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HYDRAULIC SERVOMOTOR AND THE LIKE

Filed May 27, 1950

4 Sheets-Sheet 1

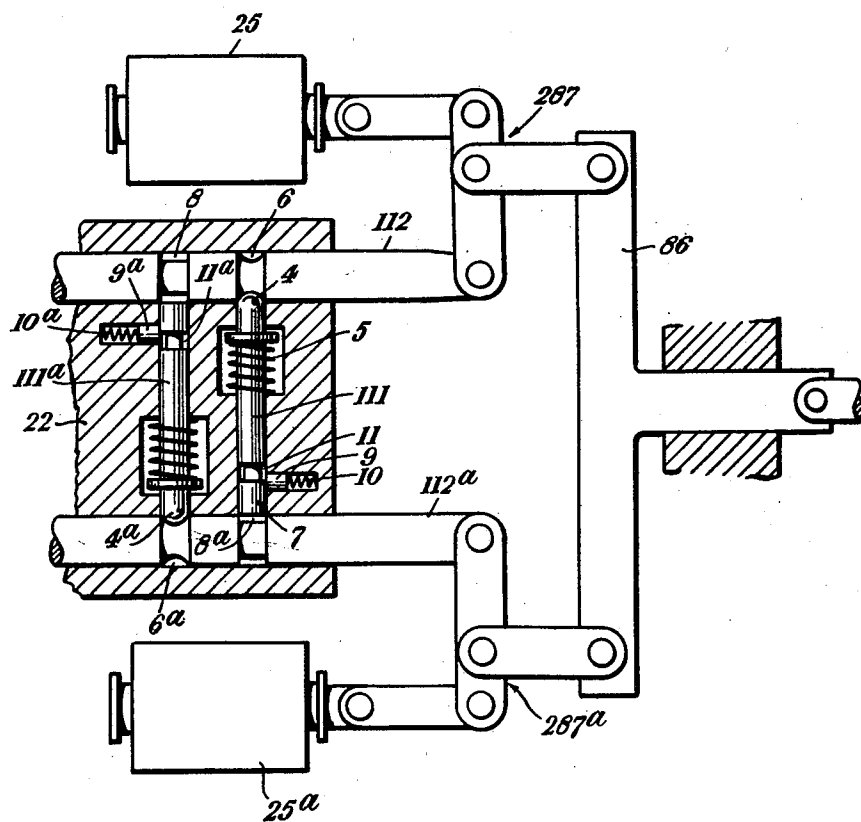


Fig. 1.

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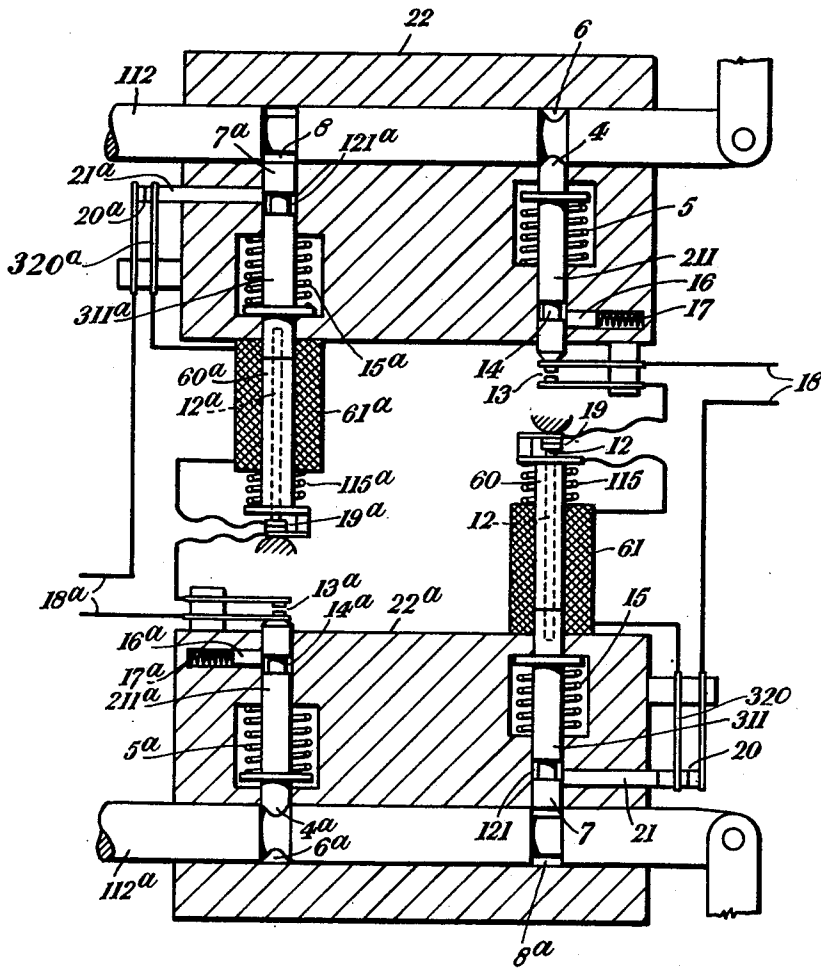


Fig. 2.

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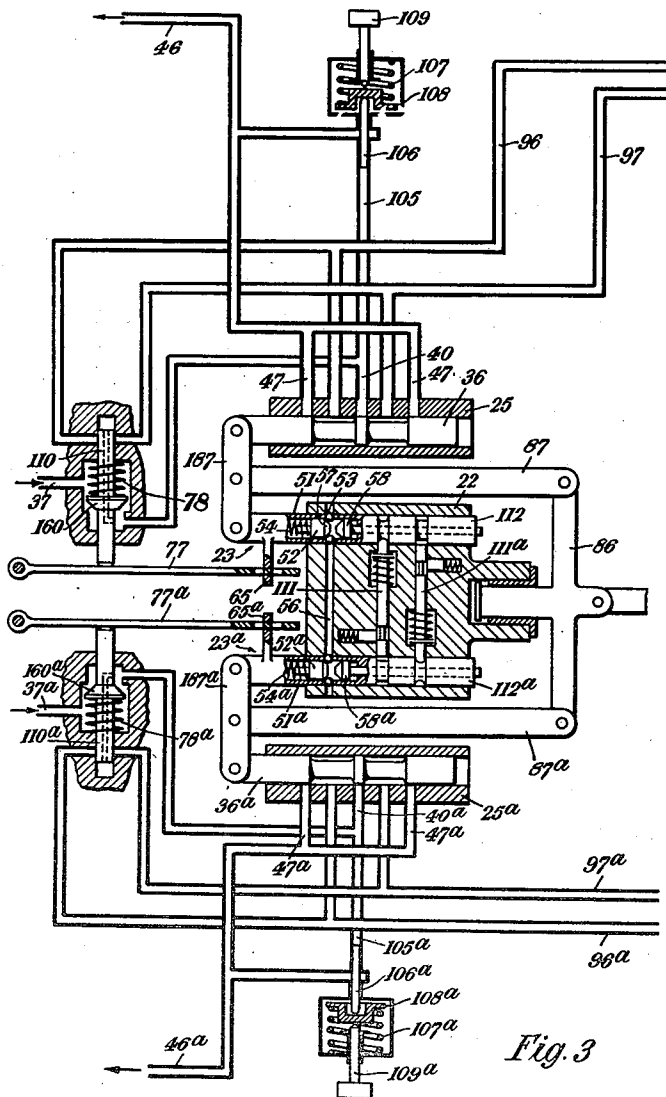


Fig. 3

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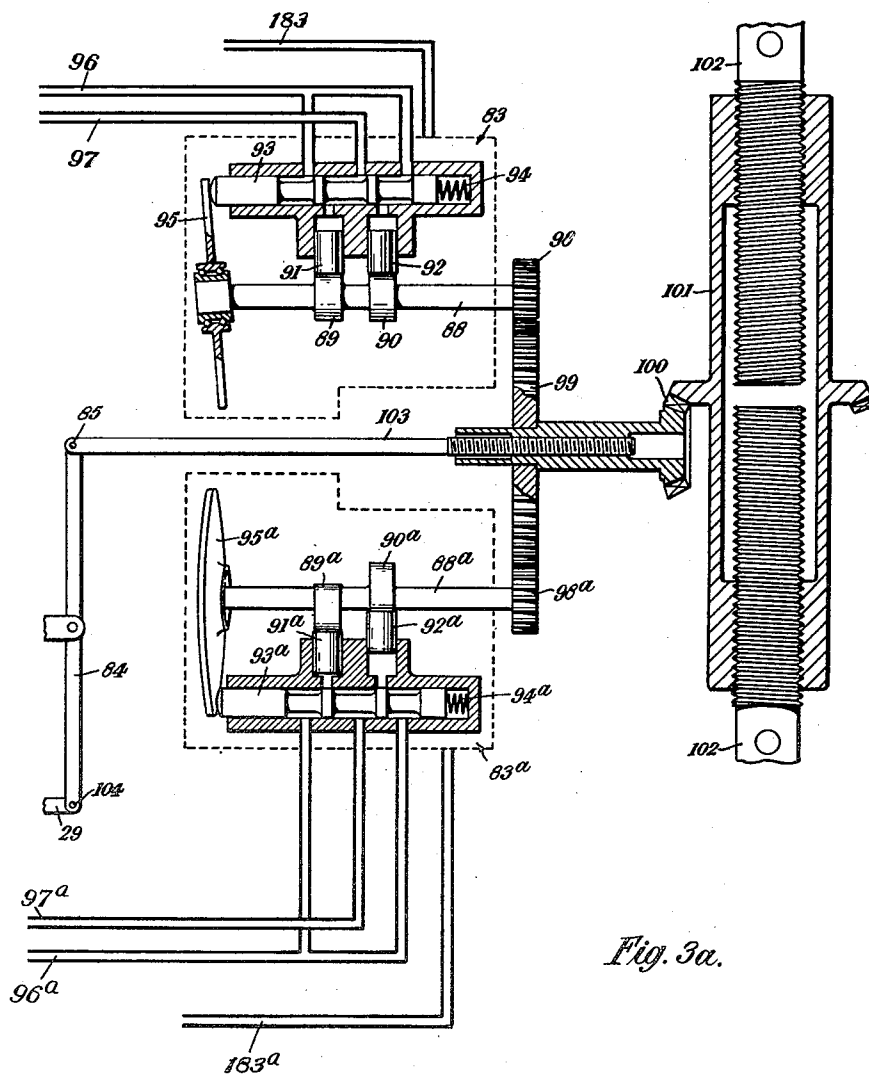


Fig. 3a.

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UNITED STATES PATENT OFFICE

2,597,361

HYDRAULIC SERVOMOTOR AND THE LIKE

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 In Great Britain June 2, 1949

8 Claims. (Cl. 60—97)

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Certain types of hydraulic jacks and motors are controlled by a control valve, which controls the rate and direction of the supply of liquid under pressure to produce movement of an output member in a direction and to an extent determined by the movement imparted to the control valve by a manually operable input member. When such servomotors are used for the directional control of aircraft, ships or vehicles it is necessary to take precautions against failure of the servomotor to move in response to the operator's signal, or continued movement in a contrary direction to that desired by the operator, as a result of seizure of the control valve. Provision for this may be made by connection of the manually operable input member, by which movement is imparted to the control valve, to a collapsible link which will collapse under the extra force applied to the input member in the event of seizure of the control valve, and thereby actuate mechanism for rendering the servomotor ineffective, despite continued seizure of its control valve, to prevent movement of the output member to the desired position, either manually or by means of another servomotor. In United States application Serial No. 164,654 there is described an arrangement of this character, in which collapse of the collapsible link operates a valve to cut off the pressure supply to the control valve and establish a connection between the opposite ends of the jack or motor.

As a precaution against loss of control due to failure of the supply of liquid under pressure, or any functional defect except seizure of the output member, two identical servomotors with separate sources of pressure supply may be coupled to a single output member, the control valves of both servomotors being controlled by a common input member and each control valve being associated with a collapsible link arranged, when it collapses, to render the associated servomotor ineffective to prevent positioning of the output member by the other servomotor. When, however, either of the collapsible links operates, the associated servomotor loses its irreversibility. Operation of the remaining collapsible link, again as a result of valve seizure, will result in a complete loss of irreversibility and, where the output forces are so large as to render manual force insignificant, loss of control.

The probability of the two collapsible links collapsing in succession during a flight of an aircraft is small, but as the results are so serious it is probably less hazardous to prevent the second link from collapsing and to rely on the pilot's ability to free the second seized valve by appli-

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cation of manual force to the input member. If this procedure is adopted, the pilot at least has a chance of remedying matters if the second control valve seize partially.

The invention accordingly provides the combination, with a manually operable input member and an output member, of a pair of hydraulic actuators (i. e. jacks or motors) arranged normally to cooperate in moving the output member in a direction and to a position determined by the movement imparted to the input member, each actuator having a control device linked to the input member and a collapsible member arranged to collapse on seizure of the control device, to render the actuator ineffective to prevent movement of the output member by the other actuator, and means operative on collapse of either member to lock the other member against collapse.

In the cases hereinafter described with reference to the drawings, the control devices of the actuators are constituted by control valves. In some cases, however, the actuators may be controlled by variable stroke hydraulic pumps so as to position the output member in accordance with the position assumed by the input member.

Where hydraulic jacks are used of the type described in United States application No. 785,837, now Pat. No. 2,566,273 issued August 28, 1951, so that they are irreversible in the event of pressure failure, the jacks may derive pressure from the same source, provided provision is made, in the event of collapse of either member, for cutting off the pressure supply from the control valve of the affected jack. I prefer, however, to provide a separate source of pressure for each jack.

Some embodiments of the invention will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 shows a purely mechanical interlock between the two collapsible members,

Fig. 2 shows an electromagnetically operated interlock between the two collapsible members.

Figs. 3 and 3a are diagrams showing the application of the interlock of Fig. 1 to a system embodying duplicated hydraulic motors.

Like reference numerals indicate like parts throughout the figures.

It will be convenient first to describe the system shown in Figs. 3 and 3a thereafter to describe in detail the forms of interlock shown in Figs. 1 and 2.

In the arrangement shown in Fig. 3a, two hy-

draulic motors 83, 83^a serve to operate a control surface. Parts associated with the servomotor 83^a bear the same reference numerals as corresponding parts associated with the servomotor 83, with the addition of the suffix *a*.

The pilot's input member 29 is connected to a link 84 which, on movement of the input member, turns about a pivot 85 to shift a linkage 86, 87, 87^a, 187, 187^a, thereby moving the two control valves 36, 36^a in the same direction.

But one of the hydraulic motors, 83, will be described, the other 83^a, being of precisely similar construction. The motor 83 comprises a shaft 88, carrying a pair of eccentrics 89, 90 spaced at 180° (i. e. in antiphase) on the shaft. Associated with the eccentric 89 is a set of six cylinders, each containing a piston 91, these cylinders being located radially in relation to the shaft 88. A similar set of six cylinders each containing a piston 92, is associated with the eccentric 90. Associated with each aligned pair of cylinders is one of six distributing valves 93, each of which is held by a spring 94 in contact with a swashplate 95 on the shaft 88. For simplicity but one pair of aligned cylinders, containing pistons 91, 92, and but one associated distributing valve 93, are shown in Fig. 3^a. The motor has a drain connection 183 for leading away liquid which may leak past the pistons 91, 92 or the distributing valves 93.

Pressure is supplied, from an inlet 37, via a normally open valve 160 to an inlet port 40 associated with the control valve 36. The valve 36 also controls outlet ports 47 connected to an exhaust outlet 46. Associated with the control valve 36 is a collapsible member 23, and during normal operation the link 187 pivots about its point of attachment to the member 23 to impart sliding movement to the control valve.

As will readily be seen, sliding movement of the control valve 36 establishes alternative pressure and exhaust connections to lines 96, 97 leading to each of the distributing valves 93. This results in sympathetic movement of the pistons 91, 92 thereby actuating the eccentrics 89, 90 to rotate the shaft 88 in a direction determined by the direction of movement of the control valve 36. Thus, if line 96 is connected to pressure, and line 97 to exhaust, the piston 92 will be caused to move in and the piston 91 to move out. As the shaft 88 rotates, the swashplate 95 imparts continuous reciprocating movement to all of the valves 93 so that the associated pistons 91, 92 will be alternately connected, at the proper times, to pressure and exhaust.

The shafts 88, 88^a of the two motors drive, through gear wheels 98, 98^a a common gear wheel 99 connected, by bevel gearing 100 to a threaded sleeve 101, engaging a pair of screw jacks 102 which are moved inwards or outwards, according to the direction of rotation of the member 101, to impart movement to the two portions of the control surface, not shown.

In screw threaded engagement with the boss of the gear wheel 99 is a follow-up rod 103 which operates, by rocking the link 84 about its pivotal attachment 104 to the input member 29, to return the control valves 36, 36^a to neutral position.

The collapsible member 23 is of the construction described in United States application Serial No. 164,653 and comprises a tube 51 mounted to slide in a housing 22, a number of balls 53 which project through holes in the tube and into holes 56 in the housing, and a plunger 52 having a

conical head 57 which is held by a compression spring 54 in position to hold the balls 53 in the position shown. Normally a catch 65 on the tube 51 coacts with a catch 77 associated with the valve 160 to hold the valve open against the action of its spring 78 as shown.

If the valve 36 should seize, the force exerted by the pilot on the input member 29 will cause the member 23 to collapse, as described in United States application Serial No. 164,653. The following sequence of events will then occur:

The catch 77 will be freed, allowing the valve 160 to be closed by the spring 78. This cuts off pressure from the control valve 36, and also from a line 105. As long as there is pressure in the line 105, a plunger 106 is held, against the action of a spring 107, to maintain contacts 108, 109 closed. When the pressure is cut off, the spring 107 causes the contacts 108, 109 to be separated, thereby lighting a warning lamp. When the valve 160 closes, its stem 110 moves into position to open a connection between the lines 96, 97, thereby allowing the hydraulic motor 83 to run freely, as it is driven through the gears 99, 98, on continued operation of the still effective motor 83^a.

On seizure of the control valve 36^a, a precisely similar action takes place. The member 23^a collapses and the valve 160^a closes, to cut off pressure from the valve 36^a, to energize the associated warning lamp, and to connect together the lines 96^a, 97^a.

Interlocking bolts 111, 111^a extend between plungers 112, 112^a, constituting extensions of the tubes 51, 51^a of the two collapsible members and their function and operation will now be described with reference to Fig. 1. Within the plungers 112, 112^a are disposed resetting plungers 58, 58^a for the collapsible members which operate as described in United States application Serial No. 164,653.

In Fig. 1, the link 86 operated by the input member is shown connected to the plungers 112, 112^a of the two collapsible members and to control valves of two hydraulic jacks or servo motors, contained in housings 25, 25^a by linkages 287, 287^a. Each of the plungers 112, 112^a may be normally prevented from moving in relation to the housing 22 by a shear pin, instead of by a resettable collapsible member of the kind shown in Fig. 3. The two locking bolts 111, 111^a are of identical construction. One only will therefore be described. The plunger 111 has, at one end, a rounded head 4 which is held by a spring 5 in engagement with a rounded groove 6 in the plunger 112 and at the other end a square head 7 which is held, by the spring 5, clear of a square groove 8^a in the plunger 112^a. The rounded heads 4, 4^a of the two bolts face in opposite directions, the head 4^a of the bolt 111^a normally engaging the rounded groove 6^a in the plunger 112^a.

When either plunger 112, 112^a moves axially, in response to an excessive load, the rounded head 4 or 4^a of the bolt engaging it is forced out of the rounded groove 6 or 6^a in the plunger, and the square end 7 or 7^a of that bolt engages the corresponding groove 8 or 8^a in the other plunger to lock the other plunger against axial movement. When either bolt is so moved into locking position, a pin 9 or 9^a, loaded by a spring 10 or 10^a, snaps into a recess 11 or 11^a in the bolt to hold it in locking position.

Thus, while both plungers 112, 112^a are initially free to collapse, collapse of either will move one

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of the locking bolts to hold the other against collapse.

This type of interlock can only conveniently be used where the two actuators are actuated fairly close together. If it is desired to place the actuators further apart, e. g. at opposite ends of an aircraft control surface, the interlock may be effected electrically, as shown in Fig. 2.

In this arrangement, each of the locking bolts is divided into two parts. As the locking bolts are of identical construction, but one will be described. Corresponding parts of the other are given the same reference numerals, plus the suffix *a*. The locking bolt comprises a part 211 having a rounded head 4 urged by the spring 5 into engagement with the square groove 8^a in the other plunger 112, and a part 311 having a square head 7 which is normally held by a spring 15 out of engagement with the square groove 8^a in the other plunger 112^a. The part 311 abuts at its upper end against a core 60, disposed in a solenoid 61 and attached to the part 311 is a rod 12 of insulating material which passes upwardly through the core 60. The core 60 and rod 12 each carry one of a pair of contacts 19 which are normally held closed by a spring 115.

When the plunger 112 is displaced axially, it forces the part 211 inwards, against its spring 5, into position to make a pair of contacts 13, the part 211 being locked in this position by entry, into a groove 14 in it, of a bolt 16 loaded by a spring 17.

Closure of the contacts 13 completes a circuit between leads 18, and normally closed contacts 19, 20 to energise the solenoid 61. This attracts the core 60 and forces the part 311 outwardly to the locking position in which its head 7 engages the groove 8^a in the plunger 112^a. A bolt 21 is then forced inwards, by a blade spring 320 supporting one of the contacts 20, to engage a groove 121 in the part 311 to hold the latter in locking position. Movement of the bolt 21 to locking position opens the contacts 20, thereby de-energising the solenoid 61. The core 60 of the solenoid will then be moved, by its spring 115, to carry its associated contact 19 away from the other contact 19 which is mounted on the rod 12 fixed to the member 311. This prevents restoration of the flow of current through the solenoid should partial contact subsequently take place at the contacts 20.

What I claim as my invention and desire to secure by Letters Patent is:

1. The combination, with a manually operable input member and an output member, of a pair of hydraulic actuators coupled to said output member, each of said actuators comprising a control device linked to the input member and movable by said input member in opposite directions to effect through the agency of the actuator movement of said output member in a direction and to an extent determined by the movement imparted to the input member, a collapsible member linked to the input member and arranged to collapse, on seizure of the control device, as the result of abnormal manual effort applied to the input member, means responsive to collapse of said collapsible member for rendering the actuator ineffective to prevent continued actuation of the output member by the other actuator under control of the input member, and means operative on collapse of the collapsible member associated with either actuator to lock against collapse the collapsible member associated with the other actuator.

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2. The combination, with a manually operable input member and an output member, of a pair of hydraulic actuators coupled to said output member, each of said actuators comprising a control valve linked to the input member and movable thereby to effect alternative pressure and exhaust connections to said actuator and thereby to effect movement of said output member in a direction and to an extent determined by the movement imparted to the input member, a collapsible member linked to the input member and arranged to collapse, on seizure of the control valve, as the result of abnormal manual effort applied to the input member, means responsive to collapse of said collapsible member for rendering the actuator ineffective to prevent continued actuation of the output member by the other actuator under control of the input member, and means operative on collapse of the collapsible member associated with either actuator to lock against collapse the collapsible member associated with the other actuator.

3. The combination, with a manually operable input member and an output member, of a pair of hydraulic actuators directly coupled to said output member, each of said actuators comprising a control valve linked to the input member and movable thereby to effect alternative pressure and exhaust connections to said actuator and thereby to effect movement of said output member in a direction and to an extent determined by the movement imparted to the input member, a collapsible member linked to the input member and arranged to collapse, on seizure of the control valve, as the result of abnormal manual effort applied to the input member, a conduit for allowing of free circulation of liquid within the actuator, a valve normally closing said conduit, means responsive to collapse of said collapsible member for effecting automatic opening of said valve, and means operative on collapse of the collapsible member associated with either actuator to lock against collapse the collapsible member associated with the other actuator.

4. A combination as claimed in claim 1, comprising a housing having parallel bores, a member mounted to slide in each bore, said members being coupled respectively to the collapsible members of the two actuators and each of said sliding members being normally restrained by its associated collapsible member against movement in its bore but being arranged to slide in said bore on collapse of said collapsible member, a pair of locking bolts mounted to slide in bores in said housing extending transversely to the bores containing said slidable members, and a spring acting on each locking bolt, each of said locking bolts having a head normally held by its associated spring in engagement with a correspondingly shaped groove in one of said slidable members and being adapted to be displaced against its spring, by sliding movement of said member in relation to the housing, into position to lock the other slidable member positively against sliding movement in relation to the housing.

5. A combination as claimed in claim 1, comprising a housing having parallel bores, a member mounted to slide in each bore, said members being coupled respectively to the collapsible members of the two actuators and each of said sliding members being normally restrained by its associated collapsible member against movement in its bore but being arranged to slide in said

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bore on collapse of said collapsible member, a pair of locking bolts mounted to slide in bores in said housing extending transversely to the bores containing said slidable members, and a spring acting on each locking bolt, each of said locking bolts having a head normally held by its associated spring in engagement with a correspondingly shaped groove in one of said slidable members, having a square head at its other end and being adapted to be displaced against its spring, by sliding movement of said grooved slidable member, to engage its square head with a square groove in the other slidable member and so lock said other slidable member positively against movement in relation to said housing.

6. A combination as claimed in claim 1, comprising a housing having parallel bores, a member mounted to slide in each bore, said members being coupled respectively to the collapsible members of the two actuators and each of said sliding members being normally restrained by its associated collapsible member against movement in its bore but being arranged to slide in said bore on collapse of said collapsible member, a pair of locking bolts mounted to slide in bores in said housing extending transversely to the bores containing said slidable members, a spring acting on each locking bolt, each of said locking bolts having a head normally held by its associated spring in engagement with a correspondingly shaped groove in one of said slidable members and being adapted to be displaced against its spring, by sliding movement of said member in relation to the housing, into position to lock the other slidable member positively against sliding movement in relation to the housing, and a pair of spring loaded latches for respectively latching said bolts against movement from their displaced positions.

7. A combination as claimed in claim 1, comprising, in association with each collapsible member, a displaceable bolt engaging a groove in said member, a locking bolt, a spring normally holding said locking bolt out of engagement with another groove in said collapsible member, normally in-

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effective electromagnetic means for moving said locking bolt to locking position, and a switch associated with the displaceable bolt, said switch being actuated on displacement of said displaceable bolt as a result of collapse of its associated collapsible member, to complete a circuit to energize the electromagnetic device associated with the other collapsible member and thereby cause movement into locking position of the locking bolt associated with said other collapsible member.

8. A combination as claimed in claim 1, comprising, in association with each collapsible member, a displaceable bolt engaging a groove in said member, a locking bolt, a spring normally holding said locking bolt out of engagement with another groove in said collapsible member, normally ineffective electromagnetic means for moving said locking bolt to locking position, and a switch associated with the displaceable bolt, said switch being actuated on displacement of said displaceable bolt as a result of collapse of its associated collapsible member, to complete a circuit to energize the electromagnetic device associated with the other collapsible member and thereby cause movement into locking position of the locking bolt associated with said other collapsible member, and further comprising a pair of spring loaded latches for respectively latching said locking bolts against movement from their locking positions.

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