

Nov. 28, 1961

T. GEFFNER

3,010,752

EJECTION BOLT MECHANISM

Filed Nov. 29, 1957

6 Sheets-Sheet 1

FIG. 1

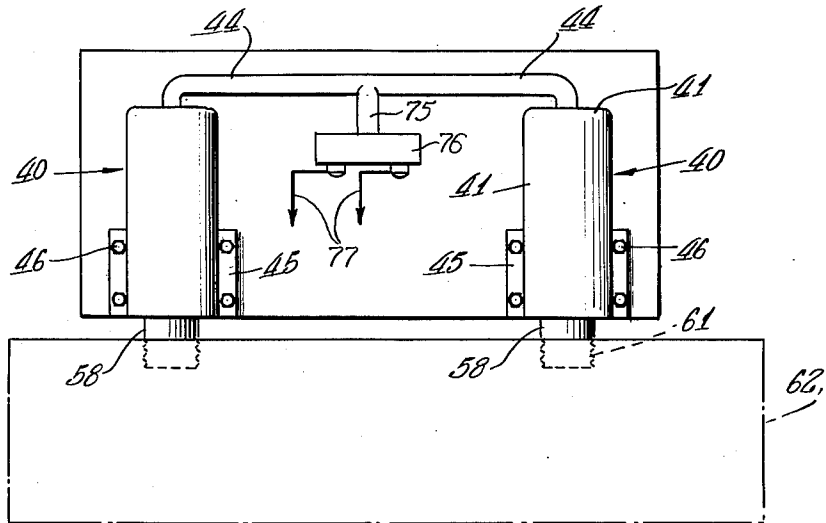


FIG. 2

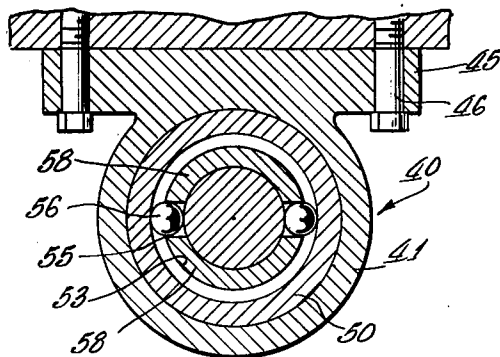
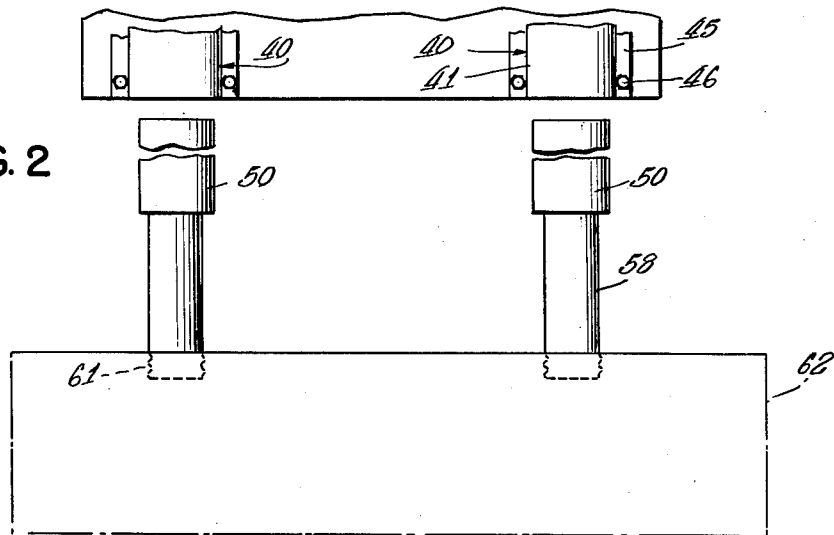


FIG. 6

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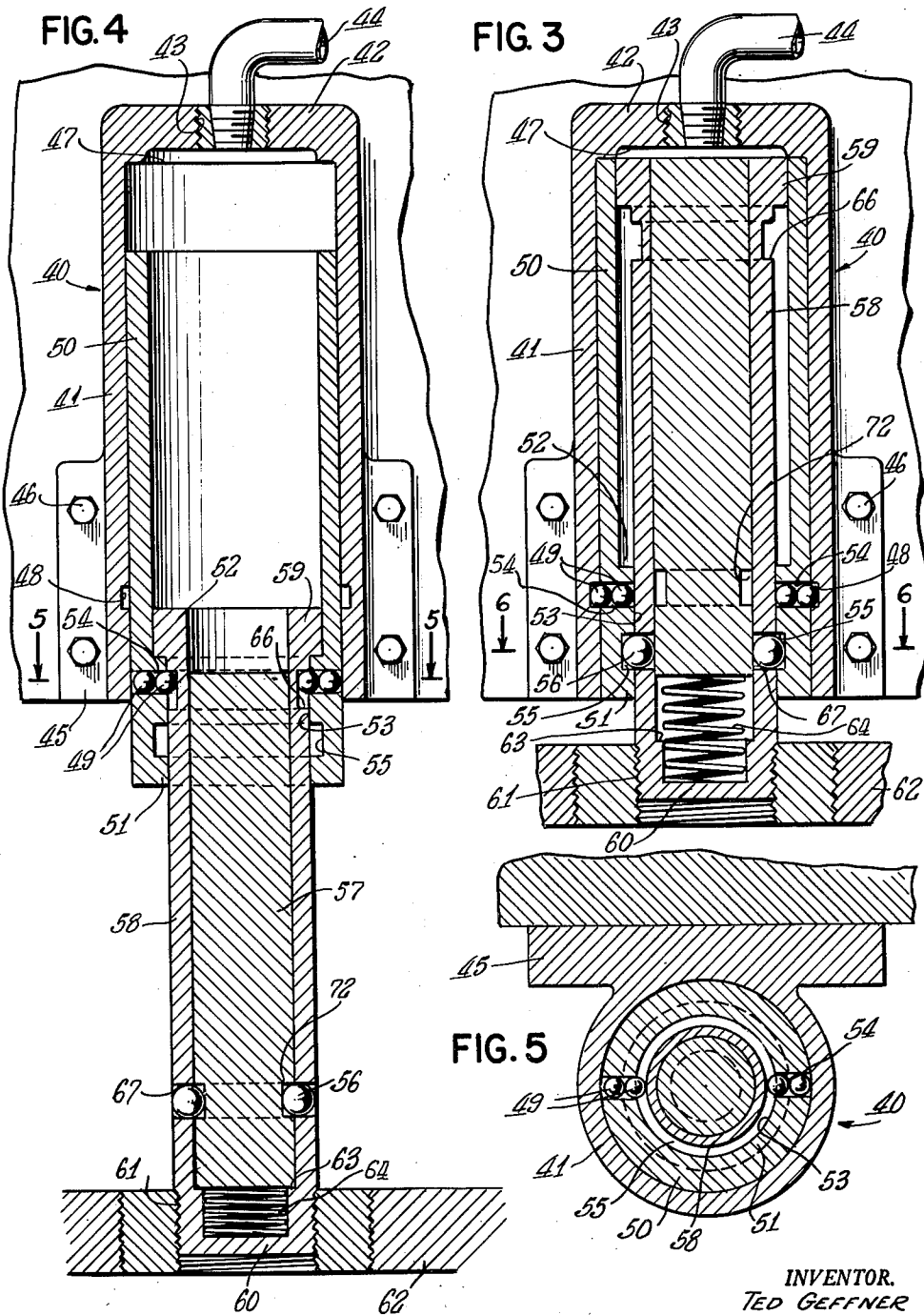
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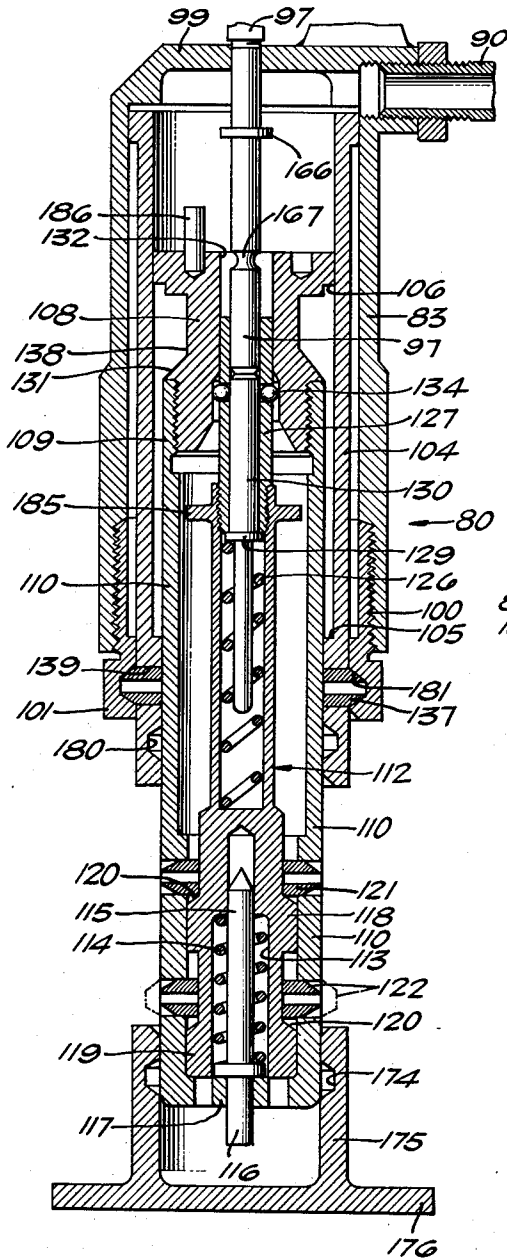


FIG. 14.

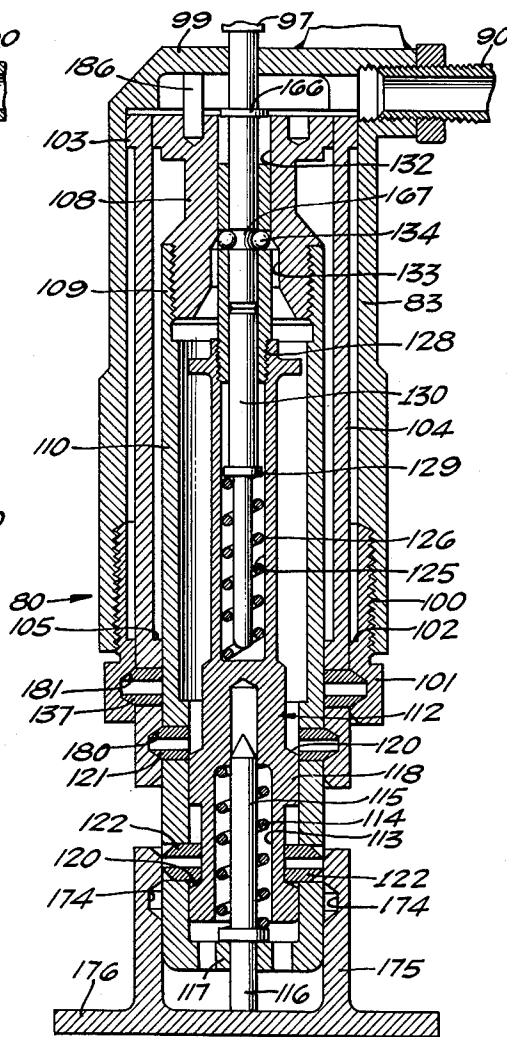


FIG. 15.

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FIG. 7.

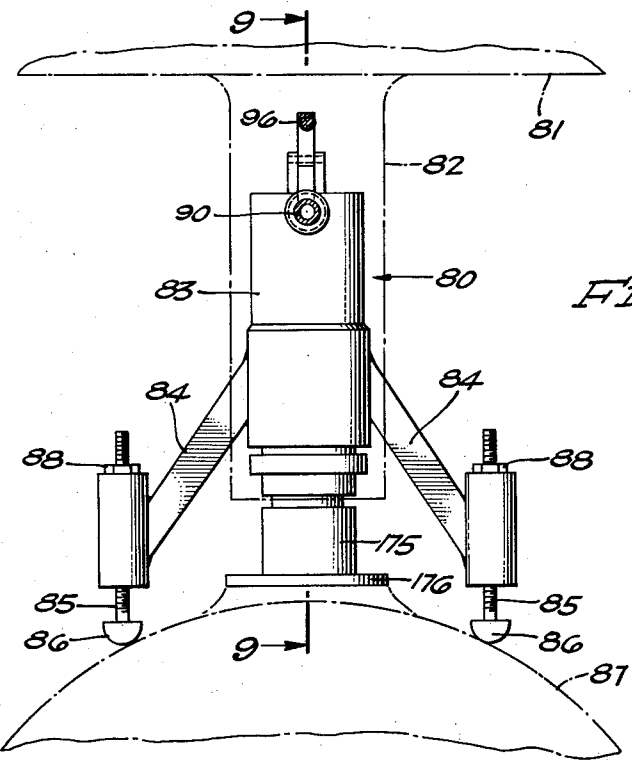
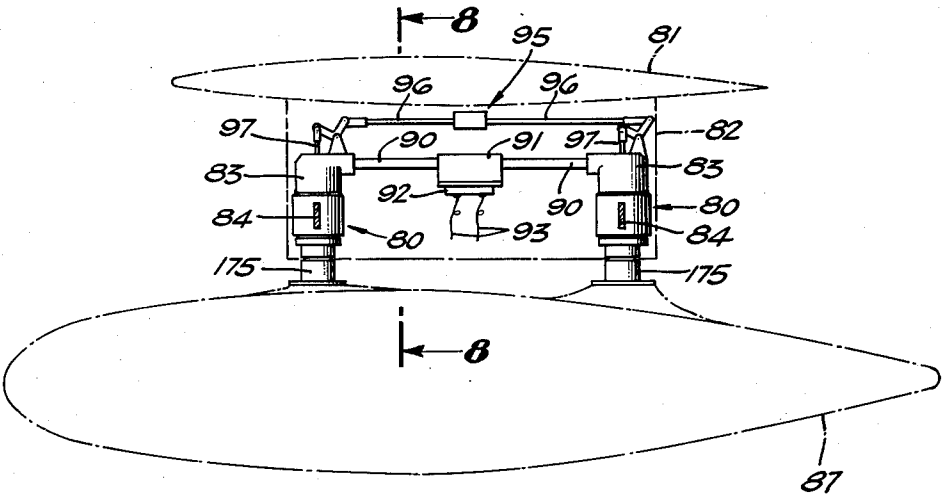


FIG. 8.

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EJECTION BOLT MECHANISM

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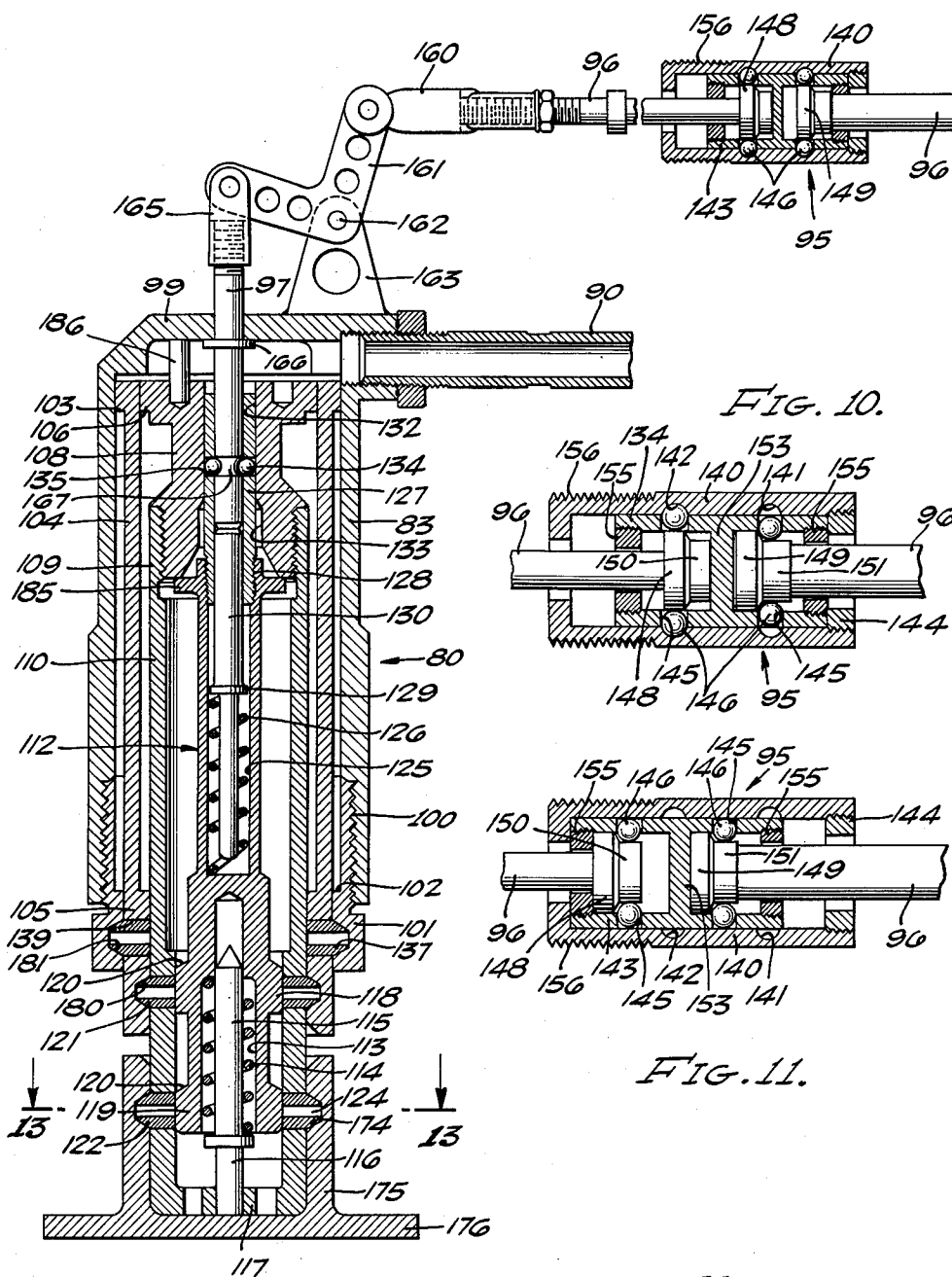


FIG. 9.

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3,010,752

EJECTION BOLT MECHANISM

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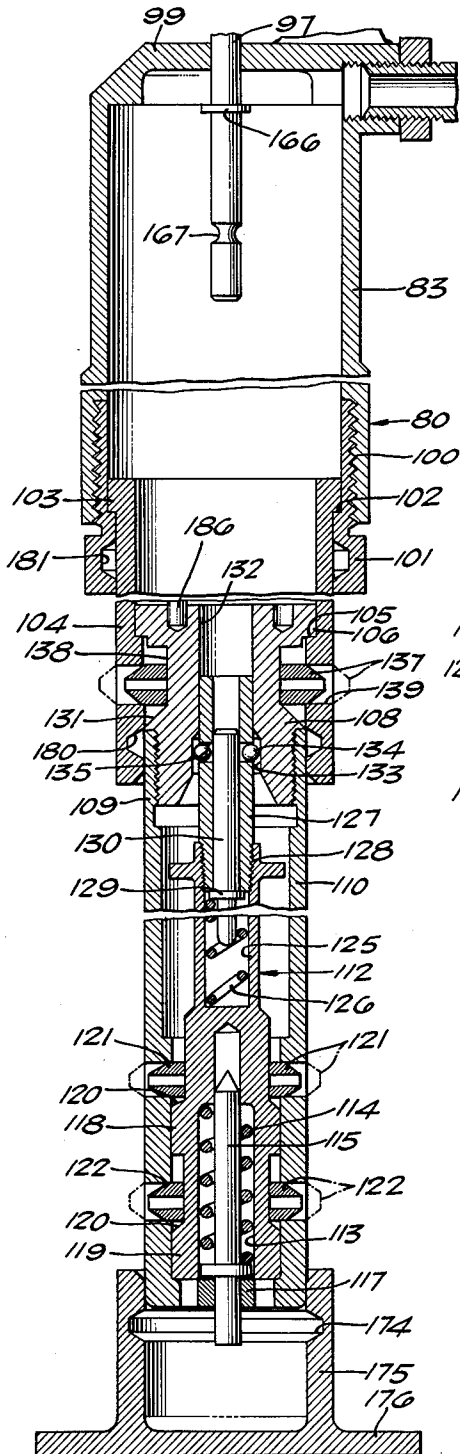


FIG. 12.

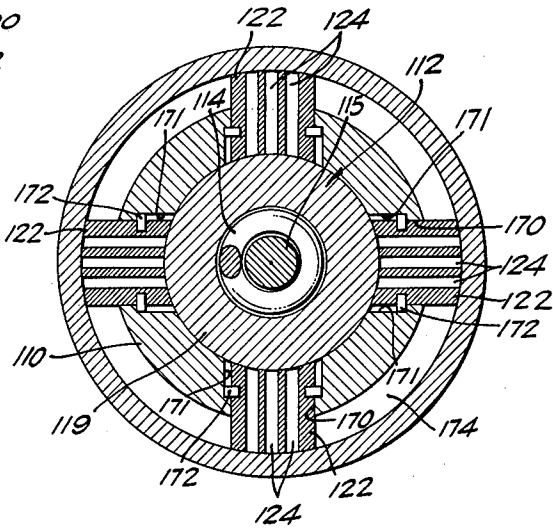


FIG. 13.

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3,010,752
EJECTION BOLT MECHANISM
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Filed Nov. 29, 1957, Ser. No. 699,864
3 Claims. (Cl. 294-83)

This invention relates to explosive bolts and more particularly to a special and improved ejection bolt designed to perform multiple functions substantially simultaneously, including the release of a load supported thereby and the ejection of that load away from its place of support with marked speed and force.

The present application is a continuation-in-part of my co-pending application for United States Letters Patent Serial No. 629,025, filed December 18, 1956, entitled, Ejection Bolts, now abandoned.

Among the numerous applications for a bolt of the type referred to are those involving the release of components or loads from airborne craft, as for example, aircraft, wherein it is of importance not only to detach the load while in high speed flight, but to eject instantly such released load at maximum speed to avoid serious damage to the craft and hazard to the crew. The use of fast-burning gas generating materials such as explosives to effect the rapid release of loads carried by aircraft has been proposed heretofore, but devices designed to utilize energy generated by these materials have met with indifferent success. There have been many reasons for this which may or may not be understood accurately. In some of the devices as heretofore proposed, certain of the essential components of the mechanism are expended as an incident to each firing and must be replaced before the mechanism can be reused. Others, if not all, of the mechanisms are characterizable as unduly complex and as requiring attention by highly skilled technicians to avoid malfunctioning and misfunctioning. Furthermore, they incorporate insufficient provision for checking the operability of components after assembly. Another and serious shortcoming of prior designs of the type here dealt with is inadequate provision for ejecting heavy loads with sufficient force or over a period of sufficient duration to assure clearance of the craft from which ejected.

The present invention provides ejection bolt mechanism designed to obviate the foregoing and other serious deficiencies of prior structures by providing a greatly improved device characterized by its compactness, ruggedness, reliability in operation and so designed that its components need not be expended with each firing but instead are retained and are reusable repeatedly. In preferred embodiments the bolt mechanism per se is formed of multiple telescoping parts which nest together compactly and have provision for locking them so nested along with the load to be jettisoned until intentionally and deliberately released by the detonation of the explosive material.

A particularly important aspect of the invention resides in the utilization of the bolts in parallel and in such manner that detonation of the ejecting charge is effective to eject the opposite ends of a single load at the same precise instant while imparting the same impetus to all parts of the load so jettisoned. The significance of such an arrangement will be appreciated when the load being carried by bolts in parallel is a military bomb or other missile which it is desired to eject in an accurately predetermined attitude. The slightest mismatch or non-synchronized action of the parallel-arranged ejector bolts would provide completely unpredictable results, a circumstance which is intolerable in the release of missiles

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from aircraft. Previous attempts have been made to obtain synchronized action of two or more ejectors but the results obtained have been so completely erratic that the devices are unuseable against targets for all practical purposes. The present invention provides means for coupling a plurality of ejector bolts together for synchronized firing with unerring accuracy, this result being assured by an innerlock mechanism providing a positive lock against the extension of any bolt until all are in complete readiness for extension in unison.

Another feature of the invention is the provision of a store ejecting assembly in which all parts of the bolt assembly are retained captive with the supporting craft following a firing operation and are reusable repeatedly. Of particular importance also is the fact that the construction is such that the bolt can be relocked to a load and in its retracted position automatically merely by pressing the load against the extended end of the bolt until the components are fully retracted at which position all locking detents seat. All that remains to be done is to reload the firing chamber with an explosive charge and to reset the firing mechanism.

Accordingly, it is a primary object of the present invention to provide an improved ejection bolt having capabilities and advantages not known heretofore.

Another object of the invention is the provision of an ejection bolt assembly for the transport of stores by aircraft or the like together with means for assuring the release and ejection of the store simultaneously from a plurality of the bolts arranged in parallel.

Another object of the invention is the provision of an ejection bolt having a plurality of telescoping stages arranged to be fully retracted in store carrying position and adapted upon being fired to be extended as a store is released therefrom.

Another object of the invention is the provision of a store ejector in which the store carrying and releasing function is performed by the same unit as the store ejecting function thereby providing for the merging of the separate structures heretofore required; all being done in the interest of economy of space, structural and operational simplicity and greater efficiency.

Another object of the invention is the provision of a synchronizer mechanism having operational connections with two or more ejection bolts and responsive to the energization of such bolts to hold all bolts positively locked against extension until each is in full readiness, and thereupon automatically releasing all simultaneously.

Another object of the invention is the provision of a linkage interconnecting a plurality of explosively actuated ejection bolts and featuring a common release for all which is dependent for its operation upon a pre-conditioning for assuring that each is in complete readiness for operation.

Another object of the invention is the design of an ejection bolt utilizing multiple telescopically arranged stages, together with multiple locking detents arranged for operation in predetermined sequence.

Another object of the invention is the provision of a multiple stage ejection bolt featuring separate locking detents for holding each stage locked in a collapsed position together with means for preventing the locking of the bolt in its retracted condition under load until and unless all locking detents are in their proper locking position.

Another object of the invention is the provision of a store carrying facility particularly suited for use on airborne craft carrying stores which it is desired to release instantly accompanied by an ejection force, and utilizing a plurality of couplings with the store and in-

stantly operable to detach the store from the craft simultaneously upon being activated as by the detonation of an explosive charge.

Another object of the invention is the provision of a combined store release and ejection mechanism for use on airborne craft utilizing two or more couplings in parallel between the store and the mechanism and which are locked closed automatically as incident to the movement of the store fully into its carrying position on the craft.

These and other more specific objects will appear upon reading the following specification and claims and upon considering in connection therewith the attached drawings to which they relate.

Referring now to the drawings in which preferred embodiments of the invention are illustrated:

FIGURE 1 is a side elevational view of a pair of synchronized ejection bolts employed in parallel to support a common load;

FIGURE 2 is a fragmentary view similar to FIGURE 1 but showing the load being ejected from the main support;

FIGURE 3 is a longitudinal sectional view through one of the ejection bolts shown in FIGURE 1 with all parts locked in retracted position;

FIGURE 4 is a longitudinal sectional view through one of the bolts with the parts partially extended;

FIGURE 5 is a transverse sectional view on line 5—5 of FIGURE 4;

FIGURE 6 is a similar transverse sectional view along line 6—6 on FIGURE 3;

FIGURE 7 is a side elevational view of a second embodiment of the invention showing in phantom line the disposition thereof in a pylon of an aircraft wing and supporting at its lower end an aerodynamically contoured store such as a missile;

FIGURE 8 is a transverse sectional view taken on line 8—8 of FIGURE 7;

FIGURE 9 is a longitudinal sectional view through one of the ejection bolts and a portion of the synchronizer mechanism taken along line 9—9 on FIGURE 8;

FIGURE 10 is a longitudinal sectional view of the synchronizer device per se as one of the detents becomes unlocked;

FIGURE 11 is a view similar to FIGURE 10 but showing the position of parts after both synchronizer detents have been released and the device has moved to a position releasing both ejector bolts;

FIGURE 12 is a longitudinal sectional view through one of the bolts in fully extended position and with the store coupling only partially telescoped over the end of the ejector;

FIGURE 13 is a transverse sectional view on line 13—13 of FIGURE 9 showing details of the locking detents;

FIGURE 14 is a longitudinal sectional view through one of the bolts in the process of being retracted for re-use; and

FIGURE 15 is a view similar to FIGURE 14 but showing the store being shifted into locking carrying position as one of the final steps in the rearming of the bolts.

Referring first to FIGURES 1 and 2, there is shown a load-carrying and ejection assembly comprising a pair of ejection bolts designated generally 40 each having an outer tubular housing 41 provided at its lower end with mounting flanges 45 adapted to be rigidly secured by cap screws 46 to any suitable supporting structure such as the fuselage of an aircraft. The upper end of housing 41 is closed by an end wall 42 threadedly seating therein a bushing 43 (FIGURES 3 and 4) to facilitate the connection of a high pressure conduit 44 forming part of the synchronizer mechanism.

Slidably and freely telescoped through the lower end of casing 41 are one or more tubular members as, for

example, telescoping tubular members 50 and 58, outer tube 50 being freely slidable along the interior surface of housing 41. As is made clear by FIGURE 4, the opposite ends of members 50 and 58 are provided with oppositely directed radial flanges 51, 52 which provide limiting stops during the extension of the members axially of one another for a purpose which will be explained in greater detail below. Slidably supported within inner tube 58 is a detent control plunger 57 normally urged upwardly into locking position by a compression spring 64, this spring being designed to support plunger 57 in its locking position illustrated in FIGURE 3 with its upper end substantially even with the inner end 52 of member 58.

The lower end of inner tubular member 58 is closed by an end wall 60 and is provided about its circumference with threads 61 which may be threaded directly into the threaded opening of a load structure 62 or, if the opening thereof is larger than the end of member 58, a bushing ring 65 may be employed. It will be understood that the ejection bolts are identical or similar to one another and that the lower end of each is intended to be rigidly connected to store 65 such as in the manner illustrated in FIGURES 3 or 4.

Provision is made for releasably locking the various parts in the retracted position shown in FIGURE 3 such as by cooperating grooves, recesses and ball detents in the manner now to be described. The locking mechanism includes an annular groove 48 opening into the inner side wall of casing member 41 at a point spaced inwardly of its outer end. The adjacent end of tube 50 is provided with a plurality of radial bores 54 of a diameter corresponding generally with the width of groove 48, the length of bores 54 being greater than the diameter of the bore but appreciably less than twice the diameter and providing a retaining channel for a pair of metal ball detents 49. Cooperating with bores 54 is an annular groove 66 opening outwardly through the exterior wall of member 58 at a point spaced from its inner end. Groove 66 has a width approximately double the diameter of bores 54 and a depth slightly less than this diameter. As is made clear by FIGURE 4, the depth of groove 66 taken with the radial length of bores 54 is slightly greater than double the diameter of balls 49 for the purpose of conveniently accommodating a pair of these balls when groove 66 is opposite the inner ends of the bores. The described relationship of bores 54 and groove 66 is equally true of groove 48 when the bores are aligned with this groove as they are in the retracted and locked position of the ejection bolts.

The means for locking the inner tubular member 58 fully retracted within housing 41 comprises an inwardly opening annular groove 55 formed at the lower end of member 50. This groove is adapted to be aligned with radial bores 67 through the side wall of inner tubular member 58 when the latter is fully retracted as it is in FIGURE 3. Groove 55 has a width corresponding to the diameter of bores 67 and a depth somewhat less than one-half the diameter of these bores in order that less than one-half of the balls 56 is seated in this groove in the locked position of the bolt. Locking plunger 57 is slidable along the bore of the tube 58 and is provided with an annular recess 72 near its outer end having a width equal to the diameter of bore 67 and a depth appreciably less than this diameter. As is clearly shown in FIGURE 4, the length of bore 67 taken with the depth of groove 72 is equal to or slightly less than the diameter of locking balls 56. Accordingly, when groove 72 is aligned with these balls member 58 is freely slidable into member 50 until bores 67 are aligned with groove 55. Under these conditions, spring 64 is effective to move plunger 57 upwardly as the locking balls 56 roll outwardly into groove 55. Continued upward movement of the plunger moves flange 52 out of alignment with the bores and positively locks the balls into position so that part thereof lies in groove 55 and part in bores 67. In this position,

it is impossible to extend tubes 50 and 58 axially of one another. It is pointed out that the outer ends of bores 67 and peened inwardly to the slight extent required to prevent escape of balls 56 during retraction of the tubular members.

The retraction of the bolts in their fully collapsed position will be readily understood from the foregoing detailed description of bolt structure. The first step is to screw inner member 58 into bushing 65 of store 62, care first being taken that the outer tubular member 50 is telescoped upwardly over the lower end of tube 58. It will be understood that locking plunger 57 and spring 64 are assembled within inner member 58. After both bolts of the pair shown in the FIGURES 1 and 2 have been assembled to the store, tube 50 is telescoped inwardly and locked in place by inserting balls 49 in bores 54 while these bores are aligned with grooves 66, the escape of the balls being safeguarded by and peening over the outer rim edges of bores 54. The described assembly may now be retracted through the open end of outer casings 41, 41 of the two bolts. As bores 54 come into alignment with groove 48, balls 49 are forced to roll outwardly until they seat in this groove by reason of the engagement therewith of the edge of groove 66. As tube 58 is retracted further, groove 66 moves inwardly beyond bores 54 thereby locking balls 49 captive in the position shown in FIGURE 3 and positively lock tube 50 retracted within casing 41. Continued movement of the store toward casing 41 brings bores 67 into alignment with groove 55 allowing balls 56 to seat in groove 48 and spring 64 to shift plunger 57 upwardly to the position shown in FIGURE 3 thereby positively locking the store to casing 41 and all parts of the bolt immovable axially of one another.

The synchronizing mechanism for unlocking both bolts simultaneously and ejecting the tubular assemblies of each in unison comprises a tube 44 having its opposite ends connected to the closed upper ends of the bolt casings in the manner shown in FIGURES 3 and 4. Opening upwardly into the mid-point of conduit 44 at a point midway between the two bolts is an explosive charge chamber 75. The lower end of this chamber is closed by a removable end cap 76 which includes suitable means, such as electrical terminals 77, 77, for detonating a cartridge of explosive material installed in chamber 75 before each ejection operation. Terminals 77 may be connected in known manner to a firing mechanism either of the manual or automatically energized type for detonating the charge. Detonation of the charge acts instantly to generate large volumes of high pressure products of combustion which are conducted to each of the bolts simultaneously through the similar conduits 44.

Initially, the gas pressure is effective only on locking plunger 57 since tubes 58 and 50 are locked to one another and to casing 41. Depression of plunger 57 under the gas pressure brings grooves 72 opposite the inner ends of bores 67 allowing balls 56 to roll toward one another and to seat in groove 72. The very high gas pressure now obtaining within the bolt is effective against the inner end of tube 58 to move the same outwardly rapidly and with great power. As groove 66 of this tube comes opposite bores 54, locking balls 49 are shifted toward one another allowing outer tube 50 to be ejected along with tube 58 and bolt 62. By this time the gas pressure within the bolt chamber has increased to a very high value wherein it is effective to eject the store along with extended tubes 58 and 50 with great force and speed. Owing to the equalizing action of tube 44, the pressure interiorly of both bolts remains equal and uniformly effective on both bolts with the result that both ends of store 62 are ejected simultaneously and in a desired attitude conveniently determined by the attitude of the aircraft.

After return of the aircraft to a base, the ejection bolts

may be reconditioned and reassembled using duplicate plunger tubes and locking balls, the parts being reassembled in the same manner described above. A new charge is also placed in charge chamber 75 and the firing assembly is reconditioned for re-use in well known manner.

Another embodiment of the invention illustrated in FIGURES 7 to 15 comprises a pair of identical store supporting and ejector assemblies designated generally 80 rigidly secured to the framework of an aircraft. For example, the support may be rigid with and depending from the underside of a plane wing 81 and adapted to be enclosed within a streamlined pylon 82, one of the assemblies 80 being located near the opposite edges of the wing, it being understood that this arrangement is by way of example only. The axes of the two bolts are parallel to one another as in the first described embodiment.

The outer cylindrical casing 83 of the bolts is preferably provided with a pair of downwardly diverging struts 84 fitted with threaded bores each supporting a threaded strut 85 having a rounded head 86 which may be covered with resilient material and is adapted to rest against the surface of a store such as that of an aerodynamically contoured jettisonable fuel tank, fire bomb, missile, demolition bomb or the like 87 to be ejected from the aircraft. The struts are locked in adjusted position as by lock nuts 88.

Interconnecting the upper ends of casings 83 is a high pressure gas conduit 90 communicating at a point midway between the bolts 80, 80 with a chamber 91 for the cartridge of explosive material chargeable into the chamber through a removable cover 92 fitted with a detonator such as the electric wires 93. Cover 92 may be tightly secured in place in any suitable manner such as by threads, bolts or the like. In addition to a common gas distributing conduit 90 generally effective in synchronizing the operation of the ejector assemblies, the second embodiment is provided with a supplemental and positive type synchronizer mechanism designated generally 95. This mechanism includes linkage connections 96 extending to an actuating plunger 97 projecting through the upper end of tubular casings 83 of the bolts and will be described more fully presently.

As will be recognized, ejection bolts 80 are shown in several different operating positions in FIGURES 9, 12, 14 and 15. Referring first to FIGURE 9, it will be seen that outer cylindrical casing 83 has a closed end 99 and an internally threaded outer end 100 fitted with a bushing 101 formed with an inwardly projecting flange 102 forming a stop shoulder for a complementary outwardly-projecting flange 103 on the inner end of an outer telescoping sleeve 104. The lower end of sleeve 104 is provided with an inwardly projecting flange and shoulder 105 which acts as a stop for an outwardly projecting flange 106 of a bushing 108 threaded into the upper end 109 of the inner tubular member 110. Slidably supported axially of inner tube 110 is a detent control plunger 112 having an axial bore 113 at its lower end housing a compression spring 114. This spring encircles the shank 115 of a plunger 116 having its lower end slidable axially of a central bore through end wall 117 of tube 110.

Plunger 112 has a pair of lands 118, 119 spaced axially of the plunger and provided at one edge with inclined shoulders 120 which act to cam the locking detents 121 and 122 outwardly into locking position during the final cocking phase of locking a store to the bolts as will be described presently. It will be understood that each bolt is provided with a plurality of locking detents such as 121, 122 arranged circumferentially of the several tubular members. Preferably these detents are of rectangular form in cross-section and are provided with one or more longitudinal passages 125 acting to vent gaseous fluids used to operate the bolt, such purging taking place primarily after the bolts have been fully extended in ejecting a store from the carrying craft.

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Referring to FIGURE 12, it will be seen that the upper end of locking plunger 112 has an axial recess 125 housing a compression spring 126, this spring being retained assembled in well 125 by a pilot tube 127 threadedly seated in the end thereof in the manner indicated at 128. The upper end of spring 126 bears against shoulder 129 of a plunger 130 loosely supported in tube 127 having its outer end loosely supported in axial bore 132 of bushing 108. The lower end of bore 132 merges with a camming shoulder forming the bottom of a well 133, the latter serving to receive and retain ball detents 134 mounted in radial bores 135 of tube 127. It is pointed out that when tube 127 of plunger assembly 112 is depressed until bores 135 are opposite the side wall of well 133, the locking ball detents 134 may move outwardly allowing the end of plunger 130 to be pressed past the balls by spring 126 until flange 129 thereon abuts the lower end of tube 127. When the parts are so positioned, it is impossible for plunger 112 to move upwardly a substantial distance and the lower end of the plunger is held seated against the lower end 117 of inner tube 104. In this position locking detents 121 and 122 at the lower end of tube 104 may be fully retracted against the reduced diameter sections of the plunger with their beveled outer ends lying inside the surface of tube 104 in the manner clearly shown in FIGURE 12. Likewise, the similar locking detents 137 slidably mounted in bores 139 at the lower end of tube 104 may lie retracted against the bottom of annular groove 138 in bushing 108. During the retraction of the tubular assembly the cammed lower side wall of groove 138 does not act to extend detents 137 because the upper cammed surface of the detent ends is engaged by the inner edge of bores 139 in a manner urging the detents inwardly.

Referring now to FIGURES 9 to 11, the structural features of synchronizer mechanism 95 will be described. This mechanism comprises a cylindrical outer housing 140 provided with two annular grooves 141, 142 offset to one side of the longitudinal center of the cylinder and opening inwardly thereinto. Slidably supported within the cylinder is a piston 143 held assembled therein as by a threaded ring 144. Piston 143 is provided with pairs of radial bores freely seating ball detents 146. As is clearly shown in FIGURES 9 to 11, the diameter of bores 145 is considerably greater than the thickness of piston wall 143, the thickness of this wall taken with the depth of grooves 141 being substantially the diameter of the balls.

The means for selectively locking and unlocking ball detents 146 with respect to grooves 141, 142 comprises independent linkage rods 96 on the inner end of each of which are fixed flanged heads 148, 149 associated with lands 150, 151 respectively. Piston 143 is provided with a transverse dividing partition 153 midway between bores 145 and serving as a stop limiting movement of rods 96. The flanged heads on the adjacent ends of linkage rods 96 are held assembled within the opposite ends of piston 143 by threaded rings 155, the adjustment of the latter being such as to provide limited, relative movement of a predetermined amount axially of piston 143. More specifically, the relative axial movement of the heads within the opposite ends of piston 143 is just sufficient to permit movement of detent balls 146 into and out of locking position with respect to grooves 141, 142. Of importance also is the fact that ring 144 in outer casing 140 is so adjusted that bores 145 of piston 143 are in exact alignment with their respective grooves 141, 142 when the piston is shifted fully to the right hand end of casing 140 as viewed in FIGURE 10. In this position, the ball detents are seated in their respective grooves by appropriate movement of linkage rods 96 to the right.

Outer casing 140 is provided with threads 156 or with a bracket by which it may be rigidly secured to a stationary part of the craft on which the bolts are mounted. Threads 156 permit shifting of housing 140 if necessary

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for the proper adjustment of the parts. The fully locked position of the synchronizer is shown in FIGURE 9; the fully unlocked position is shown in FIGURE 11; and FIGURE 10 shows one pair of balls in locked position and the other pair in readiness for movement into locked position.

The means by which synchronizer 95 is effective to hold both bolts rigidly and positively locked irrespective of vibrations, shocks or any other conditions except the generation of a sufficiently high fluid pressure within both bolts will now be described. Stated differently, it will be understood that with the synchronizer parts positioned as shown in FIGURE 9 there is provided positive assurance against the unlocking of any component of either bolt or of the synchronizer as well as any possibility of the load becoming detached from the bolt until and unless a predetermined fluid pressure exists internally of both bolts. The only provision made for unlocking the assembly is the detonation of an explosive charge within explosive chamber 91 although it will be recognized that the release thereof of high pressure would also be effective and is a suitable mode of activating the bolt assemblies.

The remote ends of rods 96, 96 are threaded into knuckles 160 having a pivotal connection with one end of a bell crank 161 pivotally supported by pin 162 on a bracket 163 at the upper end of the ejector bolts. The other end of the bell cranks are pivotally connected to a clevis 165 having an adjustable threaded connection with the outer ends of plungers 97 extending downwardly through a close fitting opening axially of end walls 99. A flange 166 acts as a stop limiting outward movement of plungers 97 thereby assuring that locking groove 167 is properly positioned to receive locking ball detents 134 carried in aligned radial bores 135 through the side walls of pilot tube 127. The several sections of the bolt cannot be locked in their fully retracted position, the load cannot be locked to the bolt, plunger 97 cannot be locked to tube 127 and the synchronizer linkage rods 96, 96 cannot be locked immovably with respect to the stationary synchronizer casing 140 unless and until all detents are in locked position. It will be further understood that the shifting of each of these components into locked position occurs sequentially and in a predetermined order as will be explained in detail below in connection with the mode of operation.

As will be recognized from a consideration of FIGURE 9, the unlocking of the two ejector mechanisms 80, 80 can be programmed to occur simultaneously or, if desired, in some predetermined timed sequence depending on the adjustment of plungers 97 relative to their associated clevis 165. For example, if plungers 97 are identically adjusted, the two ejector mechanisms will extend simultaneously. Likewise, non-simultaneous ejection is readily achieved by rotating one of plungers 97 relative to clevis 165 thereby changing the movement of the associated linkage 96 required to release the locking detents of the ejector stages. In this manner either end of the store may be ejected momentarily before the other end thereby facilitating the discharge of the store along a desired trajectory and in a predetermined aspect relative to the path of traveling of the transport vehicle.

Before proceeding with the mode of operation it is desired to make reference to certain structural features not previously described. Referring to FIGURE 13, for example, a preferred construction of relocking detents is seen to comprise elongated metal members 122 of generally rectangular configuration and provided with one or more vent ports 124. These detents are freely slidable in rectangular bores 170 of the tubular members and have curved opposite inner ends conforming with the radial distance thereof from the center of the bolt. The opposite side walls of each of retaining bores 170 is preferably provided with notches 171 to receive the outer ends of retaining pins 172 which act to prevent the accidental loss of the detents following extension of the

tubular members during firing of the explosive charge. When the detents 122 are held in their extended locked position as they are by land 119 of locking plunger 112, their beveled outer ends seat in a retaining groove 174 opening inwardly through the inner wall of a cup-shaped coupling or socket 175 having flanges 176 at its bottom for rigid attachment to a missile or other store 87. It will therefore be understood that so long as land 119 of locking plunger 112 is positioned as shown in FIGURES 9 and 13, it is impossible for store 87 to be released from the ejection bolt, such release being possible only after land 119 has moved downwardly beyond the lower corner of detents 122.

Likewise, similarly constructed detents 121 are slidably located in bores spaced above the lower end of tube 110 and are adapted to have locking engagement in annular groove 180 formed in the inner wall of the lower end of tube 104. Similar locking detents 137 are also slidably supported in radial ports at the lower end of tube 104 and seat in annular groove 181 formed in the interior side wall of bushing 101 in the retracted position of the described components.

Mention should also be made of stops not previously referred to, one being a stop flange 185 projecting from the upper end of locking plunger 112 so positioned as to abut the lower end of bushing 108 and functioning to lift member 110 to its fully retracted position during the assembly of the bolt or the reassembly thereof following a firing operation. Provision for limiting upward movement of tube 110 is provided by one or more stop pins 186 having their lower ends firmly seated in the upper end face of bushing 134. It is pointed out that stop pins 186 move with the bushing and with tube 110 during the extension of the bolt and that the outer end of pin 186 is properly positioned to abut end wall 99 of the bolt casing as the parts reach their fully retracted position during a resetting operation.

Operation

The operation of the device will be described referring first to FIGURE 9 showing the bolt fully retracted and a store coupling 175 locked to its outer end by detents 122. Although only one of the bolts is shown in FIGURE 9, it will be understood that a second bolt 80 is similarly fully assembled and that the synchronizing mechanism 95 and linkage rods 96 are locked against movement by the seating of detent balls 146 in grooves 141, 142. It will be further understood that an explosive cartridge is properly assembled within charge housing 91 and that the firing leads 93 are connected to an open source of electrical energy for detonating the charge. As is apparent from FIGURE 9, synchronizer linkage rods 96, bell crank 161 and plunger 97 are now locked against movement by detent balls 134, the latter being seated in groove 167 of plunger 97. Tube 127, carrying balls 134, is prevented from moving upwardly by stop flange 185 and by stop pins 186; downward movement is prevented by the very stiff spring 114. Under these conditions all parts of the synchronizer assembly 95 are immovable, locking balls 146 being held seated in their respective grooves 141, 142 by the underlying flanges 149, 148, and the fact that the rods are held firmly in abutment with surfaces of piston 143 in the manner made clear by FIGURE 9.

It is a simple matter for the operator to check the locked condition of the bolts by attempting to move linkage rods 96 in opposite directions. If these are firmly locked against movement in either direction, it is known that all detents are firmly locked, including detents 122 locked the lower end of the bolt to cup 175 of the load. If either of the rods 96 is movable longitudinally thereof, the operator knows that balls 134 are not locked in groove 167 of plunger 97. He further knows that detents 122 at the lower end of the bolt are not locked in groove 174 of the load coupling member 175. If they are so locked in groove 174 then spring 114 is effective to lift

the locking plunger 112 until flange 185 abuts the lower end of bushing 108. When in this position, spring 126 carried within the locking plunger is effective to lift plunger 130 against the lower end of plunger 97 elevating the latter until its grooves 167 is in alignment with locking balls 134. Under these conditions flanges 148, 149 of linkage rod 96 are located beneath balls 146 locking the latter seated in grooves 141, 142 thereby locking the linkage against movement in either direction.

The ejection bolts are now in readiness for operation to eject store 87 instantly upon the closing of the electrical circuits through leads 93 to detonate the cartridge within chamber 91. Upon the detonation of this charge, a very large volume of combustible gases evolves almost instantaneously creating very high pressure conditions within conduit 90 and in the closed ends of bolts 80, 80. Although this high pressure condition is reflected substantially uniformly and at the same instant to the top of both chambers, it is possible and not uncommon for a detent releasing pressure to occur in one bolt before it does in the other. This happenstance cannot operate to release the detents in one bolt in advance of the other in the described construction because of the overriding effect and positive locking action provided by synchronizer mechanism 95. This is for the reason that the pressure within the upper end of the bolts is initially ineffective to extend tubular members 104 and 110 because they are locked retracted. But the pressure is effective against the inner end of tube 127 and tends to extend the locking plunger assembly 112 carrying with it plunger 97 due to the locking action of detents 134 in groove 167.

Let it be assumed that the pressure referred to is effective to move plunger 97 and linkage 96 of the left bolt as viewed in FIGURE 7 prior to a corresponding movement of the linkage of the other bolt. Plunger 97 of the left bolt will move with its associated tube 127 and locking assembly plunger 112 causing bell crank 161 to pivot counterclockwise shifting linkage rod 96 to the left and allowing the left hand pair of ball detents 146 to ride off the periphery of flange 148 onto lower land 150. At this point it is important to note that the left hand linkage 96 can move only sufficiently to allow balls 146 to move out of grooves 142 of the synchronizer by reason of the engagement of flange 148 with ring 155 in the end of piston 143. This axial movement of rod 96 is less than that required for lands 118 and 119 at the lower end of locking plunger 112 to move past the lower end of locking detents 121 and 122 and the latter remain fully seated in their respective locking grooves 174, 180. Accordingly, it is impossible for the load to be released or for the tubes of the bolt assembly to extend themselves until such time as the right hand set of ball detents 146 of the synchronizer are still locked in groove 141 thereby holding piston 143 against movement.

Let it now be assumed that after a brief interval of a small fraction of a second the pressure in the second and right hand one of the bolts increases sufficiently to extend its locking plunger assembly thereby extending its plunger assembly and rocking its bell crank 161 counterclockwise to shift linkage rod 96 to the left as viewed in FIGURE 9. As this occurs, the right hand pair of detents 146 ride off flange 149 onto lower land 151 allowing piston 143 for the first time to shift to the left within housing 140. The plunger assemblies of both bolts are now free to continue their downward movement in synchronism under high pressure within the bolts allowing balls 134 to shift outwardly against the wall of well 133 in bushing 108 as both plunger assemblies continue their rapid extension. Since land 119 at the lower end of the plunger is axially narrower than land 118, detents 122 move inwardly to uncouple the load from tube 110 before detents 121 are released from engagement with the groove at the lower end of tube 104. The continually developing pressure within each of the bolts remains effective on

the upper ends of each tubular member forcing the tubes to telescope outwardly at high velocity.

As tubes 104 and 110 extend it is to be noted that inner tube 110 must extend substantially its full distance before the upper set of detents 137 is opposite the small diameter portion of bushing 108 and therefore free to move inwardly. The beveled outer ends of each of the detents provide cams serving to force the detents inwardly as soon as the backing is removed from their inner ends. The tubes continue to extend until each comes to rest against the stop provided by the described cooperating radial flanges. The position of the parts in their fully extended positions is illustrated in FIGURE 12 wherein the outer end 116 of plunger 115 will be observed as projecting beyond the lower end of the bolt. The importance of this will become apparent in the description of the reassembly of the bolts now to be set forth. At this point it should be noted that the central passage provided in the several detents aids materially in purging the products of combustion from the bolt following its firing. Any escape of these gases during extension of the bolt is so small as to be negligible. Thereafter the gases slowly seep from the assembly so that after a brief interval of time the parts may be telescoped inwardly and connected with a new store to be jettisoned.

Reconditioning of the assembly for refiring is a relatively simple procedure for which foolproof safeguards against improper or incomplete reconditioning are provided in a manner which will now be explained. First the new store 87 is positioned beneath the extended ends of the bolts with the upwardly opening coupling cups 175 fixed to the store and underlying the respective bolts. The store is elevated with coupling cups telescoping over the extended end of the bolts as is indicated in FIGURE 12, all detents then being positioned in their retracted positions. If, for any reason, they should not be in this position it is immaterial since the elevation of the parts in cooperation with the beveled entrance edges provided on each of the telescoping parts serves to cam the detents inwardly.

Continued elevation of the assembly causes lower end 116 of plunger 115 to strike the bottom of cup 175 thereby tending to compress spring 114 and lift plunger 112 upwardly. However, no substantial movement of the plunger assembly can occur owing to the engagement of detents 122 against the inner side wall of cup 175. In consequence, larger tubular member 104 is raised along with tubular member 110, the upper detents then being held retracted by the engagement of their upper beveled surfaces with the overlying inner corner of their supporting bores in tube 104. When tube 104 has been fully elevated camming shoulder 131 on bushing 108 underlying the inner ends of detents 137 cams them outwardly into their seating groove 181 in bushing 101 thereby allowing the inner tube 110 to be elevated until continued pressure on the lower end of the tube cams detents 121 into seating engagement in grooves 180 in which position they are positively locked by land 118 on plunger 112.

It is emphasized, however, that the parts are so made that it is impossible to move the locking plunger 112 upwardly to effect the described outward extension of the two sets of detents 121, 122 until ball detents 134 at the upper end of this plunger are seated in groove 167. It will therefore be understood that as tube 110 approaches its fully nested position, synchronizing plunger 97 enters the upper end of tube 127 depressing plunger 130 in opposition to spring 126. The substitution of plunger 97 for plunger 130 maintains balls 134 pressed outwardly into well 133 thereby preventing tube 127 from being elevated until such time as groove 167 is directly opposite balls 134. It is important at this point to bear in mind that spring 114 is appreciably stronger than spring 126 with the result that coupling cup 175 secured

to the store cannot be elevated into locking position until the bolt components have been fully retracted and the synchronizing mechanism has been positively locked coupled to plunger 112, this being possible only after balls 134 are seated in groove 167. This condition is illustrated in FIGURE 15 wherein all parts are shown locked except detents 122. Further elevation of the store now acts to compress stiff spring 114 as the lower end of plunger 112 seats against the bottom of cup 175. When in this position spring 114 is effective through the plunger and the lower cam surface 120 of the plunger to urge locking detents 122 into their fully seated position in groove 174.

By reference to FIGURE 9 it will be seen that the upwardly acting forces applied by the elevation of the store cooperate to lift plunger 97 until its flange 166 seats against the top wall 99 of the bolt. The pressure then acting upwardly through the plunger rotates the bell crank 161 clockwise to urge the link 196 fully to the right carrying piston 143 with it until the latter strikes the right hand end of casing 140 and elevates ball detents 146 into their respective grooves 141 and 142. All parts of the mechanism are now locked and in readiness for a repeat firing operation. This fully locked condition may be checked with certainty by the simple expedient of attempting to shift both linkage rods 96 to the right and to the left with sufficient force to compress spring 114. It will be impossible to move link rods 96 in either direction if all detents are properly locked. Assuring himself of this fact, the operator then knows that all components are positively locked and that the elevating hoist used in lifting store 87 into position can be removed with complete safety.

All that remains is to remove cover 92 of charge chamber 91 and replace the remnants of the old charge with a new cartridge.

While the particular ejector bolt and synchronizer mechanism herein shown and disclosed in detail is fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that it is merely illustrative of the presently preferred embodiments of the invention and that no limitations are intended to the details of construction or design herein shown other than as defined in the appended claims.

I claim:

1. In a device of the character described, a synchronizer mechanism adapted for use in coordinating the action of separate means arranged for actuation by suddenly released fluids under pressure, said mechanism comprising a cylindrical chamber reciprocably supporting piston means therein, axially separated annular grooves in the side wall of said chamber, a plurality of axially spaced detent means carried in the wall of said piston means adapted to seat in adjacent ones of said grooves, and independently movable linkage means operatively coupled with said piston means, one at each end of said piston means, and movable between a locking and unlocking position each with respect to said adjacent one of said detent means whereby either linkage and associated detent means is effective to hold said piston means in locked position.

2. A synchronizer mechanism as defined in claim 1 characterized in the provision of separate pneumatic cylinders each having an extendable piston therein, and means holding said pistons releasably locked to a different one of said linkage means when said piston means is locked against movement in said chamber, and means for disconnecting said linkages from said extendable pistons following the unlocking of said synchronizer piston means for movement in the enclosing chamber therefor.

3. A synchronizer mechanism as defined in claim 1 characterized in the provision of means for locking a

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store to the outer end of said extendable piston means, and means responsible to movement of said linkage for releasing said store.

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