Nov. 9, 1954 W. S. BAER, SR., ET AL 2,693,708

LEVER SYSTEM

Filed Sept. 30, 1952 3 Sheets-Sheet 1

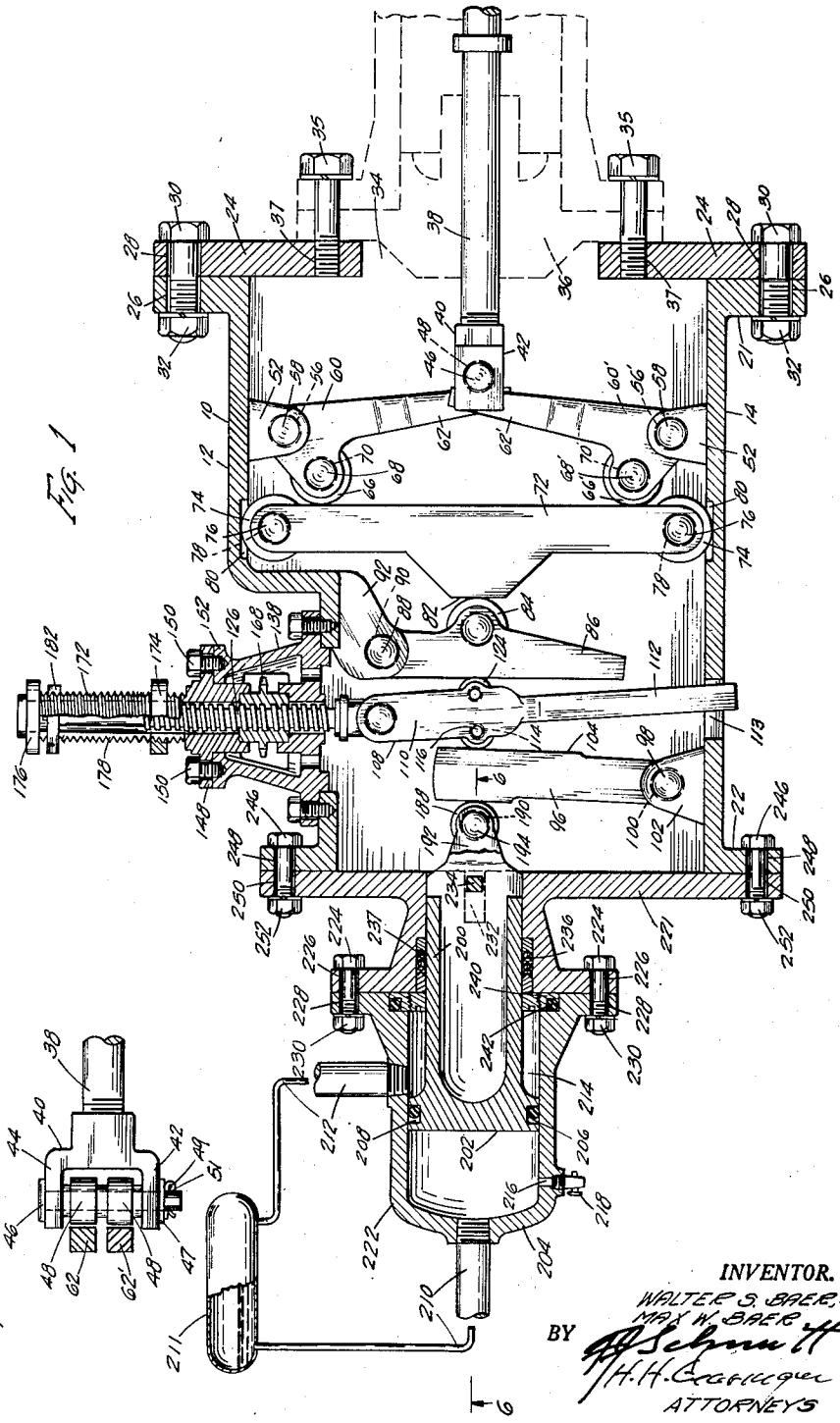


FIG. 1

FIG. 4

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LEVER SYSTEM

Filed Sept. 30, 1952 3 Sheets-Sheet 2

FIG. 3

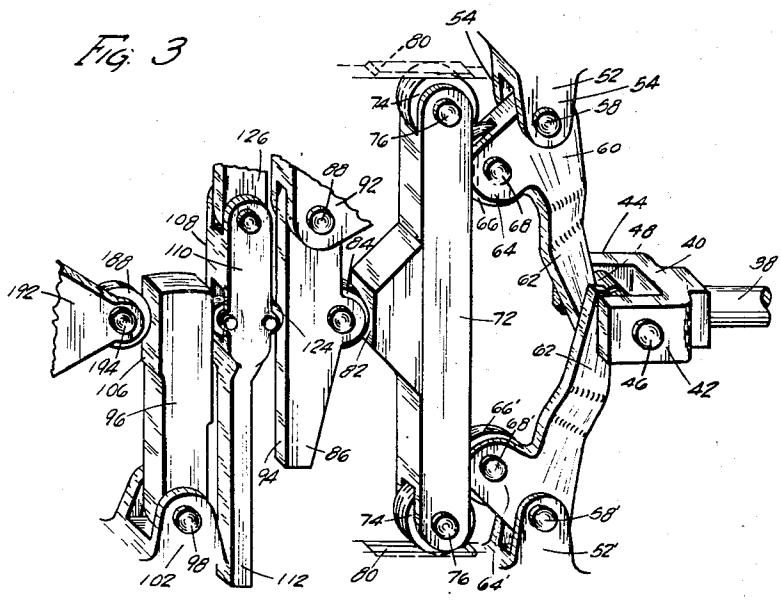


FIG. 5

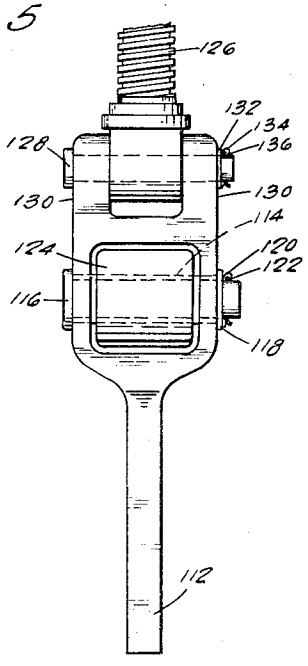
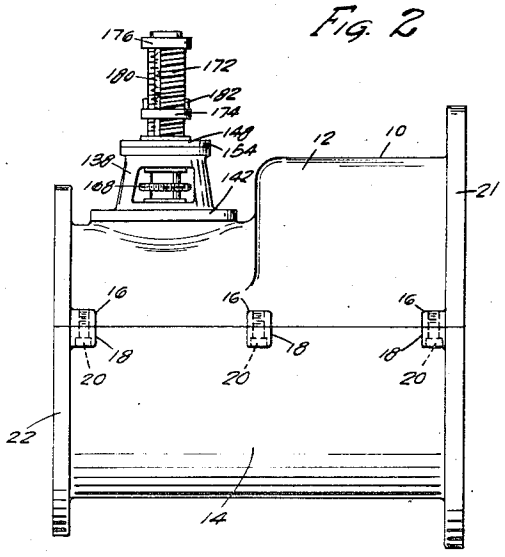


FIG. 2



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Nov. 9, 1954 W. S. BAER, SR., ET AL 2,693,708

LEVER SYSTEM

Filed Sept. 30, 1952 3 Sheets-Sheet 3

FIG. 6

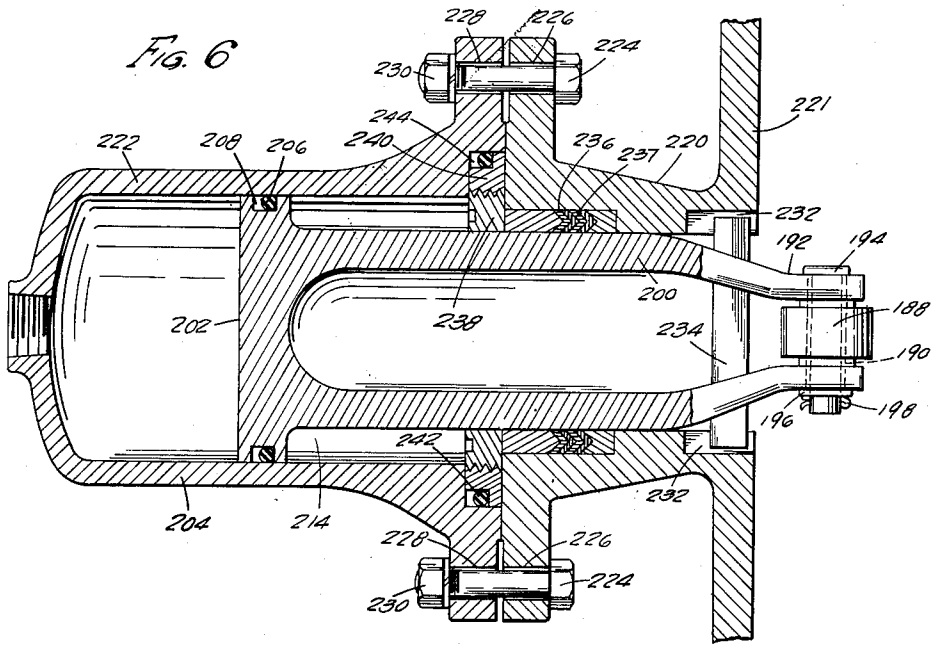
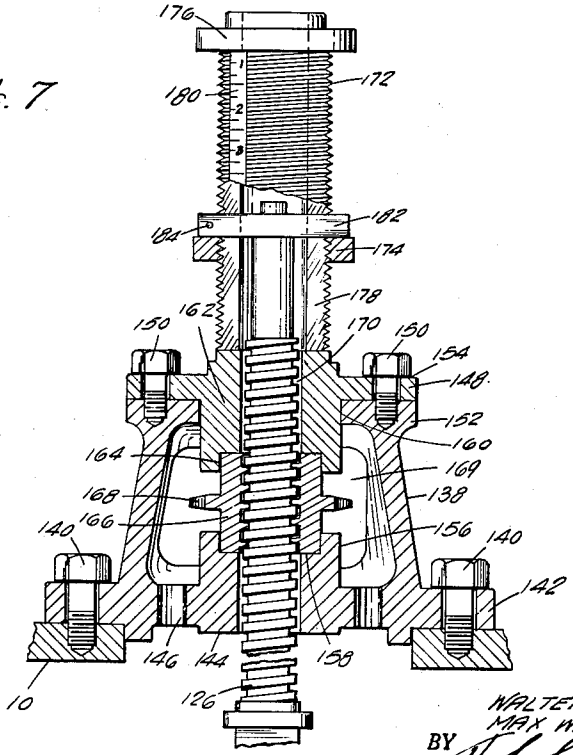


FIG. 7



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LEVER SYSTEM

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Application September 30, 1952, Serial No. 312,423

4 Claims. (Cl. 74—110)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The invention relates to a lever system and more particularly to a lever system which is adapted to be used in conjunction with an airplane arresting gear on an aircraft carrier.

When an airplane comes in for a landing on the deck of a carrier it must be brought to a stop after a relatively short run since, otherwise, its original momentum would carry it over the side of the ship. For this purpose, a hook is carried on the plane which is engaged by a cable when the plane comes in for a landing. This cable is connected to the arresting mechanism. The cable pulls a piston or "ram" through a tube or cylinder arranged below the deck. This cylinder contains a fluid ahead of the ram and as the ram is driven forward it compresses the fluid which is then forced into a constant pressure valve chamber. The constant pressure control valve comprises an orificed sleeve on a stem. The fluid under pressure impinges against the end of the stem, which projects out of the valve chamber, and pushes the valve forward. This movement causes the orifices in the sleeve to mate with corresponding orifices in the valve chamber wall and allows some of the pressure fluid to meter through these orifices and through the adjacent chamber and check valve to an "accumulator" or storage tank. When a sufficient amount of the pressure fluid is metered off in this way, the pressure against the valve stem is lessened. There is a counter-acting force in contact with the other end of the valve stem, and this force acts to return the valve toward its original position when the pressure of the fluid from the ram cylinder is sufficiently relieved. This counter-acting force is here illustrated as an oil piston which slides in an oil cylinder and in turn is acted upon by a constant air pressure from separate air-oil flask, or dome, that has an air volume 25 times the oil piston displacement for steadiness of pressure. The force transmitting means between the valve stem and the piston takes the form of a lever system, and it is this lever system which forms the basis of this invention.

The invention generally comprises a series of separate pivoted levers which extend between the valve stem and the counterbalancing force. Each of these levers acts either directly or indirectly on another lever to transmit the force from one direction or the other.

The central lever in the system is mounted for longitudinal adjustment between the adjacent levers on either side so as to vary the amount of pressure thrust between these adjacent levers. This central lever is adjusted to a predetermined position depending on the pressure which is expected to be applied on the valve stem by the fluid coming from the ram cylinder. The angular travel of the aforesaid adjacent levers is kept at a minimum for all pressures of the "ram" fluid by utilization of the mid-cycle reversible levers hereinafter described, and there are, as a consequence, no sideward thrust forces on the oil piston and attached parts but instead, at the appropriate setting of the central lever, the entire acting forces created by the ram cylinder pressure through the valve stem exert their energy only in a direction perfectly parallel with the center lines of the oil piston and the sleeve valve.

One object of this invention is to eliminate or minimize the varying pressure effect on a constant pressure valve counter-balancing means, which is due to the varying angular travel of the levers connecting the valve to the counterbalancing means.

Another object of this invention is to provide a lever system that will enable the constant pressure valve of an airplane arresting gear to provide a steady pressure reduction of the ram cylinder fluid throughout the working stroke of the ram, thereby producing as nearly perfect an indicator pressure curve as is mechanically feasible, and causing an even deceleration in the speed of the arrested aeroplane on the flight deck.

Another object of this invention is to provide a lever system that is of much smaller size and lighter weight than those used previously.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a view partly in section and partly in elevation showing the lever system in battery position, that is, with no pressure on the valve stem and with the oil piston head under valve closing pressure.

Fig. 2 is a side elevational view of the lever housing.

Fig. 3 is a perspective view showing the lever elements in relation to each other.

Fig. 4 is a top plan view of the bearing means on the valve stem showing their relation to the front levers.

Fig. 5 is an elevational view of the central ratio adjusting lever.

Fig. 6 is a view partly in section and partly in elevation taken on line 6—6 of Fig. 1.

Fig. 7 is an enlarged detailed view of the micrometer adjusting means for the central lever.

Referring now in detail to the drawings wherein similar reference characters refer to similar parts, there is shown a lever housing **10** which is constructed in two sections consisting of upper section **12** and lower section **14**. A plurality of bosses **16** are cast integrally with the section **12** and a like number of bosses **18** are cast integrally with section **14**. An Allen head screw **20** connects each of the bosses **16** to its complementary boss **18**.

The housing **10** is open at each end and each of these open ends is provided with a peripheral flange as indicated at **21** and **22**. The open end **21** is adapted to be closed by a closure member **24**. Drilled holes **26** in the flange **21** are adapted to mate with drilled holes **28** in the closure member **24**. Bolts **30** pass through the mating holes **26** and **28** and are locked in position by nuts **32**. A central opening **34** in the closure member **24** is adapted to receive the member **36** shown in outline. The member **36** is a closure for the valve housing, not shown. Bolts **35** extend through openings in the member **36** and are screwed into tapped holes **37** in member **24**, thereby connecting the member **36** to the member **24**.

The valve stem **38** projects from the valve housing **36** into the lever housing **10** as illustrated in Fig. 1, and threaded on the end of the valve stem is a yoke **40** having legs **42** and **44**. A pin **46** extends through openings in the legs **42** and **44** and on this pin there are mounted a pair of ferrules **48**. The pin is held in position by a washer **47** and cotter pin **49** bent through a hole **51** in the pin **46**.

Extending from the section **12** of the housing is a bearing **52** comprising a pair of ears **54** integral with the housing, a bushing **56** and a pin **58**. A cotter pin and washer, not shown, hold the pin in place. Pivotally mounted in this bearing is a lever **60**. The lever **60** comprises a bent arm **62** and a off-set portion consisting of a pair of ears **64** between which a roller **66** is mounted on a bushing **70**. A pin **68** holds the bushing in place. A cotter pin and washer, not shown, hold the pin in place. A similar lever assembly extends from the bottom section **14** of the housing and the similar parts are identified as **52'**, **54'**, **56'**, **58'**, **60'**, **62'**, **64'**, **66'**, **68'** and **70'**.

The ends of the lever arms **62** and **62'** overlap each other in a horizontal plane as seen in Figs. 1 and 3, and these overlapping portions bear against the ferrules on the yoke **40**. The rollers **66** and **66'** mounted in the off-

set portions of the levers 60 and 60' meanwhile bear against a bar 72.

The bar 72 extends across the full width of the interior of housing 10 and is provided at each end with a roller 74 which is rotatably mounted on a bushing 78 through which extends a pin 76. A cotter pin and washer, not shown, hold the pin in place. These rollers 74 are adapted to move in grooves 80 which are provided in the top and bottom sections of the housing. The bar 72 is also provided with a centrally located bearing surface 82 made of cobalt or the like, this surface being located on that side of the bar which is remote from the levers 60 and 60'. The surface 82 bears against a roller 84 mounted on a pivoted lever 86.

The lever 86 is pivotally mounted on a bushing 90 which is held between the ears 92 by a pin 88. A cotter pin and washer, not shown, hold the pin in place. The ears 92 are made integral with the upper housing section 12. The aforementioned roller 84 is mounted on one face of the lever 86 while on the opposite face of the lever is provided a bearing surface 94 made of cobalt or the like.

Opposite to and spaced from the lever 86 is a lever 96, illustrated in Figs. 1 and 3. This lever 96 is pivotally mounted between the ears 102 on a bushing 100 through which extends a pin 98. A cotter pin and washer, not shown, hold the pin in place. The ears 102 extend from and are integral with the bottom housing section 14. A bearing surface 106 is provided on the opposite face of the lever. Both of these bearing surfaces are made of cobalt or the like.

Extending between the pivoted levers 86 and 96 is the central or ratio adjusting lever 108. The lever 108 consists of a yoke portion 110 from which depends a guide rod 112 which extends through a guide slot 113 in the housing. A pair of bushings 114 are positioned in the yoke in side-by-side relation, each by a pin 116 which passes through the bushing. A washer 118 holds each pin in place and is locked in position by a cotter pin 120 which is bent through a hole 122 in the pin 116. A pair of rollers 124 are rotatable by the bushing and pins within the yoke. Preferably these rollers are in line contact with one another as well as the adjacent links 86 and 96. The yoke is, in turn, pivotally mounted on the end of a partially threaded shaft 126 by means of a pin 128 which connects the ears 130 of the yoke to the shaft. A washer 132 holds the pin in place and a cotter pin 134 bent through a hole 136 in the pin 128 holds the washer in place.

The partially threaded shaft 126 extends through a housing 138 which is separable from the main lever housing 10 but which is connected to the section 12 of that housing by means of screws 140 which pass through a flange 142 on the housing 138. A wall 144 separates the interior of the housing 138 from the interior of the housing 10. Perforations 146 in the wall are provided for lightening purposes. The top of the housing 138 is closed by a cap 148 by means of screws 150 which screw into flange 152 of the housing 138 and pass through flange 154 of the cap 148. In the housing 138 there is a boss 156 in the wall having a recess 158.

The top of the housing 138 is provided with a central opening 160 and through this opening depends a boss 162 integral with the cap 148, this boss having a central recess 164. An internally threaded bushing 166 is held within the recesses 158 and 164 and is so arranged that the threaded shaft 126 extends therethrough. An opening 169 is provided in the housing 138 to allow a chain to extend into the housing from a control means, either manual or power driven, for the purpose of rotating the sprocket 168 on the bushing 166. A central bore 170 is formed in the cap 148 and an externally threaded hollow housing 172, integral with the cap and having an interior wall coincident with the bore 170, extends from the cap. An internally threaded ring 174 is vertically adjustable on the upper part of the housing 172. The housing 172 is further provided with a pair of oppositely disposed vertical slots 178 and a vertically positioned plate having a micrometer scale 180. The slots and the plate interrupt the screw threads on the exterior of the housing. Attached to the upper portion of the shaft 126 is an indicator bar 182. The bar 182 is loosely held on the shaft 126 and extends through the slots 178, so that when the shaft is moved vertically within the housing the bar will also move vertically but will be prevented from turning with the shaft by the walls of the slots. The bar 182, as it moves up and down, will register the amount of vertical movement of the shaft by means of an indicating pin 184 mounted on the bar and passing over the micrometer scale 180. The vertical movement of the indicator bar is limited by the adjustable stop 174 on one end and by the adjustable stop 176 at the other end.

Bearing against the surface 106 of the lever 96 is a roller 188 which is mounted on a bushing 190 held within a yoke 192 by a pin 194. The pin 194 is secured by a washer 196 and by a cotter pin 198 bent through a hole in pin 194. The yoke 192 is integral with a hollow piston 200 which is provided with a flanged piston head 202 at one end. The hollow piston slides in an oil cylinder 204. An O-ring 206, set in groove 208 in the piston head, is used for the purpose of providing a sealing means between the piston and the cylinder wall. An inlet pipe 210 leads from a constant pressure air dome 211 to the interior of the oil cylinder behind the piston head. Another pipe 212 leads from the same air dome to a chamber 214 formed in front of the piston head. The fluid in the chamber 214 serves as a dashpot during the counterbalancing movement of the piston within the oil cylinder. A drain opening 216 closed by a stop-cock 218 is provided in the oil cylinder behind the piston head.

The oil cylinder, itself, is composed of two sections 220 and 222, the sections being bolted together by bolts 224 passing through drilled holes 226 and 228 and secured by nuts 230.

In the front end of the section 220 of the oil cylinder are provided a pair of oppositely disposed guide slots 232 and in these slots ride the ends of a guide bar 234 which passes laterally through the piston 200. The slots 232 act as key-ways and the bar acts as a key to keep the piston from rotating.

Behind and slightly spaced from the slots 232 in the oil cylinder an annular groove 236 is located and in this groove are provided a plurality of V-rings 237 set between a follower and an adapter. A gland ring 238 holds the V-packing in place and a ring 240 holds the ring in position. An O-ring 242 is set in a recess 244 formed in the ring 240.

The oil cylinder section 220 is flanged at 221 to provide a closure member for the opened end of the lever housing opposite to the thrust member 38. Bolts 246 passing through drilled holes 248 and 250 and cooperating nuts 252 serve to secure the end closure to the lever housing. The operation of the lever system is as follows:

During the working stroke of the ram in the ram cylinder of the arresting engine, pressure is brought to bear on the end of the valve stem. When this pressure exceeds the resistance offered by the oil piston, acting through the lever system, the valve stem moves to the left as illustrated in Fig. 1.

The lever system is so arranged that by merely varying the position of the central ratio adjusting lever 108, a mechanical efficiency ratio varying from "one to one" to "four to one" can be attained between the valve stem and the pressure-actuated oil piston.

When the lightest type of airplane is arrested, the ram cylinder pressure is comparatively low. The ratio determined for this type of airplane is "one to one." This means that the central lever is adjusted to the correct position wherein the rollers 124 are on the axis which runs through the center of the valve stem and through the center of the oil piston as illustrated in Fig. 1. With this "one to one" ratio there would be no angular travel of the levers 86 and 96.

When the heaviest airplane is arrested, the ram cylinder pressure is comparatively high. The ratio determined for this type of airplane is "four to one." To obtain this ratio, the central lever 108 is moved to the position where the indicator pin 184 points to "4" on the micrometer scale. In this case, the actual travel of the valve stem under pressure from the ram cylinder is 5/16 inch, the bar 72 travels only 0.0586 inch and the ends of the levers 86 and 96 angularly travel only 0.1172 inch. This slight travel is primarily due to the fact that the levers 60 and 60' are mid-cycle reversible levers. In other words, when the stem 38 moves under pressure from the ram cylinder, its force is taken up by the elongated bent arms 62 and 62' adjacent their free ends but transmitted to the lever system by the short off-set por-

tions adjacent their other ends. The free ends of the arms move a relatively greater distance toward the oil piston under pressure from the stem, while the off-set portions are moved a much smaller distance under the same pressure and even, after a certain point, tend to move back toward the valve while the free ends of the arms are still moving forward. This is because although both the free ends of the arms and the off-set portions have a rotary or rocking movement about the pivots **58** and **58'**, the arc described by each of the off-set portions is much smaller than the arc described by each of the arms. Since the transmitted force from the valve stem to the lever system acts through the off-set portions bearing against the bar **72**, only a short movement of the bar is affected, and this results in but slight movement in the remainder of the lever system. Since the pivots of the levers **86** and **96** are so located that in mid-travel the levers are perfectly vertical, the lever ends actually only move 0.0586 inch from the vertical at maximum travel in either direction. It is, therefore, seen that even for the heaviest airplane the angular travel of the levers **86** and **96** is negligible. The constantly varying pressure effect due to the angular travel of the levers used in older systems is, therefore, eliminated or minimized. There are no sideward thrust forces on the oil piston and its attached parts or on the levers and, therefore, at any setting of the levers, the entire acting forces created by the ram cylinder pressure acting through the valve stem, or by the air dome pressure acting through the oil piston, exert their energy only in a direction perfectly parallel with the common axis of the oil piston and valve stem.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A force transmitting system comprising a member which is periodically actuated from a first position to a second position; means for resisting movement of the said member from its first to its second position; a lever system operatively positioned between the member and the resisting means, said lever system including a pair of bell crank levers respectively pivotally disposed on opposite sides of the axis of displacement of the said member, the longer arms of the crank levers being arranged to overlap adjacent a point where they are operatively connected to the said member and the shorter arms of the crank levers being operatively connected to the said resisting means, said lever system further including means for adjustably controlling the magnitude of thrust transmitted through the system.

2. A force transmitting system comprising a housing; a shaft member which extends through an opening in one extremity of the housing and which is periodically displaced along its axis from a first to a second position; means disposed adjacent the opposite extremity of the housing for resisting movement of the shaft member from its first to its second position; a pair of bell crank levers respectively secured on a pair of opposite sides of the housing and arranged such that the longer arms thereof overlap adjacent the center of the housing at a point where they are operatively connected to the shaft member; an elongated bar which extends between the said opposite sides of the housing across the interior thereof, the said bar being operatively connected to each of the shorter arms of the said bell crank levers and also to the said resisting means.

3. A force transmitting system comprising a housing; a shaft member which extends through an opening in one extremity of the housing and which is periodically displaced along its axis from a first to a second position; means disposed adjacent the opposite extremity of the housing for resisting movement of the shaft member from its first to its second position; a pair of bell crank levers respectively secured on a pair of opposite sides of the housing and arranged such that the longer arms thereof overlap adjacent the center of the housing at a point where they are operatively connected to the shaft member; an elongated bar which extends between the said opposite sides of the housing across the interior thereof, the said bar being operatively connected to each of the shorter arms of the said bell crank levers; and means operatively positioned between the said bar and the said resisting means for adjustably controlling the magnitude of thrust transmitted through the system.

4. A force transmitting system comprising a housing; a shaft member which extends through an opening in one extremity of the housing and which is periodically displaced along its axis from a first to a second position; means disposed adjacent the opposite extremity of the housing for resisting movement of the shaft member from its first to its second position; a pair of bell crank levers respectively secured on a pair of opposite sides of the housing and arranged such that the longer arms thereof overlap adjacent the center of the housing at a point where they are operatively connected to the shaft member; an elongated bar which extends between the said opposite sides of the housing across the interior thereof, the said bar being operatively connected to each of the shorter arms of the said bell crank levers; a first lever member which is pivotally secured to one of the said opposite sides of the housing and which extends inwardly toward the interior of the housing where it is operatively connected to the said bar; a second lever member which is pivotally secured to the other of the said opposite sides of the housing and which extends inwardly toward the interior of the housing where it is operatively connected to the said resisting means; and means operatively positioned between the said first and second lever members for adjustably controlling the magnitude of thrust transmitted through the system.

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