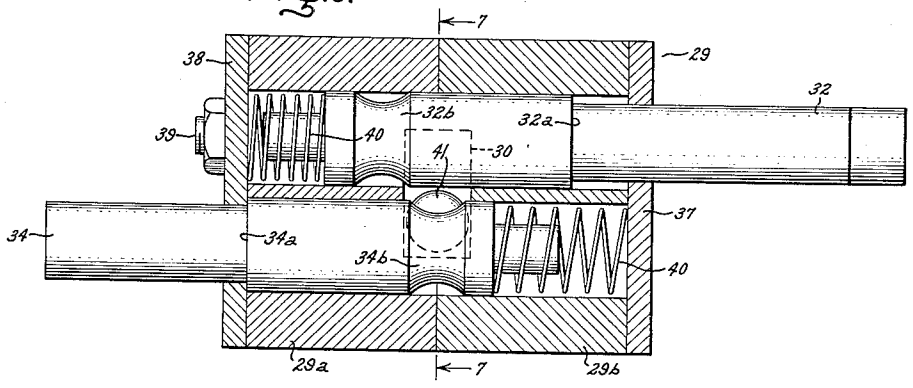
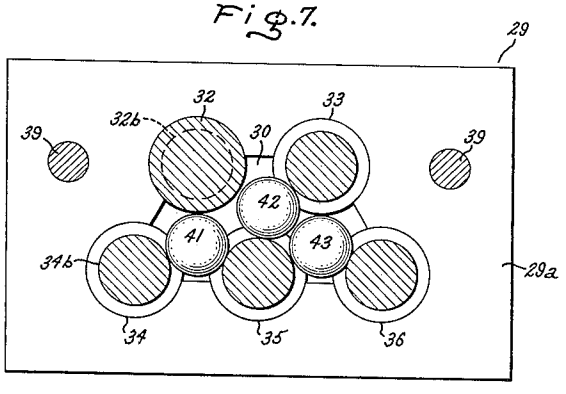


Fig. 7.



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INTERLOCKING MECHANISM

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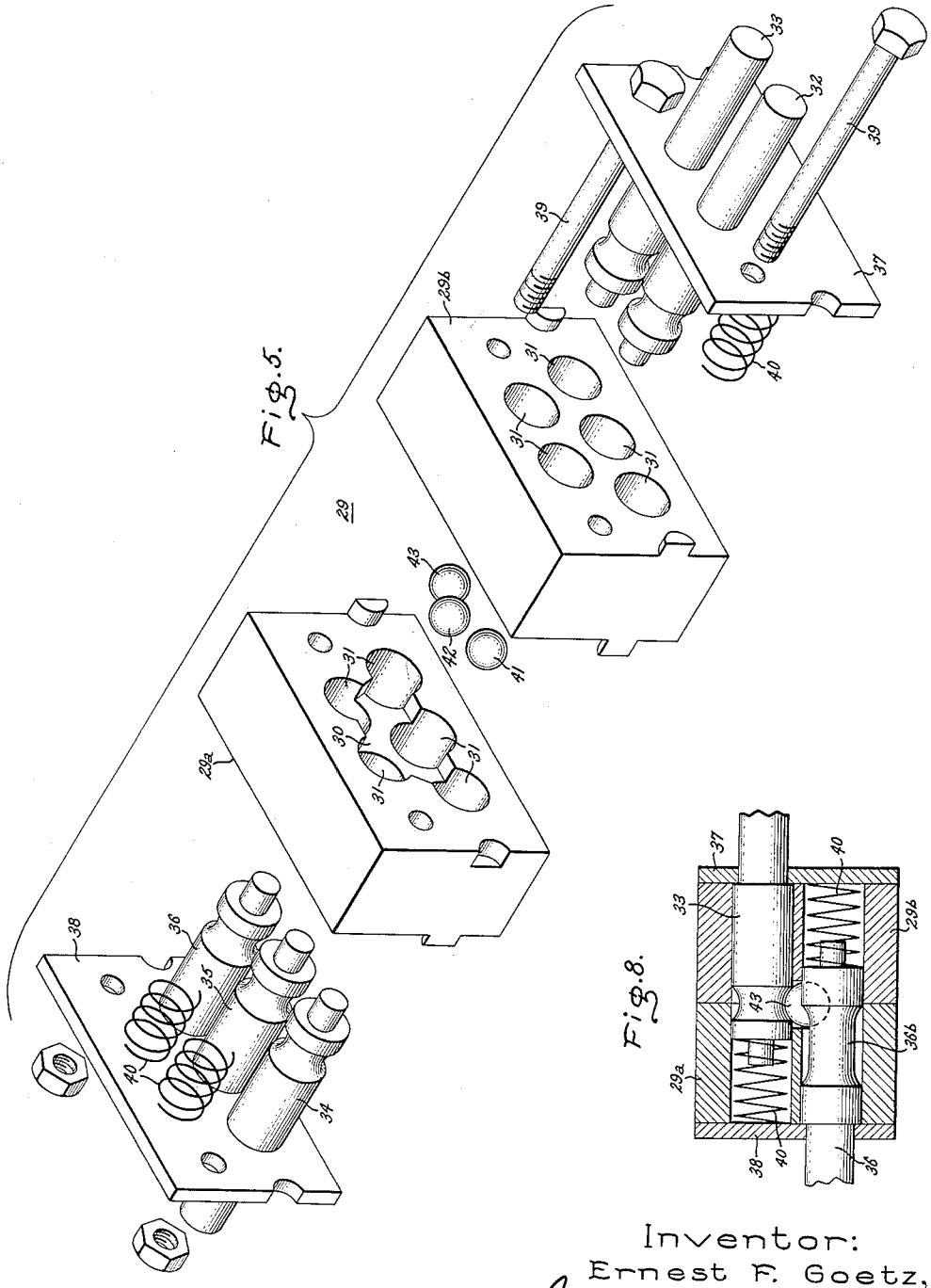

Fig. 5.

Fig. 8.

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United States Patent Office

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INTERLOCKING MECHANISM

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Filed Sept. 9, 1959, Ser. No. 838,897

10 Claims. (Cl. 200—50)

This invention relates to interlocking mechanism for circuit control equipment which comprises the combination of a switch and a fuse electrically connected in series and which is constructed as a structural unit that can be advanced in a horizontal direction into and withdrawn from a suitable enclosure, and a general object of the invention is the provision of a simple, reliable, improved and inexpensive interlocking system for circuit control equipment of this character. Such equipment may include high voltage current limiting fuses, high voltage supply source disconnects and one or more contactors of the electromagnetically operated type for connecting a load such as a motor to a source of supply, together with associated control devices and instruments mounted in suitable metal cabinets that may be assembled to meet widely varying circuit control requirements.

The invention is particularly concerned with an interlocking mechanism for a switch-fuse combination of which the fuses are mounted on a shelf which is slidably mounted on the draw out unit for forward and backward movement between an advanced and a retracted position and in which the movable contacts of high voltage supply source disconnects are also mounted on the fuse shelf for mating engagement with cooperating stationary disconnect contacts when the draw out unit is wholly within its enclosure and the fuse shelf is in its advanced position and for separation of the movable and stationary disconnect contacts when the shelf is moved from its advanced position to its retracted position and a primary object of the invention is the provision of means for requiring opening of the contactor and deenergization of its operating coil prior to movement of the fuse shelf into its advanced position. Another object of the invention is the provision of means for requiring opening of the contactor and interruption of its energizing circuit prior to movement of the fuse shelf from its advanced position to its retracted position. A corollary object is the provision of means for preventing any movement of the fuse shelf in either direction while the contactor is closed or while its operating coil is energized. Still another object is the provision of a simple and inexpensive interlock unit which may be advantageously employed in an interlocking system for draw out circuit control equipment of the character described.

In carrying the invention into effect in one form thereof, there are provided in combination, a draw out switch unit having a fuse shelf slidably mounted on the draw out unit for movement between a retracted and an advanced position and carrying movable disconnect contacts for mating engagement with enclosure mounted stationary disconnect contacts when the draw out unit is wholly within its enclosure and the fuse shelf is in its advanced position and an interlocking mechanism between the movable contact of the switch and the movable fuse shelf which requires the movable contact of the switch to be in the open position prior to movement of the fuse shelf in either direction between its advanced and its retracted position.

For a better and more complete understanding of the invention reference should now be had to the following specification and to the accompanying drawings in which Fig. 1 is a side elevational view of draw out switching apparatus of the type to which the invention is applied with part of the side wall of the enclosure broken away to reveal certain internal structural features. The apparatus comprises a horizontally movable switch-fuse draw out unit in position within an enclosure. Fig. 2 is a front elevational view of the apparatus of Fig. 1 with the access door of the enclosure in the open position. Fig. 3 is a view in perspective of one embodiment of the interlocking mechanism of this invention. Fig. 4 is a simple single line, single phase schematic diagram of the electrical connections employed in the switching apparatus. Fig. 5 is an exploded view in perspective of an interlock unit which is utilized in the complete interlocking mechanism of Fig. 3. Fig. 6 is a longitudinal section of the interlock unit of Fig. 5. Fig. 7 is a sectional view of the unit taken on the line 7—7 of Fig. 6 looking in the direction of the arrows and Fig. 8 is a modificacation of Fig. 6.

Referring now to the drawing, the switch apparatus shown in Fig. 1 comprises a stationary enclosure **1** and a draw out unit **2** in the form of a fuse-switch assembly. The removable assembly **2** comprises a truck **3** mounted on suitable wheels **4** to provide for rolling the assembly **2** into and out of the enclosure **1**.

Suitably mounted on the inside surface of the rear wall and on the floor of the enclosure are three sets of plug type stationary disconnect contacts **5**, **6** and **7**. Carried on the rear and bottom walls of the roll out unit are two sets of socket type movable disconnect contacts **6***a* and **7***a* into which the stationary contacts **6** and **7** are fully inserted when the draw out unit is in its fully rolled in position. Movably mounted in slides on the top of the draw out unit is a shelf **8** upon which a set of current limiting fuses **9** are mounted by means of insulators **10** and associated fuse clip assemblies **11**. Secured to the rear fuse clip assemblies are a set of movable disconnect contacts **5***a* into which the mating stationary set of disconnect contacts **5** are fully inserted when the draw out unit is in its fully rolled in position and the fuse shelf **8** is moved from the retracted position in which it is illustrated to the advanced position which is indicated by dotted lines.

For the purpose of advancing and retracting the fuse shelf a handle **12** mounted on the draw out unit for independent rotational and axial movements and a shelf operator **13** actuated thereby are provided, as shown in Fig. 3. The handle **12** projects through an opening in the door of the enclosure to enable the operator to grasp it when the door is closed. On the draw out unit, as illustrated in Figs. 1 and 2, is mounted an electromagnetically operated switching device such as the three pole contactor **14**. Briefly the electrical connections of the parts thus far described comprise a set of three phase high voltage power buses **15** to which the stationary disconnect contacts **5**, mounted within the shutter box **16**, are connected by suitable conductors such as insulated buses **17**. With the fuse shelf in its advanced position the shutter **18** is in its elevated position to uncover ports through which the set of movable disconnect contacts **5***a* are advanced to a position in which they engage the set of stationary contacts **5**. From the fuse clip assemblies **11** at the front end of the fuse shelf **8** electrical connections are made by means of buses **19** to a set of flexible shunt connections **20** the terminals of which are mounted by means of insulators on the underneath side of the fuse shelf. Preferably these flexible connections are made of braided copper. The opposite, i.e., the lower terminals of the three flexible connections are connected to three

corresponding movable stab contacts 6*a* which are fully inserted into mating stationary disconnect contacts 6 when the draw out unit is in its fully rolled in position. By means of suitable cabled conductors 21 two of the stationary disconnect contacts 6 are connected to the primary winding of a step down transformer 22 with fuses 23 included in the circuit. This control transformer furnishes the low voltage power for the operating coil 14*c* (Figs. 3 and 4) of the contactor 14 and for various control relays and auxiliary devices not shown and not necessary to an understanding of the invention.

As shown in Figs. 1 and 4, the lower terminals of flexible connections 20 are connected by means of suitable conductors to the stationary contact tips 14*a* of contactor 14, the movable contacts 14*b* of which are connected to the set of movable disconnect contacts 7*a*. An external load device such as a three phase induction motor 24 may be connected to a set of terminals 25 which in turn are connected to the stationary disconnect contacts 7.

For the purpose of requiring the contactor 14 to be dropped out to its open circuit position and its operating coil 14*c* to be deenergized before the fuse shelf 8 can be moved from its retracted to its advanced position or withdrawn from its advanced position, an interlocking mechanism such as shown in Fig. 3 is provided. In order to ensure deenergization of the operating coil prior to initiating movement of the fuse shelf in either direction a switch 26 usually known as a "dump" switch having contacts in the secondary circuit of the control transformer is provided. This dump switch is mounted on the frame of the draw out unit by means of a suitable mounting bracket 26*b*.

In Fig. 3 the high voltage contactor is represented by its magnet 14*d* and movable armature 14*e*. It will be understood however that movable contact assemblies (not shown) are mounted on the same shaft 14*h* as channel member 14*f* to which the armature 14*e* is secured, and that the movable contacts 14*b* (Fig. 4) of this assembly cooperate with stationary contacts 14*a*. As shown, the magnet is mounted on a vertical channel member 27 of the draw out unit. Mounted above the magnet and preferably on the same channel member is a ball and plunger interlock unit 28 the structural features of which are shown in Figs. 5, 6 and 7. A preferred embodiment of this unit comprises a ball case block 29 formed of two identical matching parts 29*a* and 29*b* which face and interlock each other. This block may be made of a suitable molded compound. Formed in the block on either side of the dividing plane between the two parts are two recesses which, when the parts are secured in contact with each other, combine to form a ball chamber 30 in which one or more steel balls can move only in a single transverse plane. Also formed in the block and extending through it with their axes generally perpendicular to this plane are a plurality of holes 31 which serve to guide plungers 32, 33, 34, 35 and 36. Each of these plungers has a portion of full diameter and a portion of reduced diameter to provide shoulders such as the shoulders 32*a* and 34*a* on plungers 32 and 34 respectively. These plungers may be inserted into the holes from either end as best facilitates their connection to the parts which are to be interlocked. The two mating parts of the ball case are held together by suitable means such as retaining plates 37 and 38 which are secured in place by suitable means such as the through bolts 39. In these retaining plates are provided holes of the correct diameter to permit the reduced diameter portions of the plungers to pass through with moderate clearance but which prevent the passage of the full diameter portions. Suitable means such as springs 40 mounted in the holes between the ends of the plungers and the retaining plates bias the plungers outwardly so that their shoulders are held against the retaining plates through which their reduced diameter portions pass. Plunger travel is limited by the shoulder on one end and by a reduced diameter projection on the other end extending through the spring. Intermediate its shoulder and its end each plunger is provided with an annular groove. These grooves are located at such points that when the shoulders of the plungers are in contact with the retaining plates the grooves and the ball chamber are generally coplanar. The annular grooves for the plungers 32 and 34 are designated by the reference characters 32*b* and 34*b* respectively. The holes for plungers 34, 35 and 36 are arranged in a first row with their axial center lines aligned in a common plane and the holes for plungers 32 and 33 are arranged in a second row with their center lines aligned in a second common plane spaced sufficiently from the first to provide a central area in which a plurality of steel balls 41, 42 and 43 are housed and may be moved about in the general plane of the ball chamber 30. The holes in each row are in staggered relationship with respect to the holes in the other row so that in a single cross sectional plane the center line of a hole in one row and the two adjoining holes in the second row have a triangular configuration. Thus the intersections of the center lines of the holes for plungers 32, 34 and 35 with a common transverse plane constitute the apexes of a triangle. Preferably the spacing is such that the triangle is equilateral. The relationship of the diameter of the balls, the spacing and diameters of the plungers and depth of the annular grooves are such that in a triangular configuration of three adjoining plungers, a ball may occupy the space between the periphery of one of the plungers and the bottoms of the grooves of the other two but is too large for the space between the peripheries of two plungers and the groove of the third. Consequently in any one triangular configuration of three adjoining plungers only one may be depressed at one time. Thus in any one of the groups 32, 34, 35—32, 33, 35—33, 35, 36 only one plunger may be depressed at a time. Similarly in any two adjoining triangular configurations having two plungers in common only one may be depressed at one time. Thus in the groups 32, 34, 35—32, 33, 35 only one may be depressed at a time, i.e., if any one of the plungers 32, 33, 34, 35 is depressed the others cannot be. The same is true of the plungers 32, 33, 35 and 36; only one of these can be depressed at one time. It is to be noted however that in any two triangular groupings having but one plunger in common there are two and only two plungers which may be simultaneously depressed. Thus in the groups 32, 34, 35 and 33, 35, 36 having only plunger 35 in common, the end position plungers 34 and 36 may be simultaneously depressed. The overall result is that if any one of the plungers 32, 33, 35 is depressed the remaining plungers are locked and if plungers 34 and 36 are depressed, both together or one at a time, the three other plungers 32, 33 and 35 are locked.

In certain applications of interlocking mechanisms, it is desirable to provide sequencing operation. For example, in the interlocking of electromagnetic contactors it may be required that a normally closed contactor (used as a dynamic breaking contactor be opened before a normally open forward or reverse contactor can close. Such sequencing operation is provided by modifying the ball and plunger interlock unit so that the annular groove of one of the two simultaneously depressable plungers 34 and 36 is coplanar with the ball chamber only after being depressed. In the modification illustrated in Fig. 8, the plunger 36 is constructed so that in its undepressed position its annular groove 36*b* is not coplanar with the ball chamber. Consequently the balls 43, 42 and 41 are forced to positions in which they lock the plungers 32, 33 and 35. If plunger 34 is depressed, it still prevents depression of any one of plungers 32, 33 and 35 irrespective of the position of plunger 36. Assume that the movable contact of a normally closed contactor is connected to plunger 36 in such a manner that the

plunger is undepressed when the contactor is closed and further assume that a normally open forward contactor is connected to any one of plungers 32, 33 and 35 and that a normally open reverse contactor is connected to any other one of plungers 32, 33 and 35 in such a manner that when each such forward or reverse contactor is open the plunger to which it is connected is undepressed. As thus connected and arranged, the normally open contactors are locked open when the normally closed contactor is closed. Before either normally open contactor can be closed the normally closed contactor must first be opened to depress plunger 36 and permit the balls to move to positions in which any one (but only one at a time) of plungers 32, 33 and 35 can be depressed and the contactor connected thereto can be closed.

The movable armature member 14*e* of contactor 14 is connected with plunger 33 of the interlock unit by suitable means such as adjustable link 44, pivotally connected at one end to channel member 14*f*, and bell crank 45. When the armature is in its picked up position the plunger 33 is depressed and consequently all other plungers are locked and cannot be depressed.

Although the fuse shelf operating mechanism 13 may be of any suitable type it is preferably a cylinder provided with a helical cam groove for actuating a cam roller 46 that is carried on an arm 47 which is pivoted to the drawout unit at 47*a*. The operating handle 12 is provided with a sliding latch in the form of a notched plate 48 and a mechanical stop 49 which permits rotation of the external operating handle only after it has been moved axially inwardly approximately one half inch. A pin 50 mounted on the shelf 8 projects into a slot in the arm 47 and effects forward or rearward movement of the shelf in response to rotation of handle 12. Extending between the plate 48 and plunger 32 of the ball and plunger interlock unit is a rod 51 which is slidably mounted for lengthwise movement. Since the plungers 32 and 33 cannot be simultaneously depressed the fuse shelf 8 cannot be advanced or retracted if the contactor is picked up because handle 12 cannot be pushed inwardly. Conversely the contactor must be and remain dropped out while the fuse shelf is being moved in either direction.

As shown in Fig. 3, the dump switch 26 is mounted on a suitable mounting bracket 26*b* on the draw out unit between the operating handle 12 and the interlock unit. Carried on the rod 51 is a disk 53 which, when the handle 12 is pushed axially inwardly, actuates an operating member 26*a* to open the interlock contacts of the dump switch. Since plungers 32 and 33 cannot be depressed simultaneously, the handle 12 cannot be used as a start and stop push button switch by pushing it in and pulling it out.

Pivotally mounted on a bracket 54 which is suitably secured to a wall of enclosure 1 is a generally L-shaped lever 55 which at its unpivoted end is provided with a roller 56 that rests in the slot of the bifurcated end of a lever 57. Rotatably mounted in a bearing bracket 58 on the rear wall of the enclosure 1 is a shaft 59 to which the opposite end of lever 57 is suitably secured as by welding. The L shaped lever 55 is provided with a bent up portion 55*a* which is engaged and pushed by the rear edge of the fuse shelf 8 when it is moved from its retracted to its advanced position. A link 60 pivotally connected to the lever 55 elevates the shutter 18 as the fuse shelf is advanced to its stab in position.

At an intermediate point on lever 57 is mounted another roller 61 which engages a cam shaped cutout on a third lever 62 near one of its ends. This lever 62 is pivotally mounted on a pivot pin 63 which is secured to the enclosure 1. At its opposite end it has a right angle bend 62*a* which cooperates with a slot 64*a* in a door actuated latch member 64. This latch member is pivotally mounted on the enclosure and is biased by means of a spring 64*b* to a position in which the slot engages the bent up portion 62*a*.

Secured to the door 65 of the enclosure by welding or other suitable means is an interlock member 66. It is constructed so that with the door closed the latch 64 is disengaged from the bent up end 62*a* of lever 62 which is then free to rotate in a clockwise direction about the pivot 63 to a position in which the bent up end overlies the corresponding bent up end of door interlock member 66. A spring 67 biases the cut out cam surface of lever 62 against the roller 61 and a similar spring 68 biases the bent up projection 55*a* of lever 55 against the rear edge of the fuse shelf. For the purpose of preventing the operator from moving the fuse shelf to its advanced position until the draw out unit 2 is in its fully rolled in position a stop member 69 is secured by machine screws or other suitable fastening means to the side frame of the draw out unit in such a position that it is in the path of movement of a projection 70 on the lever arm 62 if the draw out unit is not fully rolled in, but is removed from its path when the unit is fully rolled in.

With the forgoing understanding of the elements thus far described, the operation is as follows: As an initial condition it is assumed that the draw out unit 2 is withdrawn from the enclosure, that the fuse shelf is in its retracted position and that the contactor 14 is open, i.e., it does not have any welded tips and its armature is not picked up responsively to the energization of the operating coil by an external test voltage. The draw out unit is moved into the enclosure 1 to its fully inserted position in which the sets of stationary contact stabs 6 and 7 are fully inserted in the sets of movable stab sockets 6*a* and 7*a* respectively.

With the access door open and the contactor 14 open it is possible to push in the operating handle 12 but it cannot be turned because the bent up portion 62*a* of lever 62 is engaged in the slot 64*a* of the pivoted door latch member 64 thereby locking the lever system 55, 57, 62; consequently the fuse shelf 8 cannot be moved to its advanced stabbed in position. Thus the access door for the enclosure and the fuse shelf 8 are interlocked so that the shelf cannot be advanced to its stabbed in position if the door is open.

Since the levers 55, 57 and 62 and bearing bracket 58 are mounted on the enclosure and since the contactor, fuse shelf, operating mechanism and handle, dump switch and ball and plunger interlock unit are mounted on the roll out unit, if the unit is outside the enclosure there is nothing to prevent pushing in the handle 12 and rotating it to advance the fuse shelf to the equivalent stabbed in position. However, if this is done, the draw out unit cannot be rolled completely into the enclosure because the rear edge of the shelf would strike against the projection 55*a* of lever 55 before the movable disconnects on the fuse shelf approached the ports in the shutter box. Consequently, since the lever system 55, 57 and 62 is locked when the access door is open, the movable disconnects could not be stabbed into the high voltage buses without first retracting the fuse shelf and closing the access door to release the lever system. Following full insertion of the drawout unit, the door 65 is closed. This results in the door interlock 66 rotating the latch member 64 in a clockwise direction to permit clockwise rotation of lever 62.

The handle 12 of the fuse shelf operating mechanism is now pushed inwardly. As a result, the rod 51 is displaced axially inwardly thereby to depress the plunger 32 of the ball and plunger interlock unit and simultaneously to cause the disk 53 to depress the switch actuator and open the contacts of the dump switch. Depression of the plunger 32 locks plunger 33 thereby locking out the contactor 14. The dump switch in opening, interrupts the energizing circuit for the contactor operating coil and consequently at this point it cannot be energized either accidentally or deliberately by depression of the

start push button switch 71. The construction of the shelf operating mechanism and handle 12 is such that the handle remains in after being rotated only a slight amount and a spring pushes it out again upon completion of a turn of approximately 330 degrees.

As the handle is turned the fuse shelf is moved inwardly to its advanced position as a result of the coaction of operating mechanism 13 and pivoted lever arm 47. During the advance of the shelf, its rear edge engages bent up portion 55*a* of lever 55 and thereby rotates the lever about its pivot in a clockwise direction. The link 60 which is carried by the lever 55 elevates the shutter 18 to uncover the ports for the movable set of high voltage stab disconnects. Simultaneously, the pin 56 causes the lever 57 to rotate counterclockwise against the tension of spring 68. The roller 61 carried on the lever 57 pushes upwardly against the sloping cam surface of the cut out thereby causing lever 62 to rotate in a clockwise direction. As a result, the bent up portion 62*a* of lever 62 will move downwardly to a position in front of the cooperating bent up portion of door interlock member 66 to lock the door. The fuse shelf has a total movement of a suitable predetermined amount, e.g., four inches; however, all of the lever movements described above take place during the early portion, e.g., the first one and one fourth inches of shelf movement.

As the lever 57 is rotated in a counterclockwise direction, the tubular shaft 59 also rotates in a counterclockwise direction. An arm 72 fastened to shaft 59 releases pressure against the movable contacts of two interlock switches 73 and 74 to interrupt an electrical test circuit and thereby prevent the application of an outside test voltage to any of the control devices or to the operating coil of the conductor. The contactor 14 may now be energized by depressing the start push button switch 71, provided the fuse shelf has been moved to its extreme inward position, and the handle 12 has been rotated approximately 330° to the position in which it is pushed outwardly by its spring. The outward movement of handle 12 permits spring 40 (Fig. 6) to move rod 51 outwardly i.e. toward the front of the enclosure and thereby restore plunger 32 of the ball and plunger interlock unit to the position in which its annular groove is lined up with the ball chamber.

In picking up, contactor 14 depresses the plunger 33 of the ball and plunger interlock unit so that the operating handle 12 cannot be pushed in; consequently the fuse shelf cannot be retracted and the door cannot be opened.

If, during operation the main contacts of the contactor should become welded closed the contactor could not be opened merely by deenergizing its operating coil. With the contactor closed and the door locked, owing to the interlocking of the door with the contactor through the fuse shelf operating mechanism, the door could not be opened by pushing in and turning the operating handle 12, because with the contactor closed this is prevented by the ball and plunger interlock unit. To provide for opening the door under these circumstances an interlock circumventor is provided in an appropriate location which is not necessarily a convenient location. For enclosures such as enclosure 1 having a low voltage control compartment above the high voltage contactor compartment, the access door to the low voltage compartment is not locked; consequently it can be opened even with the high voltage contactor and the high voltage disconnects on the fuse shelf in their closed positions. The interlock circumventor comprises a rod 75 which extends from the low voltage compartment downwardly into the high voltage compartment with its lower end resting on the upper edge of the lever 62 near the bent up portion 62*a*. Suitable means such as guide 76 are provided for maintaining the rod 75 in proper alignment with the lever 62 as it slides up or down. With the fuse shelf 8 in its fully advanced stabbed in position, the bent up portion 62*a* of lever 62 is located in front of the corresponding portion of the door interlock member 66 thereby preventing the door from being opened. However depressing the rod 75 will rotate the lever 62 about its pivot 63 until the upper edge of the bent up portion 62*a* clears the lower edge of the door interlock member 66. The door may now be swung open. In order to render access to the rod 75 somewhat difficult a shroud 76*a* is provided. A screw driver or some specially designed tool must be used to reach inside of the shroud to operate the rod 75. In enclosures which do not have an upper low voltage compartment it will be necessary to extend the rod through the top of the high voltage enclosure to the outside.

With the door opened by depression of the rod 75 the access door of the high voltage compartment cannot be closed unless the lever 62 is again rotated clockwise by depressing rod 75. Having means available to open the high voltage compartment access door may tempt an operator or an unauthorized person to open the door and roll out the draw out unit. However, with the contactor closed and the fuse shelf in the stabbed in position, withdrawing the draw out unit from the enclosure is prevented by the engagement of the stop 69 with the projection 70 on the lever 62. In order to free the stop from engagement with the projection 70 the lever 62 must be rotated in a counterclockwise direction to raise the lower edge of the projection 70 above the upper edge of the stop 69. This can only be done by operating the fuse shelf to its retracted position in which the movable disconnects contacts 5*a* and stationary disconnect contacts are separated. If the contactor is closed the shelf cannot be retracted because the interlock unit prevents pushing the handle 12 inwardly to free the shelf operator 13 for rotation.

During a normal operation in which the fuse shelf is being moved to its stab in position the lever 62 must be able to rotate in a clockwise direction. However, if the draw out unit is not fully rolled into the enclosure the stop 69 will be in the path of movement of the projection 70 thereby preventing the operator from completing the movement of the fuse shelf to the stabbed in position. However, if the draw out unit is fully within the enclosure the rear edge of the projection 70 will clear the front edge of the stop plate 69 and consequently the lever 62 can be rotated in the clockwise direction. Once the rear edge of the projection 70 has passed in front of the front edge of the stop 69 the draw out unit cannot be rolled out of the enclosure with the fuse shelf in its stabbed in position.

The description thus far applies to a single contractor in a single enclosure. Some installations require additional contactors mounted in adjacent separate enclosures with interlocking between all access doors and the movable fuse shelf in enclosure 1. For such installations the elements 57–59 and 61–70 inclusive of enclosure 1 are also required in the adjacent enclosures. The shafts 59 in enclosure 1 and in all adjacent enclosures are coupled together by means of shaft extensions 59*a* and couplings 59*b*.

If interlocking between the contracts is required, bell cranks, push rods and tie rods are provided. For example, to provide interlocking between contractor 14 in enclosure 1 and a similar contractor 77 in an adjacent enclosure, a bell crank 78 is pivotally mounted on bearing bracket 58 of enclosure 1 and a similar bell crank 79 is pivotally mounted on the bearing bracket 80 of the next adjacent enclosure. The vertical legs of bell cranks 78 and 79 are interconnected by a tie rod 81. On the rear face of the interlock unit 28, a bell crank 82 is mounted which, when rotated about its pivot depresses plunger 34 of the interlock unit. Depending from one leg of bell crank 82 is a push rod 83, the lower end of which rests on the horizontal arm of bell crank 78 near its unpivoted end.

In the adjacent enclosure, a lever 84 is pivotally

mounted above the contactor 77 and on the same vertical support. Pivotally attached to one end of lever 84 is a depending push rod 85 the lower free end of which rests on the horizontal arm of bell crank 79 near its end. Since plungers 34 and 33 cannot be simultaneously depressed the contactors 14 in enclosure 1 and contactor 77 in the adjacent enclosure are interlocked against simultaneous closure.

The push rods 83 and 85 are assembled as parts of the draw out unit and are adjusted during assembly such that their lower ends are a predetermined distance above the floor line. Also the tie rods 81 and the bell cranks assembled to their enclosures are adjusted such that the height of their horizontal arms above the floor line matches that of the lower ends of push rods 83 and 85. The draw out unit may then be rolled in or out of its enclosure without interference.

Although in accordance with the provisions of the patent statutes a particular embodiment of this invention has been described and the principle of the invention has been explained together with the best mode in which it is now contemplated applying that principle it will be obvious to persons skilled in the art that various changes and modifications may be made without departing from the true spirit of the invention or from the scope of the annexed claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In combination switching apparatus comprising an enclosure, a drawout switch unit movable into and out of said enclosure comprising a truck, a switching device mounted on said truck and having a stationary contact member and a movable contact member, a fuse shelf slidably mounted on said drawout unit, means for reciprocably moving said shelf between a retracted and an advanced position comprising a handle mounted for rotational and axial movements, and a shelf operating mechanism actuated by said rotational movement of said handle, a first set of disconnect contacts mounted on said enclosure, a second set of disconnect contacts mounted on said shelf for mating with said first set of contacts when said unit is fully within said enclosure and said shelf is in said advanced position, and interlocking means between said movable contact member and said shelf responsive to axial displacement of said handle for preventing contact closing movement of said movable contact member during rotational movement of said handle to actuate said operating mechanism to move said shelf to said advanced position.

2. In combination, switching apparatus comprising an enclosure, a drawout switch unit movable into and out of said enclosure comprising a truck, a switching device mounted on said truck and having a stationary contact member, a movable contact member and an operating coil for effecting contact closing movement of said contacts; a fuse shelf slidably mounted on said drawout unit, means for effecting forward and backward movement of said shelf between an advanced and a retracted position comprising a handle mounted for rotational and axial movement and a self operating mechanism actuated by the rotational movement of said handle, a first set of disconnect contacts mounted on said enclosure, a second set of disconnect contacts mounted on said shelf for mating with said first set of contacts when said unit is fully within said enclosure and said shelf is in said advanced position, an energizing circuit for said operating coil, an auxiliary switching device having contacts included in said energizing circuit, means responsive to axial displacement of said handle from an initial position for actuating said auxiliary switch to interrupt said energizing circuit and interlocking means between said movable contact member and said shelf responsive to axial displacement of said handle for blocking contact closing movement of said movable contact member during rotational movement of said handle to actuate said operating mechanism to move said shelf to said advanced position and responsive to prior closing of said movable and stationary contacts of said switching device for blocking said axial movement of said handle.

3. In combination, switching apparatus comprising an enclosure, a drawout switch unit movable into and out of said enclosure comprising a truck, a switching device mounted on said truck and having a stationary contact member and a movable contact member, a fuse shelf slidably mounted on said drawout unit, means for reciprocably moving said shelf between a retracted and an advanced position, a first set of disconnect contacts mounted on said enclosure, a second set of disconnect contacts mounted on said shelf for mating with said first set of contacts when said unit is fully within said enclosure and said shelf is in said advanced position and interlocking means between said movable contact and said shelf for blocking movement of said shelf to said advanced position when said movable contact member is in the contact closing position and for blocking movement of said movable contact to the closing position during movement of said shelf to said advanced position.

4. In combination, switching apparatus comprising an enclosure having a door, a drawout switch unit movable into and out of said enclosure when said door is open comprising a truck, a switching device mounted on said truck and having a stationary contact and a cooperating movable contact, a fuse shelf slidably mounted on said drawout unit, means for effecting forward and reverse movement of said shelf between an advanced and a retracted position, a first set of disconnect contacts mounted on said enclosure, a second set of disconnect contacts mounted on said shelf for mating with said first set of contacts when said unit is fully within said enclosure and said shelf is in said advanced position, and interlocking means between said movable contact and said shelf for blocking movement of said movable contact to the circuit closing position during movement of said shelf to said advanced position and for blocking movement of said shelf to said advanced position when said door is in its open position.

5. In combination, switching apparatus comprising an enclosure, a drawout switch unit movable into and out of said enclosure comprising a truck, a switching device mounted on said truck and having a stationary contact member, a movable contact member and an operating coil for effecting contact closing movement of said contacts, a fuse shelf slidably mounted on said drawout unit, means for effecting forward and backward movement of said shelf between an advanced and a retracted position comprising a handle mounted for rotational and axial movement and a shelf operating mechanism actuated by the rotational movement of said handle, a first set of disconnect contacts mounted on said enclosure, a second set of disconnect contacts mounted on said shelf for mating with said first set of contacts when said unit is fully within said enclosure and said shelf is in said advanced position, and interlocking means between said movable contact member and said shelf responsive to axial displacement of said handle for blocking contact closing movement of said movable contact member during subsequent rotational movement of said handle to actuate said operating mechanism to move said shelf to said advanced position, said interlocking means including a latching member operable in the open position of said door to block movement of said handle thereby to block movement of said shelf to said advanced position.

6. In combination, switching apparatus comprising an enclosure, a drawout switch unit comprising a truck and a switch unit mounted thereon having cooperating movable and stationary contacts and an operating coil for effecting circuit closing movement of said movable contact, an energizing circuit for said coil, a control switch having contacts included in said circuit, a fuse shelf slidably mounted on said unit, means for moving said

shelf forward and rearward between an advanced and a retracted position comprising a handle mounted for axial and rotational movements and an operating mechanism for said shelf actuated by rotational movement of said handle, a first set of disconnect contacts mounted on said enclosure, a second set of disconnect contacts mounted on said fuse shelf for engaging said first set when said unit is fully within said enclosure and said shelf is in said advanced position, and interlocking means connected between said handle and said movable contact member responsive to axial movement of said handle for blocking circuit closing movement of said movable contact and for actuating said control switch to interrupt said energizing circuit and maintain it interrupted during subsequent rotational movement of said handle to move said shelf to said advanced position, said interlocking means also being responsive to completion of said rotational movement to effect reclosure of said control switch to permit circuit closing movement of said movable contact and being further responsive to said circuit closing movement for blocking axial movement of said handle to effect de-energization of said operating coil.

7. A ball and plunger interlock unit comprising a ball casing block having a first plurality of holes arranged in spaced apart relationship with their center lines in a first row and a second plurality of holes arranged in spaced apart relationship with their center lines in a second row spaced from said first row, a ball chamber formed in said block in the central area defined by said holes for retaining a plurality of balls and permitting movement thereof in a single plane transverse to said center lines, retaining means closing each of said holes at one of its ends, a plurality of plungers each mounted in a different one of said holes and each provided with an annular groove, means biasing each of said plungers to a position in which its annular groove communicates with said chamber, and a plurality of balls in said chamber positioned in the space between said rows and each having a diameter providing moderate clearance contact with the periphery of one plunger and the grooves of two adjoining plungers.

8. A ball and plunger interlock unit comprising a ball casing block having a plurality of at least three holes arranged with their center lines substantially parallel and intersecting a transverse plane in points constituting the apexes of a triangle, a ball chamber formed in said block in the central area between said center lines for retaining at least one ball and permitting its movement in a single plane transverse to said center lines, retaining means closing each of said holes at one of its ends, a second retaining means at the open ends of said holes providing openings of reduced diameter, a plurality of plungers, one for each of said holes, each mounted with a first end extending into its hole and each provided with a shoulder and with an annular groove intermediate said shoulder and said first end, means biasing each of said plungers to a position in which its shoulder is against said second retaining means and its annular groove communicates with said ball chamber, and at least one ball in said chamber positioned in the space between three adjoining plungers and having a diameter providing moderate clearance with the periphery of one of said plungers and the grooves of the other two plungers.

9. A ball and plunger interlock unit comprising a ball casing formed of two mating blocks, a plurality of at least three holes extending through said blocks and arranged with their center lines substantially parallel and intersecting a transverse plane at points constituting the apexes of an equilateral triangle, a ball chamber formed in said blocks in the central area between said center lines for retaining at least one ball and permitting its movement in a single plane transverse to said center lines, retaining plates closing each of said holes at one of its ends and providing a reduced diameter opening to the other end, a plurality of plungers, one for each of said holes, each having a reduced diameter portion extending through the corresponding reduced diameter opening of said retaining means and each having a full diameter portion mounted in said hole terminating in a shoulder and provided with an annular groove intermediate said shoulder and the opposite end of said full diameter portion, spring means biasing each of said plungers to a position in which its shoulder rests against said retaining plate with reduced diameter openings and its annular groove communicates with said ball chamber, and at least one ball in said chamber positioned in the central space between three adjoining plungers and having a diameter providing moderate clearance between said ball and the periphery of one of said plungers and the grooves of the other two.

10. The invention set forth in claim 7 wherein the annular groove in one of said plungers is offset so that said biasing means normally positions said plunger to have said groove anti-planar with said ball chamber thereby locking said other plungers until the first said plunger is moved into a predetermined position.

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