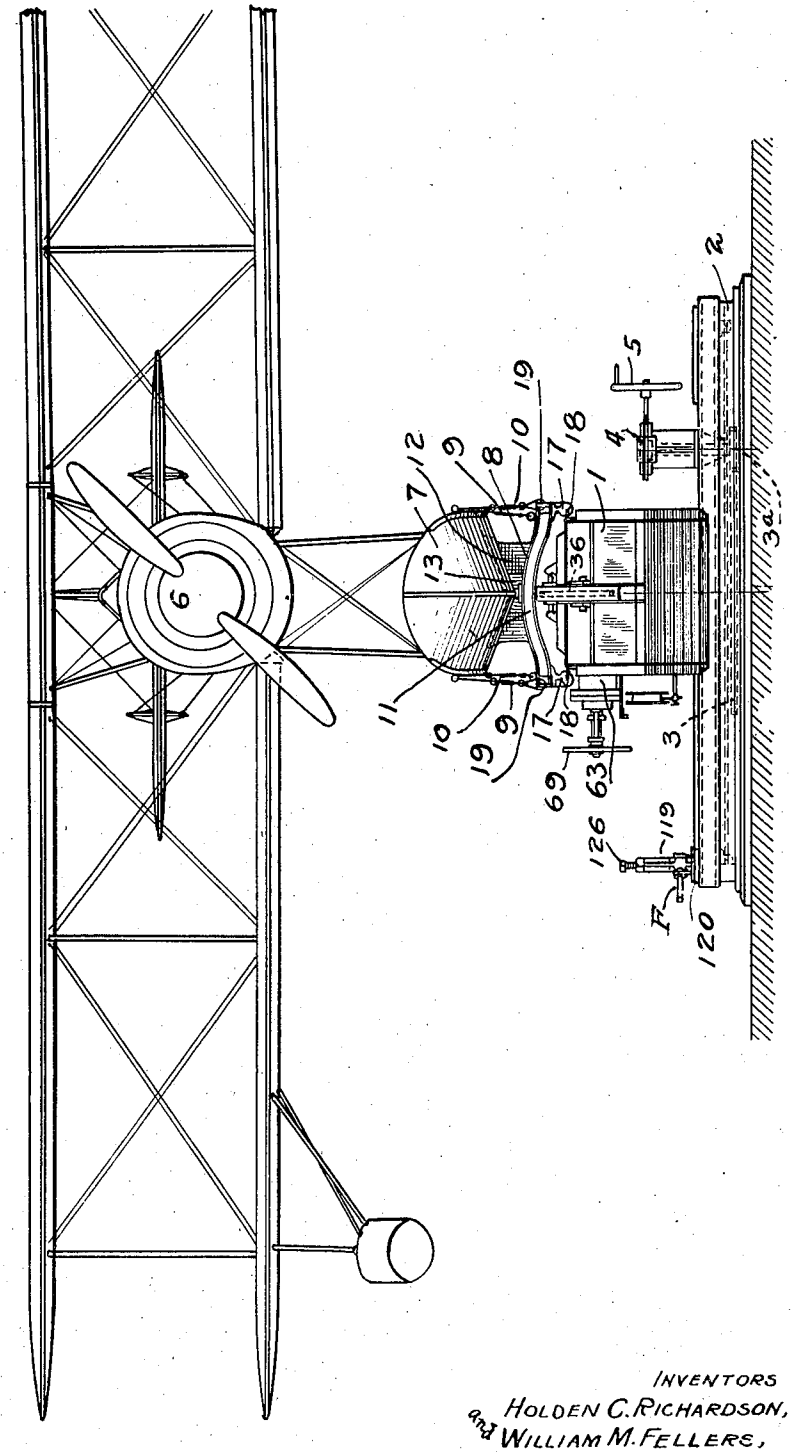
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AIRPLANE CATAPULT

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Fig. 1.




INVENTORS
HOLDEN C. RICHARDSON,
and WILLIAM M. FELLERS,
By Harold Dodd
ATTORNEY

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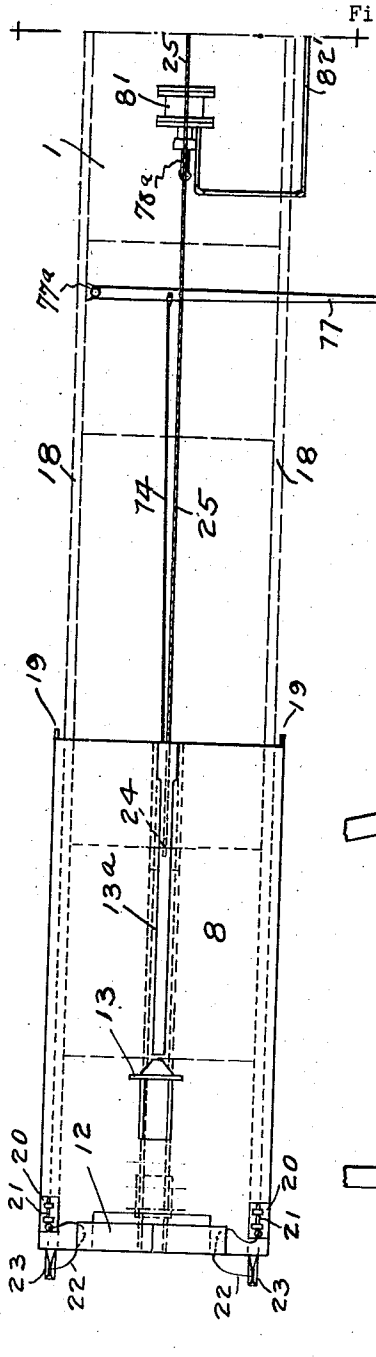


Fig. 1A.

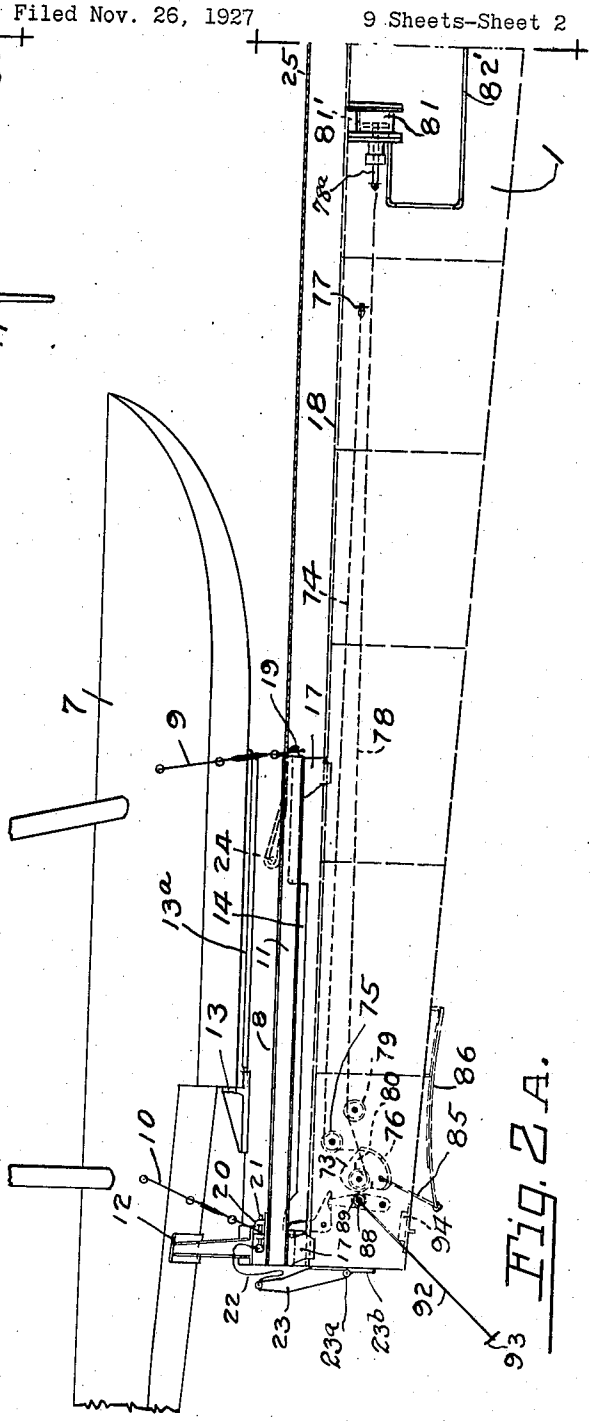


Fig. 2A.

INVENTORS
HOLDEN C. RICHARDSON,
and WILLIAM M. FELLERS,
By Howard Dodd.
ATTORNEY

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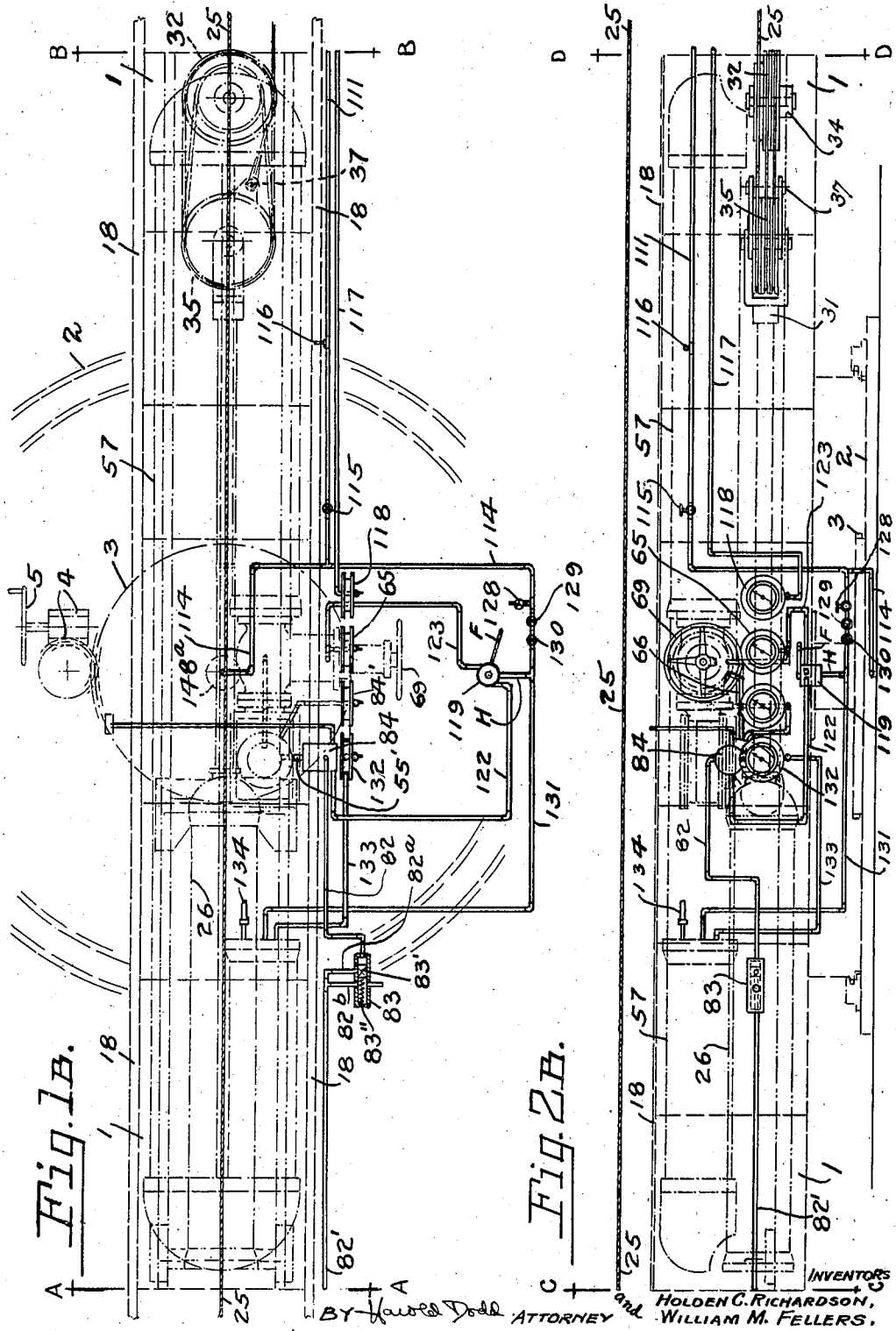


Fig. 1B.



Fig. 2B.

INVENTORS
HOLDEN C. RICHARDSON,
WILLIAM M. FELLERS.

BY Howard Dodd ATTORNEY

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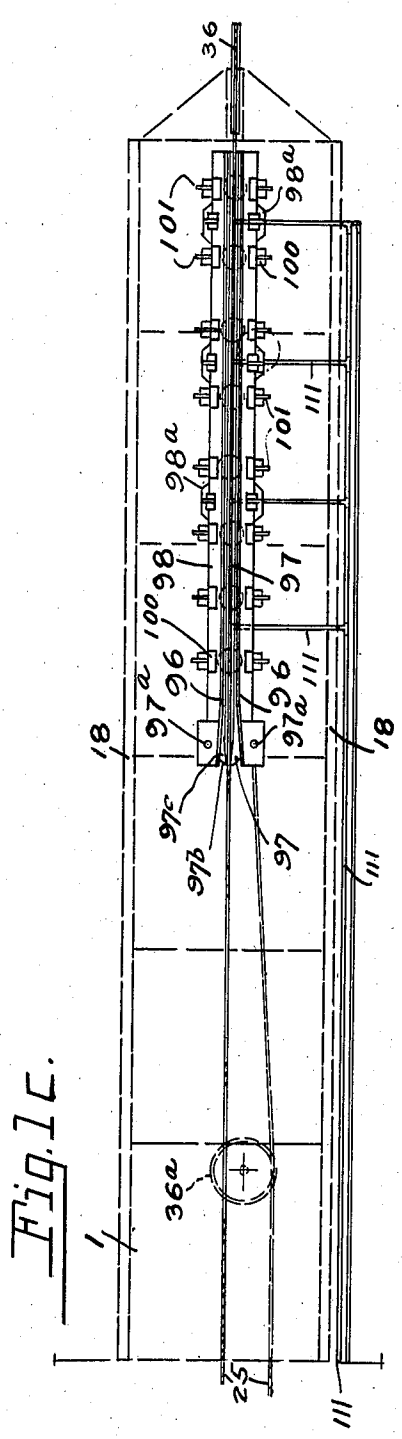


Fig. 1C.

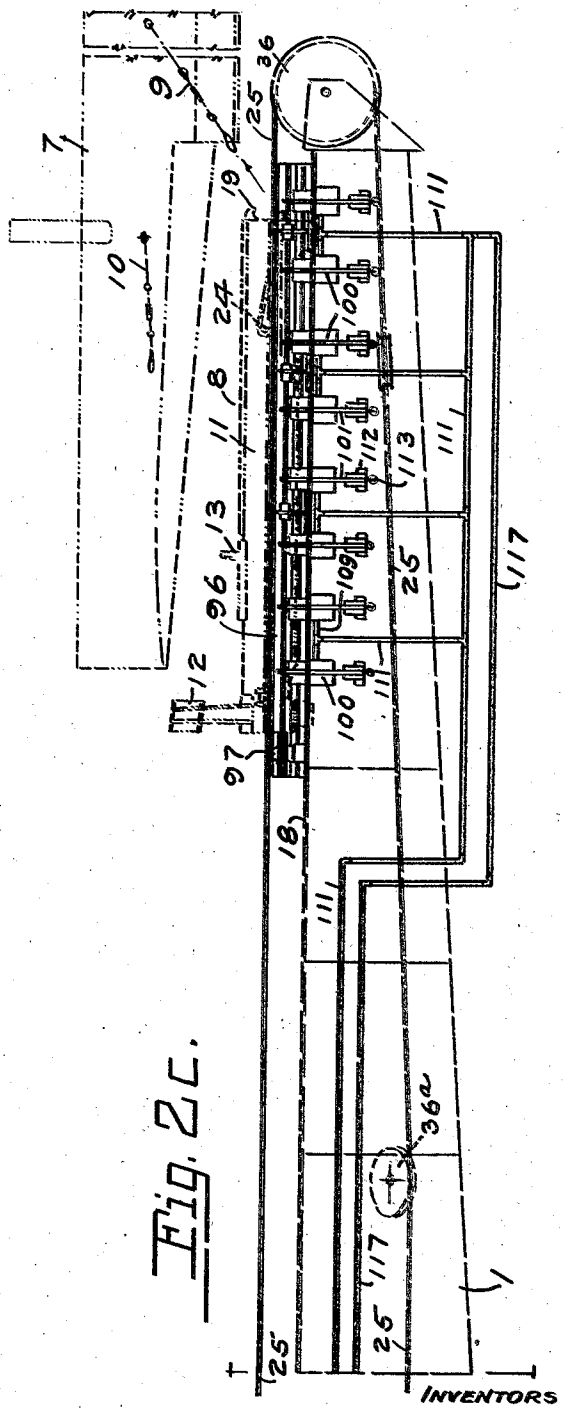


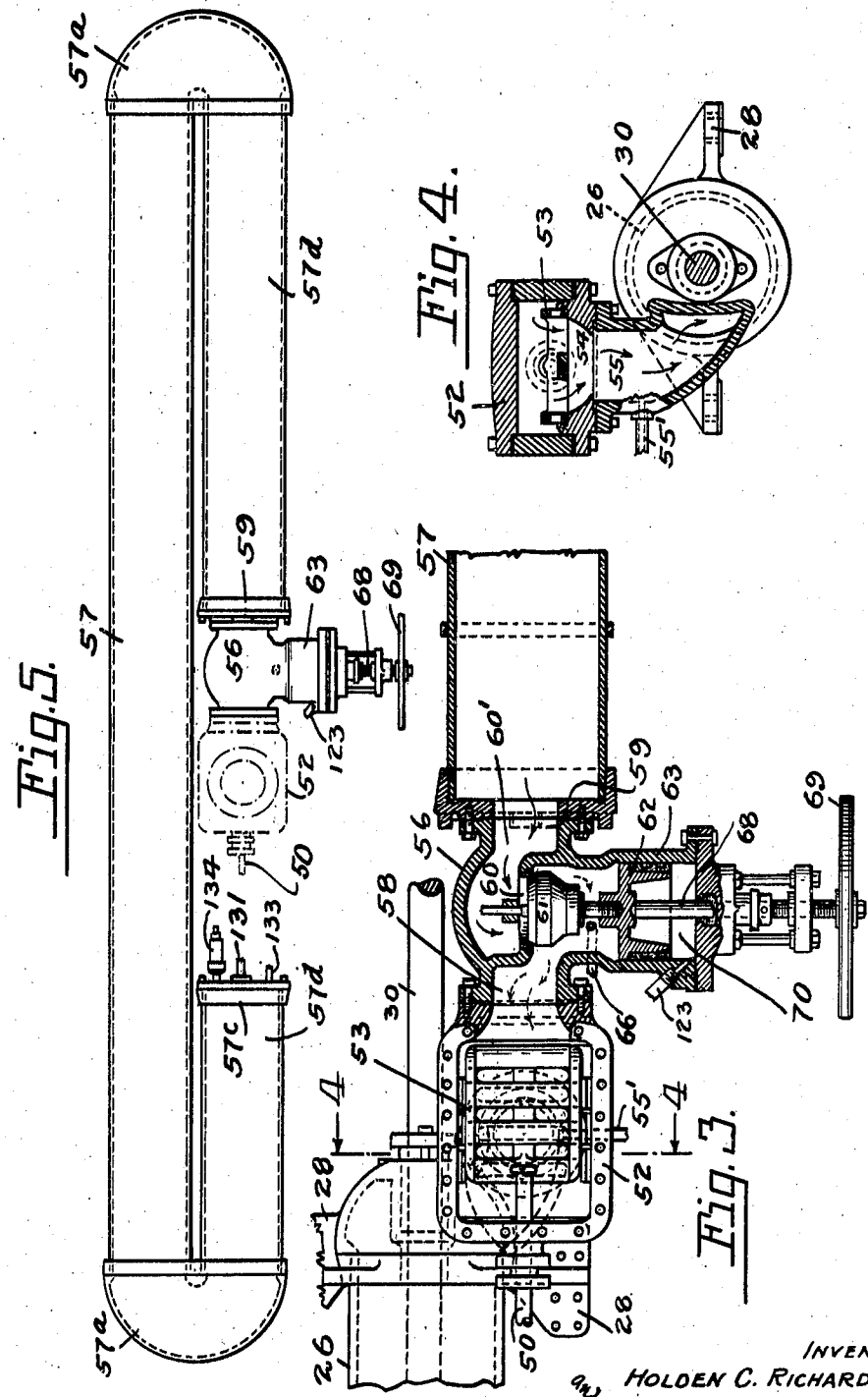
Fig. 2C.

INVENTORS
HOLDEN C. RICHARDSON,
and WILLIAM M. FELLERS,
By Harold Dodd
ATTORNEY

Aug. 23, 1938. H. C. RICHARDSON ET AL 2,127,531

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INVENTORS
HOLDEN C. RICHARDSON,
and WILLIAM M. FELLERS,
By Harold Dodd.
ATTORNEY

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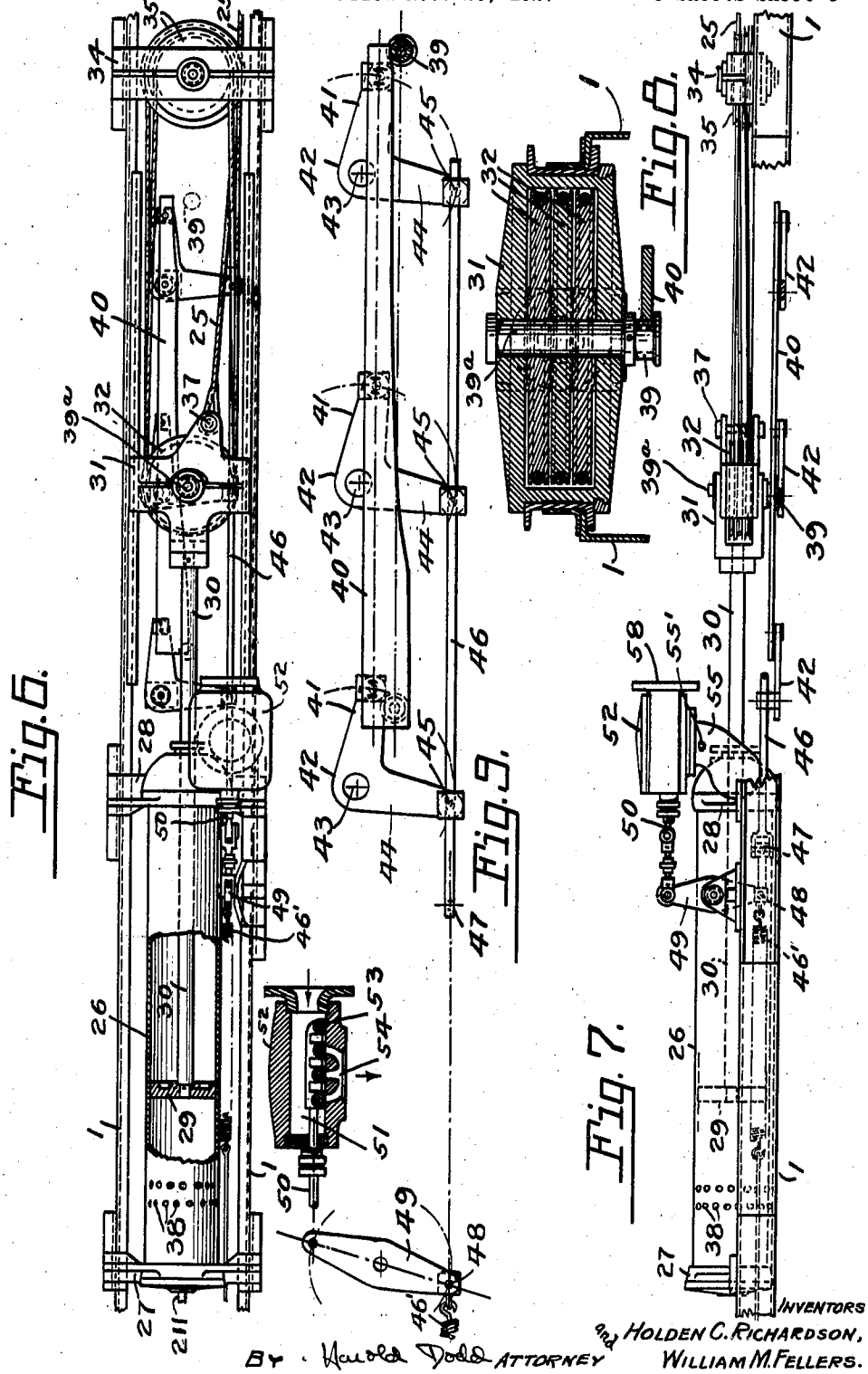


Fig. 6.

Fig. 9.

Fig. 8.

Fig. 7.

INVENTORS
HOLDEN C. RICHARDSON,
WILLIAM M. FELLERS.

BY Harold Dodd ATTORNEY

Aug. 23, 1938. H. C. RICHARDSON ET AL 2,127,531

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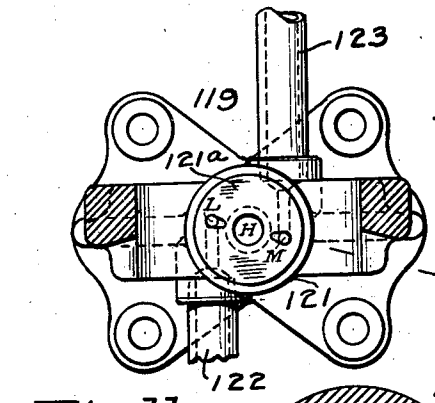



Fig. 11.

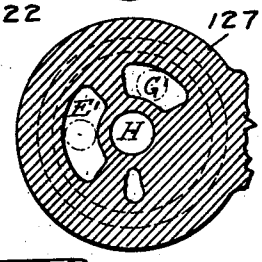



Fig. 12.

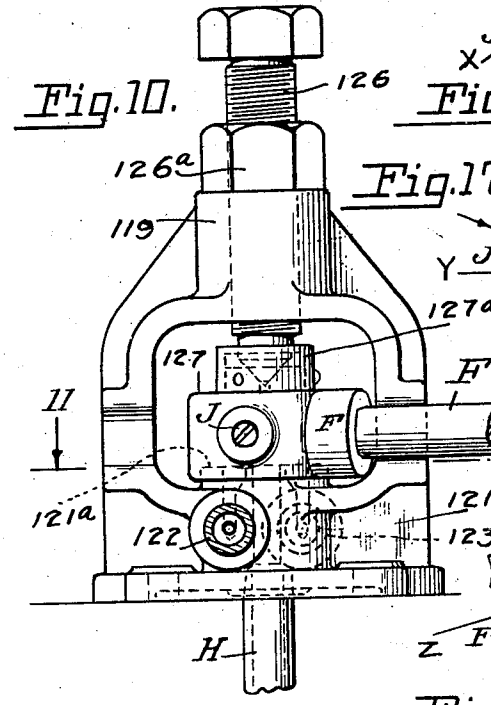
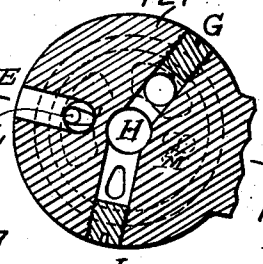



Fig. 10.

Fig. 13.



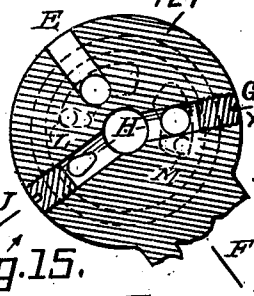




Fig. 15.

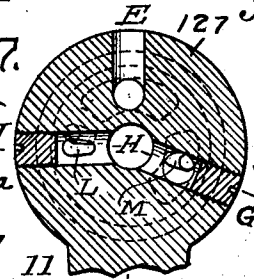



Fig. 17.

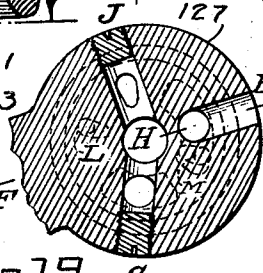
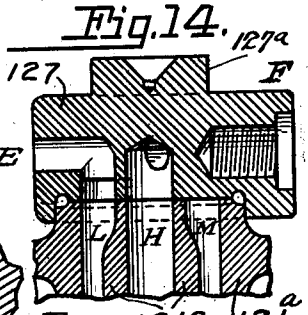



Fig. 19.

Fig. 14.



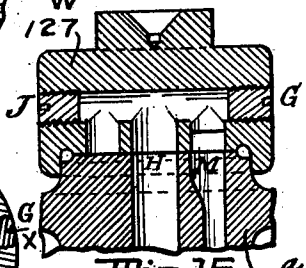




Fig. 16.

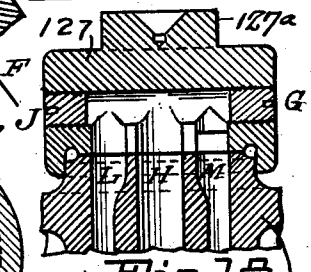



Fig. 18.

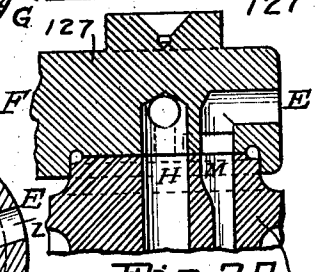



Fig. 20.

INVENTORS
HOLDEN C. RICHARDSON,
and WILLIAM M. FELLERS,
By Harold Todd.
ATTORNEY

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AIRPLANE CATAPULT

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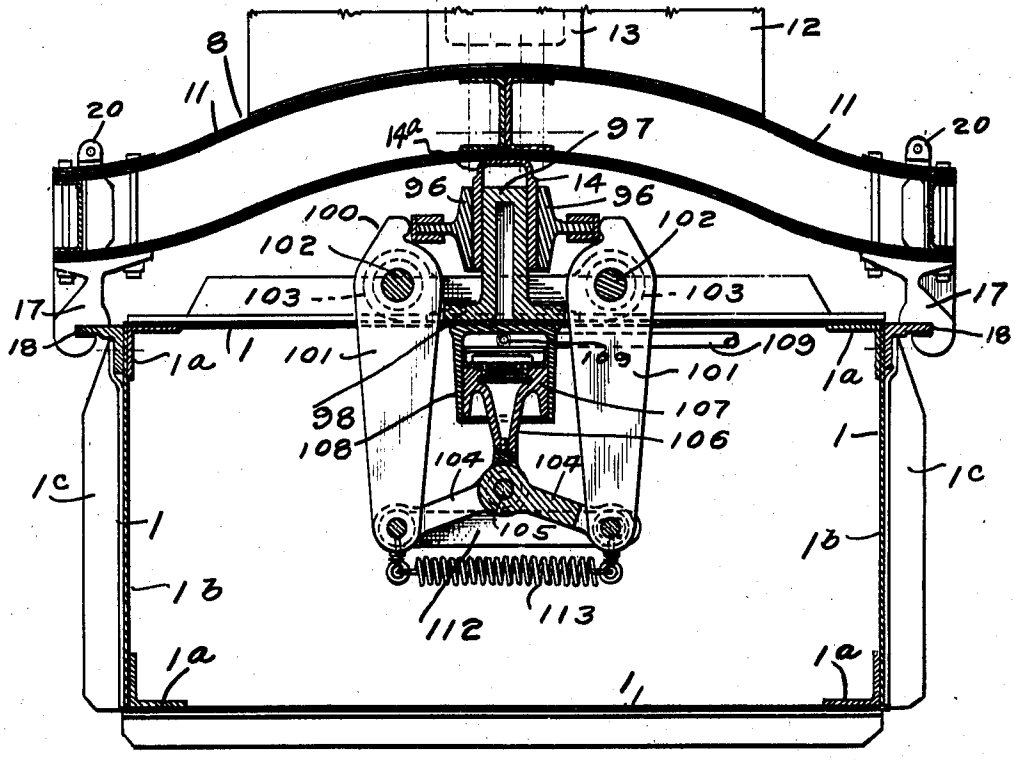
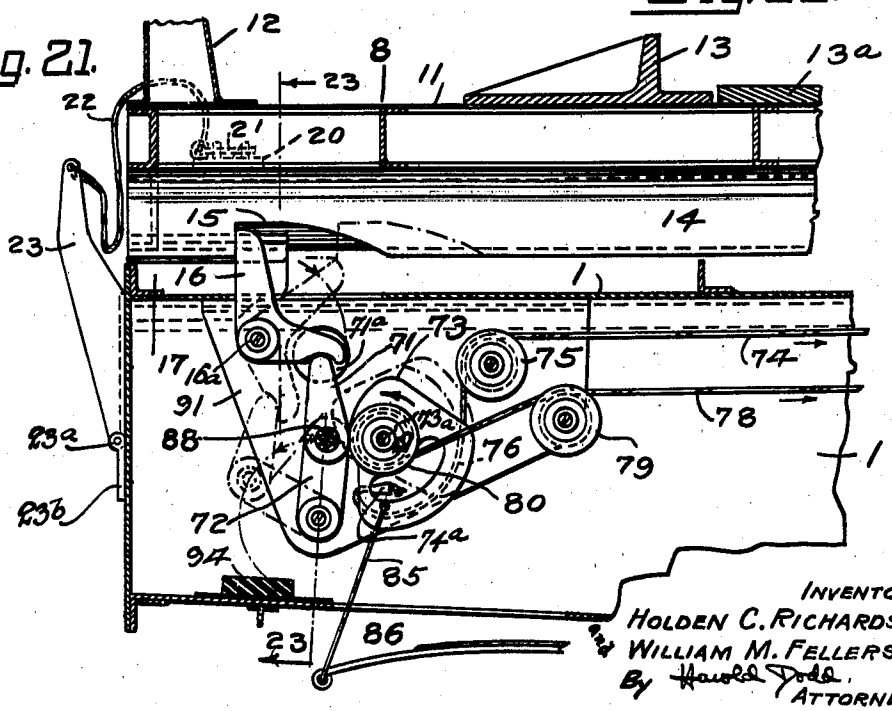



Fig. 22.

Fig. 21.




INVENTORS
HOLDEN C. RICHARDSON
WILLIAM M. FELLERS
By Harold Dodd
ATTORNEY

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Fig. 24.

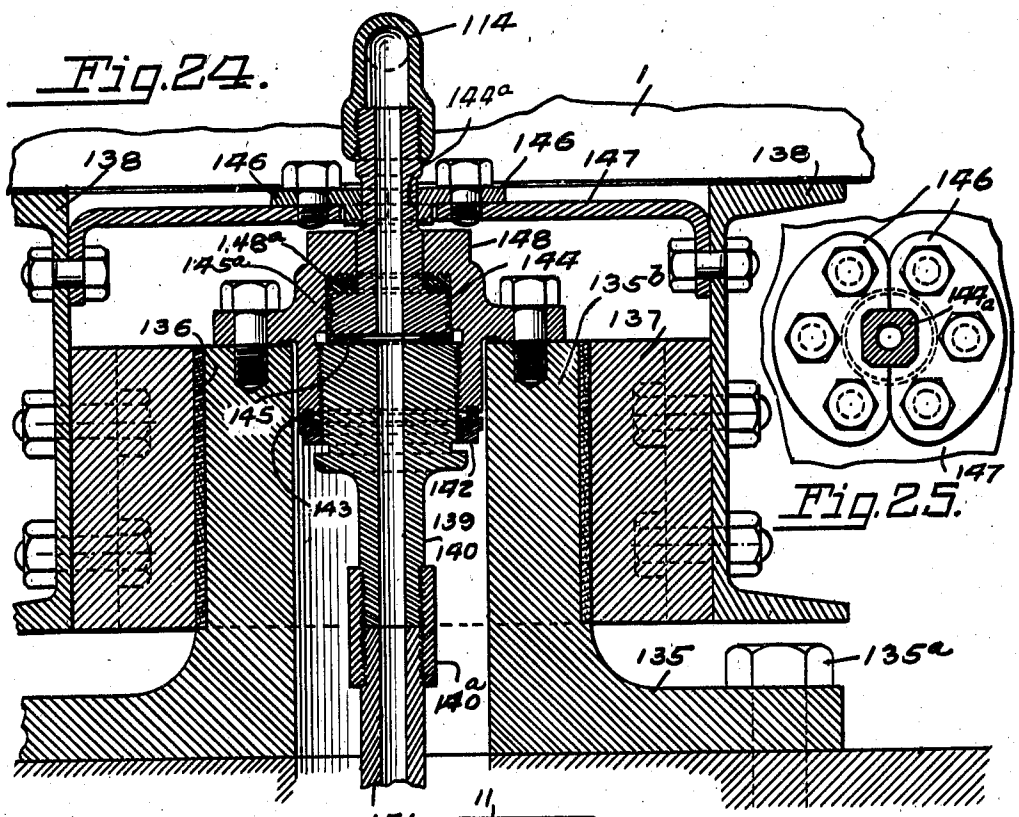



Fig. 25.



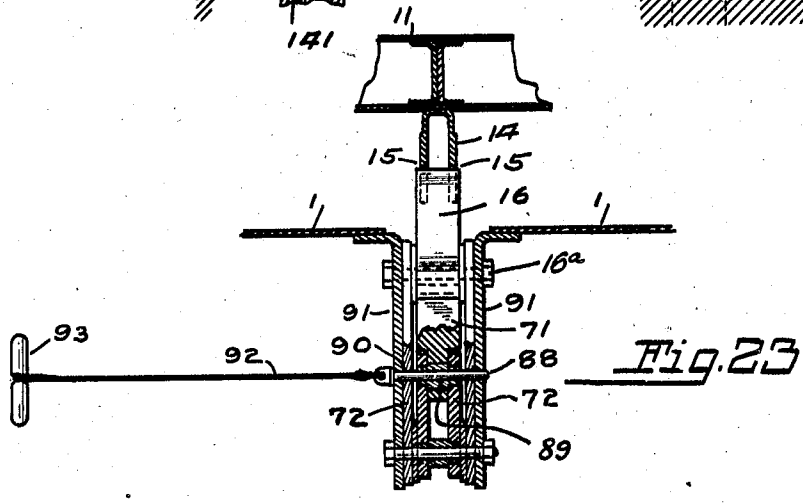




Fig. 23

INVENTORS

HOLDEN C. RICHARDSON,

and WILLIAM M. FELLERS

BY Harold Dodd ATTORNEY.

Patented Aug. 23, 1938 2,127,531

# UNITED STATES PATENT OFFICE

2,127,531

## AIRPLANE CATAPULT

Holden C. Richardson and William M. Fellers,
Washington, D. C.

Application November 26, 1927, Serial No. 235,910

33 Claims. (Cl. 244—63)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

Our invention relates broadly to method of and apparatus for airplane catapults and more particularly to catapults for launching airplanes from barges, ships, limited areas, or like restricted spaces.

Our invention more particularly relates to an improved novel method of and means for launching aircraft from limited areas on land or ships.

It has heretofore been the practice in some instances to fasten the aircraft to the launching car and to release the same at a given point in the travel of said car and to provide said car with wheels, but the high velocity of said car attained in such relatively short distance, tends to produce flattened surfaces on said wheels.

We have devised the novel method of, and, to demonstrate its utility, such means whereby, dispensing with wheels for said car and providing a relatively small bearing surface at each corner of said car and on opposite horizontal sides of each car rail, and lubricating said rails, more efficient bearing as well as guide for said car is attained; and that by securing the aircraft to said car at a plurality of points separated from each other in their direction of travel and so as to prevent substantial relative vertical movement therebetween while said securement holds, little if any lubricant is required for said rails and the action of said aircraft upon the air during the launching movement progressively lessens the load upon the car and then of said car upon its rails then tending to facilitate acceleration and upon the release of said securement, the resulting friction of said car bearings on said rails is restored and in the unlubricated condition of said rails, tends to contribute to the deceleration of said car; and further by progressively releasing said securements from the rear forward, the foremost being released substantially at the time of commencement of the deceleration of said car, that the aircraft is not only securely retained on said car during the major part of its launching movements against lateral winds and other displacing tendencies, but that said progressive releasing accomplishes said tendencies to facilitate acceleration and deceleration.

We have further devised the novel method of, and, to demonstrate its utility, such means whereby, applying pressure in one direction, launches the aircraft, and applying some of said pressure at substantially in right angle to said direction decelerates the launching means.

We have further devised the novel method of, and to demonstrate its utility, such means whereby, the launching means is secured in its initial position, pressure is applied in one direction to launch the aircraft and applying some of said pressure at a different point to release said securement after some of said first named pressure has been applied; as well as further, said first named pressure is accelerated substantially from the time of said release to substantially the time when the aircraft commences to leave the launching means.

The primary object of our invention is to provide a method of and means whereby the expansive force of compressed air may be used in launching airplanes.

Another object of our invention is to provide a method of, and means to, regulate the admission of the compressed air during the operation of the catapult so that an even acceleration in speed of launching is produced and in this manner reduce the irregularity of motion, shock and jars to a minimum.

Another object of our invention is to provide a catapult operating mechanism that is simple in construction, compact, easy to operate, one requiring a minimum of working parts, and one which safely reduces to a minimum the number of personnel required in attendance during its operation. We have accomplished this object by the utilization of a single manually operated valve, and other means conveniently located that controls the various detail movements of the catapult and the plane thereon.

Other objects of our invention are to provide a reliable and efficient means for securing under stress the airplane to the launching mechanism during the preliminary period of engine testing and warming up and during the accelerated travel, a means for releasing the stress upon the means for securing the aircraft to the launching means and automatically releasing said securing devices progressively near the termination of the run when the proper speed for launching the aircraft has been attained to enable the airplane to proceed under its own power, and also means for operating an efficient braking mechanism to bring the launching mechanism to a gradual stop at the end of the launching run.

Our method may be practiced advantageously by any of many different forms of apparatus as may be readily understood by those skilled in this art after becoming familiar with our method and the various steps thereof, and the apparatus we have devised for the most advantageous practice of the same.

Our invention consists substantially in said method, and in a means aspect, the construc-

tion, combination, and arrangement of parts associated therewith or as will be more fully hereinafter set forth as shown by the accompanying drawings and finally pointed out in the appended claims.

Reference is to be had to the accompanying drawings forming a part of this specification in which like reference characters indicate corresponding parts throughout the several views, and in which:

Figure 1 is a front elevation of a catapult showing an airplane in launching position,

Figures 1A, 1B and 1C represent a top plan view, partly diagrammatic, of a catapult embodying this invention,

Figures 2A, 2B and 2C represent a side elevation of the same, also partly diagrammatic,

Figure 3 is a view partly in plan and partly in horizontal section of a portion of the valve control and its associated mechanisms,

Figure 4 is a vertical transverse section on the line 4—4 of Figure 3,

Figure 5 is a detail plan view of a storage tank system for the accumulation of compressed air,

Figure 6 is a plan view, partly in section of the main power or driving unit,

Figure 7 is a view in side elevation of the parts shown in Figure 6,

Figure 8 is a vertical transverse section through the cross head, speed multiplying sheaves, and valve control cam shown in Figures 6 and 7,

Figure 9 is an enlarged detail view of the valve control cam and associated parts, shown and described with reference to Figure 7,

Figure 10 is a view in front elevation of the master control valve,

Figure 11 is a horizontal section on the line 11—11 of Figure 10, with the head removed to expose the air ports of the valve seat,

Figure 12 is a detail horizontal section through the valve head showing the location of the ports,

Figures 13 to 20 inclusive are detail sectional views of the master control valve shown in Figures 10 and 11 to illustrate the order in which the ports are brought into operation,

Figure 21 is a vertical section through the rear portion of the catapult beam, and launching car, showing the locking and releasing mechanism for holding the car in readiness for launching,

Figure 22 is a vertical section through the launching car and the catapult track, showing the relative position of the brake mechanisms on the car and track when the car approaches the end of the launching run,

Figure 23 is a detail vertical transverse section on the lines 23—23 of Figure 21,

Figure 24 is a vertical transverse section through the central bearing of the catapult, showing the air tight, revolving joint through which the air is supplied to the relay tank, and

Figure 25 is a detail plan view of a split collar of the joint shown in Figure 24.

Referring particularly to Figures 1 and 22, numeral 1 designates the beam or table of a catapult consisting of structural members 1*a* running lengthwise of the beam, and side, top and bottom plating 1*b*, which are reinforced at intervals by angles 1*c*. Rails 18, are provided at the side of the beam 1 for guiding a car 8 upon which an airplane 6 is mounted. The beam 1 is mounted to rotate upon a stationary turntable base 2. The rotation of the beam is controlled by a ring gear 3, a pinion 3*a*, worm gearing 4 and a hand wheel 5, Figures 1, 1B.

The airplane 6 is provided with a centrally located float 7, which is securely held to the launching car 8 by cables 9 and 10. It is to be understood that any modification of the launching car to adapt its use with any style of landing gear of the wheel or float type is within the scope of this invention.

Referring to Figures 1, 1A, 2A, 21 and 22 the car 8, consists of a body portion 11, upon which is mounted the supporting elements for the airplane 6. In the case of the particular type of float 7 shown we have found that the elements necessary for the positive acceleration and release of the airplane, are a rear saddle support 12, a step block 13, and a keel member 13*a*.

The airplane is secured to the car 8 by means of the cables 9 and 10, which are attached at their upper ends to the float 7 or other portions of the aircraft at points slightly forward of the rear and front respectively of the launching car 8. The cables 9 extend downwardly and forwardly and normally under stress engage the hooks or horizontal pins 19 located on opposite sides of a portion of the air-craft and at the forward end of the launching car. The cables 10 extend downwardly and rearwardly and the hooks in the lower ends of said cables 10 normally under stress engage their respective pins 21 at a point between the keeper plates 20. The pins 21 are each separately connected to their respective brackets 23 by a slack cable 22 of the proper length to insure the requisite delayed release of the hooked lower ends of each of the cables 10.

When, for instance, no cross wind is blowing, the cables 22 may be of uniform length and thus they will pull their pins 21 simultaneously; but with a cross wind blowing, or other lateral disturbing agency is present, the cable 22 on the side from which said wind or agency comes, is longer than the other cable 22 so as to hold said affected side of the plane against disturbance by said wind or agency as long as possible before its release.

The function of the rear cables 10 is a three fold one; first, they prevent the airplane moving forward relative to the launching car during preparatory period when the engine may be running and exerting a tendency of translation by action of the propeller; secondly, they prevent the airplane rotating forward on its nose due to engine and propeller action, and thirdly, they prevent the airplane from capsizing sideways due to side wind, lateral rolling of the support of the catapult or, other kindred cause.

Immediately after launching commences, and before the slack has been taken out of the cables 22, the acceleration force thereby exerted tends to seat the airplane 6 firmly against the step block 13 and rear saddle support 12 of the launching car. This tendency releases the stress of each cable 10 upon its pin 21 and thus makes it possible for the cables 22 to pull the pins 21 out of their keeper plates 20, simultaneously or alternately as may be controlled by the predetermined lengths of their cables 22, after a short forward travel of the launching car when the car is moving under the influence of a relatively high acceleration but with relatively slow initial velocity. Since the cables 10, have only such stresses in them as may have been normally put into them initially, and which stresses are removed by said acceleration seating said plane

against block 13 and support 12 at the deferred time for their removal, it takes very little force to pull the pins 21 out of the keeper plates 20 at a predetermined time and release the said relaxed cables 10.

This affords a safe, certain and efficient method of releasing the rear end of the airplane from car 8.

The forward cables 9, remain engaged with the hooks or horizontal pins 19 at the forward end of the car 8, and prevent the airplane from lifting away from the car 8 until near the forward terminal of the travel of the launching car 8 is reached, when the car 8 will commence to decelerate its velocity due to engagement with the braking system and the fact that the expansive force thrusting said car 8 has passed its maximum and is subsiding while the propeller is approaching the attainment of flying speed. At this point the lower looped ends of the cables 9 will free themselves from the hooks or horizontal pins 19 as the airplane leaves the car, as shown in Figure 2C, the said angularity of cables 9 and the relative forward motion of the aircraft and launching car 8 releases the stress of the hooked lower ends of the cables 9 upon, and frees from, their respective hooks or horizontal pins 19, at the time of the launching of the aircraft.

It will be apparent from the foregoing that the next precedingly described novel means has been devised by us to exemplify the practical and novel utility of our improved method for securing and releasing aircraft to and from their launching cars, which forms a unitary and related part of our invention and that said method broadly contemplates the fore and aft securement under stress of an aircraft to its launching and releasing means, relieving the stress on one of said securements, then releasing said securement the stress on which has been relieved, relieving the stress on the other of said securements, and releasing said other securements; while in its different aspects of lesser breadth said method may be qualified such that said first named stress relieving and securement release is occasioned early in the launching movement, while the latter relieving and securement release are designed to be accomplished substantially at the point of separation of the aircraft and its launching car 8.

Said method may also be fairly said to contemplate securing under stress the aircraft to its launching means at a plurality of points separated from each other in the direction in which said craft is to be launched; starting the launching; then relieving said stress upon the rearward of said securements; then releasing said rearward securement; then relieving said stress upon the forward of said securements; then releasing the forward securement preferably at the time when said craft attains a velocity substantially in excess of that of its launching means or car 8.

While in its aspects of lesser breadth the same may be qualified in the first of said relieving and releasing steps is occasioned as to its relieving by the initial relative movement of said craft and its launching means or car 8 and its release is occasioned at a definite point in the launching movement at which said point the relative velocity of said craft and the air is such that, with the forward securements still under stress, the pilot may, by the craft controls, retard any tendency of said craft toward departing from its normal navigating position on said launching means or car 8, and said relieving of said stress upon the forward securement is occasioned by the initial forward movement of said craft relative to its launching means or car 8, and releasing of said forward securement is occasioned by the continuance of said relative movement.

The brackets 23, are hinged at 23*a*, Figures 2A and 21, to a hinge plate 23*b*, secured to the rear end of the supports upon which car 8 travels and at a point below the top surface of said supports, so that said brackets 23 may be swung backward about their pivot points 23*a* and thus lowered to permit the removal or replacement of the car from the rear of the catapult, and said brackets 23 in their respective vertical position, are prevented from forward movement by contact with the rear ends of the supports to which their hinge plates 23*b* are secured.

The car 8 is guided along the track 18 of the catapult beam 1, by shoes 17 that are preferably located at the four corners of the body portion 11 of car 8 and hook over the outer web of angle iron track 18. A centrally located brake member 14 is secured to the under side of the car 8, the function of which will be hereinafter described in connection with the braking element.

Secured to the brake friction member 14, at a point 24, Figures 1A and 2A, toward the forward end of the car 8, is a force transmitting cable 25, which transmits the propelling force of the compressed air by means of a force multiplying mechanism to accelerate the car 8 and the airplane removably secured thereon.

In its launching movement car 8 travels preferably at the uniform rate of three times the acceleration of gravity while in its braking movement it is slowed up preferably at a uniform rate as high as one hundred times the acceleration of gravity. Such velocities, and their stresses which are essential to practical launching, require that car 8, and members of the launching mechanism movable therewith, be made as light as possible and that wheels be dispensed with on said car 8 and that bearing feet 17, slotted to receive loosely the rail 18, be provided in lieu of rollers as bearings for car 8 on rail 18, said slotted bearings 17 guide car 8, on rails 18, in all directions. The travel of the plane, and its fore and aft securement to car 8, in its launching movement, relieves the weight of said car and its load from the track, and when the plane is released from said car its friction on said track is restored thereby and tends slightly to effect deceleration.

While this tendency is relatively small, yet with the high velocity essential in such extremely limited space as a ship, for instance, affords therefor, great refinements of detail, and perfect coordination in all respects, are prerequisite to successful and safe practical results, and without each of which failure is inevitable with its attendant losses of life, property and otherwise.

The cable 25 extends forward over a sheave 36, Figures 1C, 2C, that is located at the forward end of the catapult beam 1; thence back over guide sheaves 36*a* and thence alternately around a plurality of the separate grooved pulleys of separate sheaves 32 and 35 and is secured at 37 to crosshead 31, Figures 1B, 2B, 6 and 7. These sheaves are carried by a movable crosshead 31 and a stationary crosshead 34.

Referring to Figures 21 and 23, the launching car 8 is locked in starting position by engagement of a right-angled rocker-arm pawl 16 in a notch 15 in the rear lower surface of the brake mem-

ber 16. The pawl 16 is pivotally mounted between brackets 91 that are secured to the rear structure of the catapult beam 1 and is locked into initial active position by a toggle link comprising members 71 and 72 the rounded free end of member 71 engaging in a curved recess is the adjacent surface of the free end of said pawl 16. When the toggle link is in working position the members 71 and 72 are at a position past dead center at their midpoints where they bear against the cam face of a segment 73, Figure 2A, revolubly mounted upon shaft 73a extending between said brackets 91.

A manual release for the car 8 has been provided and comprises a cable 74, Figures 2A, 21 and 1A, which is led over a sheave 75, within a groove 76 in a portion of the periphery of the cam segment 73, for operatively rotating the latter to the extent required to operate toggle levers 71 and 72 to release said pawl 16. One end of cable 74 is secured at 74a to segment 73. This system is controlled by a hand lever 77, pivotally mounted at 77a to one side of the support of car 8 and to which lever 77, at a point intermediate its ends, is secured the other end of said cable 74, while the free end of lever 77 projects beyond the opposite side of car 8 and its support where it may be normally operated from a position out of the path of travel of said car 8. To supplement the manual control aforesaid, operated by lever 77, a power control is also provided which comprises a cable 78 that passes over the grooved sheave 79 and about a portion of the periphery of grooved sheave 80, to which periphery one end of said cable 78 is secured and said sheave 80 is secured concentric with shaft 73a, to the side of said segment 73. The remaining end of cable 78 is secured, Figures 1A and 2A, to the rigid stem 78a of piston 81' slidable in cylinder 81 and to which air is admitted at desired times by pipe 82' entering said cylinder 81 upon the side of said piston 78 from which said stem 78a projects. This mechanism is operated by air pressure under control of the master valve 119 supplied through piping 82' to cylinder 81 from a two port valve 83 and a header 84, see Figures 1B and 2B.

To maintain the cables 74 and 78 under tension, and to return piston 78b to its normal position, a wire 85, see Figures 21 and 2A, is connected to the cam segment 73 and to the free end of a leaf spring 86 whose opposite end is securely mounted to and beneath the beam 1.

Referring to Figures 2A, 21 and 23, a pin 88 is inserted through a bore extending through the joint 89 hinging the members 71 and 72 together and said pin 88 also extending through registering apertures in the brackets 91 to prevent accidental or premature release of car 8 and launching. Unless this pin is withdrawn the airplane cannot be launched even though the valve 119 is operated. The pin 88 is attached to a cable 92 that terminates in a handle 93. A rebound cushion member 94, Figure 21, is secured to said beam 1 at the limit of the downward movement of link 72 to absorb the shock of the link 72 when it is released.

Referring to Figures 1A, 1B, 1C, 2A, 2B, 2C and particularly to Figures 6 and 7, which show the propelling mechanism, a plunger rod 30 is secured at one end to the movable crosshead 31. The plunger rod 30 passes through a packing box that is located upon the forward casting 28 of a cylinder 26 and terminates in a piston 29 within the cylinder 26. The cylinder 26 is held in position within the structure of the beam 1 by castings 27 and 28 which are secured to the beam structure 1. This cylinder is provided with a series of exhaust ports 38 located near the rear end at a point near the terminus of the power stroke.

These ports 38, when passed by piston 29, permit the greater portion of unspent pressure to be vented to the atmosphere. The rear end of the cylinder 26, between the ports 38 and the rear cylinder head contains air which is decreased in volume and increased in pressure as the piston moves toward the cylinder head, after said piston 29 passes said ports 38. This action brings a force to bear on the piston tending to stop it, the piston rod 30 and the translatable sheaves 32 without depending on the main friction brake to exert the additional force necessary to stop the piston and its attached parts, and without stressing the main cable to transmit the necessary stopping force.

The buffer chamber at the rear end of the piston chamber is provided with a small bent pipe 211. This vent allows a certain portion of the air trapped in the buffer chamber to escape so that as the piston 29 rebounds there is a rarefaction of the air produced in the buffer chamber. This rarefaction of the air within the buffer chamber entraps the piston 29 beyond the ports 38 with the result that the jerks upon the driving mechanism which would be produced by the oscillation of the piston 29 back and forth across the ports 38, are eliminated.

In order to govern the speed and to control the acceleration of the airplane during the launching period, a specially arranged control mechanism is provided for controlling the amount of compressed air entering the cylinder 26 from 125 pounds per square inch pressure at the start of car 8 to as much as 500 pounds per square inch, or more, at about the time the craft commences to separate from car 8.

One of the elements consists of a cam bar 40, Figures 7, 8 and 9, pivotally and adjustably secured to the outer ends of equal lengthed arms 41 of each of a plurality of bell crank levers 42, extending in the same direction from the fulcrum point of said levers 42. These levers 42 are mounted upon bearings 43 that are secured to the structure of the beam 1 and said cam bar 40 is mounted and moved parallel to the path of movement of said sheave 32. The cam bar 40 is engaged by a roller 39 which is mounted upon the lower end of the shaft 39a, Figures 6, 7 and 8. This shaft carries the sheaves 32 of crosshead 31. Movement is imparted to the roller 39 as the piston 29 is delivering its power stroke. A force is exerted upon the cam 40 holding it against the roller 39 by a coil spring 46[1], Figure 9, which is secured to a lever 49 and to the structure of the beam 1. Said lever 49 is pivotally mounted upon the frame structure 1 at a point intermediate the ends of said lever 49. The downwardly extending arms 44 of the bell cranks 42 are each pivotally connected to a rod 46 at points 45. This rod 46 is connected to lever 49 by universal joints 47 and pivot 48. The upper end of lever 49 operates a grid valve 53 which controls the amount of compressed air entering the cylinder 26. The lever 49 is pivotally connected to the grid valve 53 through a length adjustable link 50.

The grid valve 53 is housed in an air chamber 52, and constitutes a means for varying the openings of the ports 54 for permitting the desired amount of air to enter the cylinder 26. The air is introduced in substantial volume into the cylinder

26 through port 54, Figure 9, and thence into the air duct 55, which is located in the casing 28, Fig. 4.

It will be noted that the chamber 52, the lever 49 and its associated linkage have been shown diagrammatically in Figure 9 is order to more clearly illustrate the relation between the grid and the control cam, 40.

The following details of the grid valve shown in Figure 9 are to be noted: The necessary volume of port opening 54 is obtained by a multiplicity of port openings through valve 53. This is done to limit the force necessary to operate the valve to a practical minimum by limiting the air pressure on valve 53 and the distance and velocity of movement of valve 53 necessary to obtain desired results. There is one more grid than port so that the valve 53 may be opened and then closed by a continuous motion of the valve in each direction 53. This also reduces the force, that would otherwise be necessary to transmit through the valve mechanism, by overcoming the necessity of stopping the valve 53 and starting it again in the other direction, and it also allows for an accurate adjustment of the valve 53 even if lost motion is present in the valve system, since it may be set in the original position, with all slack of the valve gear taken up, since the motion during the power stroke is all in one direction. The valve is set so that each port has a lap of for instance three sixteenths of an inch when the catapult is in a condition to start the launching. This overlap prevents the air from the storage tanks rushing through the ports of the grid valve at the beginning of the launching stroke when the piston 29 is moving slowly and building up a pressure against the piston 29 equal to the storage tank pressure.

The cam 40 is so shaped that the grid valve 53 does not commence to open until the piston 29 has traveled for instance three inches. Air necessary to initially start the catapult car 8 flows from the storage tanks 57, 57*a*, and 57*d* through the valve seat 60 of Figure 3 through pipe 66 into the main cylinder 26, thus all of the initial starting air in cylinder 26 by-passes the grid valve 53 completely. It is to be noted that pipe 66 is small and that the quantity of air flowing through it, during for instance the second and two-fifths required to launch a plane, is negligible compared to the air that later flows through the grid valve 53 and the for instance six inch diameter passage 55, Figure 4 that connects it to the power cylinder 26. As air flows into the main cylinder 26 through the pipe 66 pressure is quickly increased in the cylinder 26 from for instance forty (40) pounds per square inch pressure used to take the slack out of the cable system 25 to the for instance 125 pounds per square inch maximum launching pressure in cylinder 26. This pressure is transmitted to the header 84, Figure 1B, by the pipe 55' and through pipe 82 to the valve 83. The increasing force acting against piston 83' in said valve gradually moves it to the left against the action of spring 83'' and, when the pressure reaches, for instance 125 pounds per square inch the port 82*a* is uncovered and port 82*b* is covered. Compressed air rushes through said port 82*a* into pipe 82' and causes the piston 81', Figure 2A, in cylinder 81 to move to the right thus releasing the launching car 8 and allowing it to start down the track under the influence of the force acting through the cable 25.

In such launching movement the crosshead 31, Figure 8, is moved toward the cylinder 26, carrying the roller 39 Figure 9 with it in contact with the cam surface of the cam bar 40. After traveling for instance three inches the roller 39 begins to move the cam bar 40 thereby bringing the ports and grids of the grid valve edge to edge. The contour of the cam is so constructed that the quantity of air passing through the grid valve 53 into cylinder 26, taken together with the air flowing through pipe 66 as heretofore described, is just the right quantity to keep the pressure in the cylinder progressively increasing enough to cause the desired launching speed. By keeping the pressure in cylinder 26 sensibly progressively increasing the force acting on the airplane is kept at a gradual progressive increase and therefore at a minimum of shock. This contributes to the comfort of the pilot and to the safety of the whole device. As the piston 29 reaches the ports 38 the cam roller 39 moves the cam 40 at a much more rapid rate in passing over the relatively steep portion of the inclined face of cam bar 40, thus drawing the grids of valve 53 quickly over and closing the ports 54 and thereby preventing air still in the storage tanks 57, 57*a* and 57*d*, from rushing through valve 53 into cylinder 26 and thence out to the atmosphere through the exhaust ports 38 in the cylinder 26. Air does continue to flow through pipe 66 but by closing the hand wheel 69 of Figure 3 as quickly as practical very little air is wasted. In this manner the air necessary to be pumped into the storage tanks 57 for a second launching is much less than would be necessary if the grid valve 53 was not automatically closed.

Referring particularly to Figures 3, 4 and 5 the grid 53 controls the compressed air entering the cylinder 26 from the valve 56, which is in communication with the storage tank 57.

The valve 56 is joined to the storage system at 59 and is provided with an air passage 58, a valve seat 60, a valve disc 61, a piston 62 operating in a cylindrical portion 63, pipe 66 for initially admitting air pressure from the passage 58 to cylinder 26, pipe 123 for admitting air pressure from valve 119 to space 70, and a threaded stem 68, movable independent of valve 61 and piston 62, which is operated by a hand wheel 69 for manually locking both the valve head 61 and piston 62 in a closed position. The valve 56 may be maintained in a closed position either by operation of the hand wheel 69 or by air pressure within the space 70.

The valve 56 consists of a housing that contains two passages 60' and 58. The passage 60' communicates with the storage tank portion 57*d*. The passage 58 communicates with air space 51 of the chamber 52 in which the grid valve 53 is slidably mounted. Between and separating the passages 58 and 60' is valve seat 60 upon which the disc 61 is seated.

Referring to Figure 5 it will be noted that a tank 57 is housed within the catapult beam structure 1. This storage tank, to enable it to be enclosed within and concealed by said beam structure 1, is composed of the several members 57*d*, joined at the ends by elbows 57*a* connected to opposite ends of tube 57, to constitute a continuous tank or container one end of which is closed by a header cap 57*c*. The opposite end of the tank is joined to the main valve 56 by a fitting 59 and is used for storage of a gradual accumulation of compressed air from a suitable air supply system that is connected to the pipe 141 (Figure 24) but not shown.

With reference to Figure 24, it will be noted that we have shown the air supply connection 145a, through which air pressure is supplied to the storage tank 57. This connection is located in the central pivot member about which the catapult beam 1 revolves in being positioned to launch the aircraft in the desired direction.

The connection 145a is located within a central bore 139 of a base fitting 135. This fitting is secured to its foundation by bolts 135a, and terminates in a cylindrical portion 135b about which a bearing 136 is fitted. The bearing 136 is engaged by a bearing block 137 secured to channel members 138 that are secured to and carried by the structure of the catapult beam 1.

The connection 145a consists of a lower nipple 140 which is threaded into a cap 148, and also an upper nipple 144 which is housed and free to rotate within the cap 148. The nipple 140 is connected by a sleeve 140a to the air supply pipe 141, and is locked to nipple 144 in adjusted position by a threaded collar 142, and sealed against leakage of air by packing gaskets 143 between said collar 142 and the adjacent face of the sleeve of cap 148. The nipple 144 is sealed against leakage of air by gaskets 145 and 149a. A squared upper portion is provided in the stem of the nipple at 144a for engagement of locking plates 146 as shown in Figures 24, 25. The plates 146 are secured to a cross member 147 by means of bolts. The cross member 147 is secured to the structural members 138 of beam 1 by bolts at opposite ends. Said plates 146 compel nipple 144 to rotate in unison with the catapult beam construction 1, 138 and 147.

A braking system shown more clearly in Figures 1C, 2C and 22 is located toward the front of the catapult beam structure 1. Its function is to progressively bring the launching car 8 to a stop at the end of the accelerated run. The brake friction member 14 carried by the car 8, at each complete cycle of movement of car 8, passes between a pair of brake shoes 96 and on opposite sides of a central rail portion 97 of a casting 98 rigidly secured to and which projects above the structure 1, and said rail 97 extends throughout the whole space in which the deceleration of car 8 is effected. The brake shoes 96 are pivotally connected at one end of 97a, and rest in bearings 98a, Figure 1C, of the casting 98. Adjacent their pivot points 97a the brake-shoes 96 are provided with a beveled throat 97c, shown in Figure 1C, which, with said pivoting of shoes 96, relieves the shock of brake friction members 14 entering between said shoes 96.

The end of said central rail 97 toward car 8 in its initial or locked position, is provided with a taper, as 97b of Figure 1C to insure the friction members 14 straddling said rail 97 without shock.

The brake system has a series of brake operating units 100, in opposed pairs. Each unit shown in detail in Figure 22 consists of a pair of levers 101. These levers are mounted on pivots 102 that rest in bearings 103, rigid on frame member 1, one on each side of the casting 98.

The lower ends of the levers are connected by toggle links 104, links 112 and a spring 113. Links 112 at the ends of the levers are provided with elongated bearings to limit the movement, and springs 113 hold the members against vibration and out of braking engagement. Connected to the toggle link 104 at the middle pivot 105 is a connecting rod 106 which terminates in a piston 107 that is slidable in a cylinder 108. This cylinder is mounted upon the lower side of casting 98.

The springs 113 normally hold shoes 96 out of braking contact with the braking friction members 14 which are connected together along their upper edges by a U-shaped member 14a, Figure 22, relatively thinner than said members 14, and, when said members 14 are under the braking pressure of said shoes 96 said members are thereby also held in braking engagement with the lateral surfaces of the center rail 97 while said last named engagement is released by the spring of the metal inherent in said U-shaped portion 14a of member 14 upon release of shoes 96.

For the application and regulation of the braking pressure compressed air is supplied to chamber between the piston 107 and the cylinder 108 by means of a pipe 109.

The pipe 109 is connected to pairs of cylinders as shown in Figure 2C. Pipe 109 also connects through pipe 111, safety blow-off valve 116, and regulator valve 115 to pipe 114, as shown in Figures 1B and 2B. The pressure in the cylinders 108 is registered on gage 118 which is connected to the fathermost end of pipe 117.

Referring to Figures 1B, 2B and 10, it is to be noted that the master control valve 119 operates the various units in their respective order of sequence, and is conveniently located upon the rotating structure of the turntable at 119. The various positions of the valve are shown in Figures 11–20.

The valve 119 has a main body portion 121, a seat 121a having an air inlet passage "H" through which air enters the valve. Mounted upon the seat 121a is a movable head 127 that carries upon its upper surface a bearing seat 127a. The movable head 127 is operated by a handle F extending therefrom. Extending through the yoke extending from the body 121 is a screw 126, the tapered lower extremity of which rests in bearing seat 127a, Figure 10, the relative neutral axis of said seat 121a head 127 and screw 126 being coincident. By adjustment of the screw 126 an air-tight connection between the movable head 127 and the valve seat 121a is accomplished and maintained. When the proper adjustment is reached at each adjustment the screw 126 is locked in position by means of a lock nut 126a.

Within the valve seat 121a are a plurality of passages L and M surrounding but separated from the concentric inlet passage "H" by partitions 121c.

Within the movable head 127 are a plurality of passages E, G, J and H. The passage H in head 127 coincides at all times with the passage H in the valve seat 121a.

The valve 119 has four operative positions, the first of which is shown in Figures 10, 13 and 14. The second position is approximately 40 degrees of rotation in a clockwise direction of the movable head 127, as shown in Figures 15 and 16. The third position is approximately 75 degrees of rotation in a clockwise direction from the initial position, as shown in Figures 17 and 18. The fourth position is approximately 150 degrees of rotation in a clockwise direction from the initial position.

Figure 14 is a sectional view through the movable head 127 and the valve seat 121a on the line w—w of Figure 13.

Figure 16 is a sectional view similar to that of Figure 14, on the line X—X of Figure 15.

Figure 18 is a sectional view of the line Y—Y of Figure 17.

Figure 20 is a similar view on the line Z—Z of Figure 19.

Figure 12 is a sectional view of the movable head 127 on the line 11—11 of Figure 10 showing the elongated ports E' and G' in the base of the movable head.

In the primary positions shown in Figures 10, 13 and 14 it will be seen that any air that has accumulated in the pressure cylinder 26 is vented through pipe 55', Figures 3 and 4, header tank 84 (Figure 2B), pipe 122, Figures 2B and 10, passage L in the valve seat and passage E in the movable valve head 127, Figure 14. The passage M, which communicates with pipe 123 which in turn communicates with valve 56, Figure 3, and gauges 65, is closed as shown in Figure 14.

The passage H connects with the source of compressed air and the storage tank 57 through pipes 131 and 114. This position maintains the entire mechanism in readiness for a launching.

The further operation of the device is as follows:

A blow-off valve 128 (Figures 1B and 2B) in piping 114 is first opened so that any moisture or foreign matter may be blown out of the air supply line 114. Then the valve 128 is closed and valves 129 and 130 are opened and which normally double seal the high pressure air supply coming from stationary piping 141 and movable piping 114. This opening of valves 129 and 130 permits air pressure to accumulate in the storage tank 57 by the flow of air through said valves to piping 131 until the proper amount of air pressure is reached in tank 57, as indicated on a gauge 132. This gauge is in communication with the storage tank 57 through piping 133. A safety valve 134 is provided in head 57C of said tank 57 to protect the accumulator system, comprising storage tank 57 and its associated piping, from receiving any substantial excess of maximum pressure.

The handle F of the valve 119 is moved from the closed position shown in Figure 13 to a position shown in Figures 15 and 16. In this position the cylinder 26 is vented to the atmosphere in the manner similar to that shown in Figures 10, 13 and 14. The passage H, however, now communicates with the passage M, through passage G. This position allows air to pass from the storage tank 57 through pipes 131 and H, passages H, G and M through piping 123, to the space 70 of the valve 56, Figure 3. The pressure in this space rises to approximately 500 pounds per square inch as may be indicated upon the gauge 65. This pressure acting upon the piston 62, (Figure 3), will hold the valve 61 closed against its seat 60, and permit the withdrawal of the valve stem 68 by operation of the hand wheel 69.

Valve 115 in piping 111, communicating with the main air supply piping 114, being closed, blow-off valve 116 is opened to release any air pressure there may be in piping 111, 109 and cylinder 108, which releases the backing pressure of shoes 96 and central rail 97 upon opposite sides of the brace friction members 14 and enables the car 8, movable cross-head 31, and piston 29 to be manually returned to normal position and said car 8 locked by detent 16 engaging in notches 15 in the rear lower surface of brake friction members 14 secured to the bottom of car 8; said manual return of said parts being by pushing car 8 back to normal position. However, in practice, when valve 115 is shut off at the conclusion of a launching the air leakage from cylinders 108 around pistons 107 is such that before further launching is required there is no pressure on pistons 107, and springs 113 have released car 8 from the braking action of shoes 96 and 97. The manual release of detent 16 by lever 77 may be accomplished when air pressure is absent from cylinder 26 to enable car 8 to be manually moved for any temporary purpose other than launching aircraft.

The valve 115 in the piping 111 is then opened to admit air pressure to the pistons 107 of the braking system (see Figures 1C and 22). This pressure is indicated by the gauge 118 connected by piping 117.

The safety pin 88 is then removed (see Figures 2A, 21 and 23) preliminary to the actual launching.

The master valve 119 (Figure 10) is advanced to the third position shown in Figure 17, and is used as a throttle to maintain an air pressure of about 40 pounds per square inch in the main cylinder 26. In this position air flows from the tank through piping 131, passages H, J and L of the master valve, (Figure 17), piping 122, header tank 84, pipe 55' to space 55 which communicates with the main cylinder 26. This pressure in the main cylinder is indicated by gauge 65.

These last named operations bring all parts of the towing mechanism under tension, and overcome any jerking at the start that would occur if any slack existed.

The master valve is then advanced to the fourth position shown in Figures 19 and 20. The passage L is now blanked off. No air flows through the master valve either into or from the main cylinder, but flows from chamber 70 (Figure 3) of the main valve 56 through piping 123 and through passages M and E, Figures 19 and 20, to the atmosphere, thus relieving the pressure previously built up in the chamber 70. As soon as the force exerted on the piston 62 of the main valve 56 falls below that exerted on the valve 61 by the pressure within the storage tank 57 the valve 61 will open and the air contained in the storage tank 57 flows through piping 66 into the header tank 84 (Figure 1B) and through piping 55' into the main cylinder. The pressure in the main cylinder 26 will begin to build up to a value somewhat lower than the pressure within the storage tank 57.

Whatever pressure is present in the header tank 84 at any time will be communicated through piping 82 to valve 83 (Figure 1B) and will act against piston 83' and spring 83''. This piston and spring are so designed that a pressure of 125 pounds per square inch is required to force the piston back far enough to open the port 82*a*, and close the port 82*b*. Until the piston is acted upon by sufficient pressure to uncover port 82*a*, any air that leaks past the piston into port 82*a* is vented by port 82*b*, through the valve casing to the atmosphere. This avoids the possibility of building up pressure in the pipe 82' which might otherwise cause the release mechanism actuated by piston 81' to function too soon. When the pressure in the main cylinder 26 and header tank 84 reaches the required pressure, the piston 83' uncovers port 82*a* and covers 82*b*, so air flows through piping 82' into the cylinder 81, Figures 1A and 2A. This pressure actuates a piston 81' inside the cylinder 81, Figures 1A and 2A, which motion releases the locking mechanism on the car as described with reference to Figures 2A and 21.

The air flowing from the storage tank 57 (Figure 5) into the main cylinder 26 through piping 66 (Figure 3) the header 84 (Figure 1B) and the

piping 55' (Figure 7), builds up sufficient pressure to cause the piston 29 to operate through the translatable sheaves 32 and 35, and cable 25 to take up the slack in the mechanisms between the car 8 and the piston 29. The removal of this slack prevents any sudden jar upon the car when the car 8 is released by the main air pressure introduced into the cylinder 26. Immediately after this operation the grid valve 53 opens and permits the direct flow of a large quantity of air from the storage tank 57 through the valve 60, the passage 58 and through the grids of the valve 53, directly into the piston chamber. This flow of air by means of the cam bar 40 control of the grid valve 53 develops a substantially constantly accelerated pressure throughout the power stroke, thus driving the plane at a uniform acceleration to the end of the power stroke; when the air supply is cut off by the grid valve 53; and the air in the cylinder commences to escape through the ports 38, just before the car enters the brake shoes 96. The purpose is to release the plane from the car when no force is acting between them, which occurs when the velocity of the plane being launched exceeds the velocity of car 8 due to the combined influence thereon of car 8 and of its propeller action.

When the car approaches the end of the track the brake friction members 14 engage shoes 96 of the braking system. By this engagement the car 8 is gradually brought to a stop by a uniform deceleration which may be safely accomplished at the rate of as much as 100 times the acceleration of gravity, requisite for the extremely limited space affordable therefor, as the airplane is released from said car 8 and continues under the force of its thus imparted initial acceleration and under its own power.

If valve 61 be omitted and grid valve 53 alone controlled the flow of air to cylinder 26, car 8 could not be manually returned to its initial position since the sharp incline on the lower surface of the cam bar 40, near its left end, in Figure 9, by the cooperation therewith of roller 39, closes grid valve 53 while the parallel lower surface of said cam bar 40 to the left of said sharp incline retains said valve 53 in its closed position, and since said return of car 8 causes said roller 39 to travel from its dotted position shown in Figure 9 toward the right, said roller in starting down said sharp incline on said bar 40, causes said valve 53 to open and the pressure in tank 57, 57d will cause said car 8 to be again exerted on piston 29 to move said car forward from said point. Therefore, before car 8 can be manually returned said valve 61 must be held to its seat either by air pressure in chamber 70 or by the independent threaded stem 68, of valve 61, operated by wheel 69.

The requisite short period of the launching time which is from about three quarters of a second to one and a half seconds, is too short to permit the manual opening of valve 61 by wheel 69 or otherwise, and to overcome this difficulty we have devised the means of making said stem 68 separate from valve 61 and adapted to contact with said valve 61 to seal it shut as well as to limit the degree said valve 61 may be opened by the force of the air it is adapted to keep from valve 53.

The air pressure from the common source, supplied through waster valve 119 by pipe 123 to chamber 70, and against piston 62, holds valve 61 firmly to its seat, when present and when stem 68 is removed from contact with said valve 61. Such air pressure in chamber 70 may be instantly released and valve 61 correspondingly opened to the degree permitted by the extent that said stem 68 is manually withdrawn from contact with a portion of valve 61, and which degree controls the velocity of car 8 in its launching movement so that said velocity may be thus controlled both within the time above specified as well as for any increase that may be desired in said specified time.

It is essential that car 8 be latched at a fixed immovable point as if said point be movable or yielding the travel space of car 8 into its launching movement is detracted from to said extent which results in a less than normal launching velocity.

The fact that in all practical launching means the pressure upon the lock locking the launching car in its initial position is from eight thousand to twelve thousand pounds, for instance, upon the relatively small area of said lock in contact with said car, at the time of the release of said lock precludes any direct manual releasing of such locks of the prior art. We have discovered that the toggle levers 71, 72 and their cooperating cam 73 provide an efficient means of locking and unlocking said lock subjected to such pressure and that such means may be actuated normally as well as by power, and further that it is essential to the aircraft personnel, as well as to the plane that accelerations of the launching movement be gradual and not sudden.

The pivoting of lock member 16 at a point 16a below its cooperating notch 15 together with the means for permitting said member 16 being tilted forward and downward, affords a definitely controlled gradual starting of car 8 such as will not distress either said personnel or plane. Besides said toggle levers 71, 72 being then in substantially a straight line and in contact with said cam 73 only at the intermediate joint of said toggle occasions but little of the force on said cam that is exerted by said car 8 upon pivoted lever 16, practically all of said force being borne by the stationary fulcrum of said toggle and thus it requires but little force of said cam 73 to move said toggle members 71, 72 beyond a straight line from which point the stress of car 8 on lock rocker-arm 16 completes the unlocking of said car. The opening 71a, through the side member 1 of the framework supporting the tracks 18, and in line with the point of contact of toggle lever 71 with rocker arm lock 16, enables the convenient insertion of pin 88 and a ready view by an operative to determine that said members are in operative relation before even the pressure is applied to piston 26 to take the slack out of the mechanism precedent to applying the supplemental lock releasing and the launching pressures.

The arrangement of the gauges 118, 65, 84' and 132 adjacent the master valve 119, see Figures 1B and 2B, has been devised to afford the operator of said valve to determine at a glance that the several coordinated means, in communication with their respective said gauges, are functioning properly.

While the proximity of valves 115, 130 and the manual control wheel 69 of valve 61 to said master valve 119 has been devised to enable the operator of said valve 119 to readily operate each of said stated other valves, when required with little if any movement from his usual operating position.

The pipe 141, Figure 24, leading from the source of air pressure supply, entering the launching mechanism through the tubular center of the swivel mounting of the launching

mechanism has been devised to relieve said swivel-mounted launching mechanism of the strain of carrying therewith the ponderous means comprising the source of air pressure supply, and to enable the launching mechanism framework and its swivel mounting to be constructed lighter and the more readily relatively moved, with less friction and wear, in the launching of the plane in the most advantageous direction.

The swivel mounting of the launching mechanism upon a relatively long stationary bearing member (135b, Fig. 24) extending between the relatively wide channel bars 138 of the launching means framework, and having a bearing surface extending substantially the width of said bars 138 and whose cooperating bearing sleeve (137) is revoluble thereon and secured to and between said bars at a point adjacent said bearing member has been devised by us for the further purpose of affording lightness, strength, compactness and disposing the main bearing so as to resist the great longitudinal stress on the launching framework occasioned by the launching and deceleration of car 8.

The nesting of the auxiliary air pressure tank members 57, 57a, 57d has been devised to carry, in compact form between and protected by, the closely spaced channel bars 138, Figure 24, of the launching framework, the supply of air pressure, in excess of the volume thereof required for any launching, and close to the means upon which such pressure is to be exerted.

The provision of the main valve means 56, Figures 3 and 5, secured directly to one end, and of substantially the diameter of auxiliary air pressure supply tank 57, with the securement of the car travel control valve 52 to the other end of said relatively short valve means 56 and the connection of said valve 52 into the end of cylinder 26, to admit the air pressure through ample short connections in the direction of working travel of piston 29, has been devised to facilitate the obtainance of the requisite launching velocity in the extremely short time and travel space affordable upon a vessel without substantial impairment of the normal other functions of such vessel.

The leakage of air around each of the pistons 107 in cylinders 108 has been devised for the purpose of avoiding undue or dangerous pressure in said cylinders and their piping 111 and 117 remote from safety blow-off valve 116 due to the impact of air-pressure, occasioned by the opening of valve 115, upon the motionless air pressure in said cylinders and their adjacent piping, which would occur, as we have discovered but for said leakage which also enables gauge 118 to indicate the substantially uniform pressure in said cylinders and their piping leading from valve 115 to gauge 118. It requires for instance, 120 pounds per square inch, of pressure, from header 84 to pipe 82 and upon piston 83' before spring 83'' permits piston 83' to close pipe 82' from the atmosphere and permit said pressure to enter pipe 82' and proceed thence to piston 81' and operate cable 78 to release lock 16 of car 8; but before said car release is accomplished the air pressure against piston 29 and 83' has been increased from the initial slack removing pressure, of for instance 40 pounds per square inch, to said higher pressure, for instance of 120 pounds per square inch, by pipe 55' from header 84, Figure 1B, into connection 55, Figure 4, opening into cylinder 26, as well as above said higher pressure to the extent of the initial application to piston 29 of the launching pressure, but not the maximum of said pressure as far as we have been able to use practically with safety to pilot and the mechanism, before car 8 is unlocked and permitted to commence its launching movement. While this places very substantial stress upon the relatively small surface of detent 16, in contact with notch 15 in car 8, yet such progressively applied pressures are essential upon piston 29 in order to practically accomplish the plane launching in the extremely limited space available, for instance upon a ship, with safety to the pilot and mechanism. Such progressive increment of said pressures before, as well as after, the unlocking of car 8 contributes substantially to the smoothness of operation of the mechanism without shock or counteracting vibrations at the necessary high velocity requisite for plane launching in the extremely limited space available.

The pressure supply means 141 supplies air pressure, from a power plant located independent of the swiveled upper portion of the launching means, to the storage tank within said latter means; and this was devised to enable said storage tank to act as an accumulator from a relatively small power plant, as if the air pressure were directly supplied from a power plant to cylinder 26 it would require a ponderous plant to deliver the required pressure volume and velocity required, as well as that such plant should start and stop in definite relation to the unlocking as well as deceleration commencement of said car, and which would be a practical impossibility with present known means. Even if same were practically possible, failure for even a tenth of a second of said power plant would result in failure to launch a plane.

The launching of a plane from a track of great length may be afforded by the plane itself or by independent power which does not ordinarily involve difficult problems; but the safe and successful launching of a plane by independent power required to be exerted, accelerated and decelerated in a relatively limited space, especially in such an extremely limited space as afforded on a ship, for instance, involves intricate problems of great difficulty whose successful solution requires and includes the selection of the agencies and means the precise coordination thereof, great refinement of detail, the ascertainment and utilization of the most efficient relative weights, acceleration and deceleration velocities of the parts and the stresses thereon, the utilization of every means even of minor separate tendencies, and their coordinated mass effect upon each of the functions as well as upon the ultimate result.

The presence or absence of many, if not all of these in such a method and structure operable in such a limited space contribute to the success or failure of the objective.

It will be understood that the above description and accompanying drawings comprehend only the general and preferred practice of our method as well as mechanical embodiment of our invention and that minor detail changes in the method, construction and arrangement of parts may be made within the scope of the appended claims without sacrificing any of the advantages of our invention.

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

What we claim is as follows:

1. In an airplane launching catapult, having a

track and a launching car thereon, the combination of a fluid storage tank, means for introducing a fluid within the tank under pressure, means for transforming the energy contained in the compressed fluid into movement of the car along the track, means for securing said car in initial position on said track, and means independent of said securing means for releasing said securing means by an independent application of said fluid.

2. In an airplane launching catapult, having a track and a launching car thereon, the combination of a fluid storage tank means for introducing a fluid under pressure within the tank, a cylinder, a piston within the cylinder, means for transferring the fluid from the tank to within the cylinder, means for transmitting the motion of the piston to the car for translation of the car along the track, means for securing said car in initial position on said track, and means independent of said securing means for releasing said securing means by an independent application of said fluid.

3. In an airplane launching catapult, having a track and a launching car thereon, the combination of a fluid storage tank, means for introducing a fluid within the tank under pressure, a cylinder, a piston within the cylinder, means for imparting movement of the piston to the car, means for transferring fluid from the storage tank to the cylinder for initially moving said car, and means including a cam for automatically admitting, regulating and closing the further flow of fluid from the storage tank into the cylinder as the car progresses along the track.

4. In an airplane launching catapult, having a track and a launching car thereon, the combination of a fluid storage tank means for introducing a fluid within the tank under pressure, a cylinder, a piston within the cylinder, motion multiplying pulleys and cables connecting the car and the piston, a braking mechanism located near the end of the catapult track, means for transferring the compressed fluid from the storage tank to the cylinder, means upon the car for engaging the braking mechanism as the car approaches the end of the track, and means including a cam for progressively admitting, controlling and discontinuing the pressure within the cylinder as the car moves along the track.

5. In combination with an airplane launching catapult having a track, a car movable along the track and means for driving the car along the track, means for locking the car in starting position, means for releasing said locking means, means for applying power to said first named means while said locking means holds said car, and means for substantially simultaneously applying further power to said first named means and independently applying said further power to said means for releasing said locking means.

6. In combination with an airplane launching catapult having a track, a car movable along the track, means for driving the car along the track, means for locking the car in starting position and means for automatically unlocking the car and actuated by the independent application of an independent part of the force which actuates said first named means.

7. In combination with an airplane launching catapult having a track, a car movable along the track, means for driving the car along the track, means for locking the car in starting position, means for automatically unlocking the car and actuated by the independent application thereto of an independent part of the force which actuates said first named means, means for securing, against vertical and other substantial relative movement, said plane and car at a plurality of separated points in the direction of said track, and means for releasing the airplane from the car.

8. In combination with an airplane launching catapult having a track and a car upon the track, means for locking the airplane to the car at a plurality of points separated in the direction of said track, and means for automatically releasing the airplane from said car successively at said points, said successive release commencing after the car and airplane have travelled a predetermined distance along the track.

9. In combination with an airplane of launching means therefor, bolt and bolt-keeper means for locking from substantial movement in all directions said airplane to an element of said means at a plurality of points separated in the direction in which said plane is launched, and means for successively releasing said locking means.

10. In combination with an airplane of launching means therefor, separate coating bolt and bolt-keeper means carried by the airplane and an element of said means at a plurality of points separated in the direction in which the plane is launched for locking said airplane to an element of said means at each of a plurality of points separated in the direction in which said plane is launched, and means for successively releasing said locking means.

11. In combination with a normal airplane, of launching means therefor, separate means for locking said airplane to an element of said means at each of a plurality of points on opposite sides of said plane, said points being separated in the direction in which said plane is launched, and means for successively releasing said locking means.

12. In combination with an airplane of launching means therefor, means for locking said airplane to an element of said means at a plurality of points separated in the direction in which said plane is launched, and means for successively releasing said locking means at intervals in the launching movement of said plane and commencing with the rearmost locking means.

13. In combination with an airplane of launching means therefor having a car adapted to support said plane; and means, including a pin and coacting keepers therefor on said car and plane with said pin extending in the launching direction, for removably securing said plane to said car.

14. In combination with an airplane of launching means therefor having a car adapted to support said plane; and means, including a plurality of pins extending substantially in the launching direction and each provided with coacting keepers therefor, for removably securing said plane to said car.

15. In combination with an airplane launching catapult having a track, and a car upon the track, means for locking the airplane to the car said means consisting of a plurality of keeper plates mounted upon the car, pins mounted within the keeper plates, a plurality of wires fastened to the airplane and held by the pins, and means for removing the pins after a predetermined distance of travel of the car along the track.

16. In combination with an airplane launching catapult having a track, and a car upon the track,

means for locking the airplane to the car said means consisting of a plurality of keeper plates mounted upon the car, pins mounted within the keeper plates, a plurality of wires fastened to the airplane and held by the pins and means for removing the pins after a predetermined distance of travel of the car along the track, said means consisting of a plurality of slack cables one end of each cable fastened to the track and the other end engaging the pin in each of the keeper plates.

17. In combination with an airplane launching catapult having a track and a car upon the track, means for locking the airplane to the car, means for releasing the airplane from the car and means acting at a substantial angle to the direction of movement of said car for producing a gradual retardation of the movement of the car along the track as the car approaches the end of the launching run.

18. In combination with an airplane launching catapult having a track and a car upon the track, means for locking the airplane to the car, means for releasing the airplane from the car after a predetermined distance of travel of the car along the track; and a plurality of pneumatic means, each progressively commencing to act upon said car for producing a gradual retardation of the movement of the car along the track as the car approaches the end of the launching run.

19. In combination with an airplane launching catapult having a track and a car upon the track, means for locking the airplane to the car, means for releasing the airplane from the car after a predetermined distance of travel of the car along the track, and pneumatic means for producing a gradual retardation of the movement of the car along the track as the car approaches the end of the launching run, said means consisting of a brake member rigidly attached to the lower side of the car, a plurality of brake shoes movably mounted upon the track and adapted to engage said brake members, a plurality of levers one end of which engage the brake shoes, the other end of which are connected together by a toggle joint, a piston connected to the mid-point of the toggle joint, a cylinder surrounding the piston and means for forcing a fluid under pressure into the space between the cylinder and the piston.

20. In combination with airplane launching means and a support therefor, of a brake shoe secured to a movable element of said means, a pair of brake-shoes mounted on said support opposite each other and on opposite sides of said brake shoe mounted on said support for actuating said shoes to produce braking stress on opposite sides of said pair of first named braking shoe.

21. In combination with airplane launching means and a support therefor, of a brake shoe secured to a moving element of said means, a plurality of pairs of brake shoes mounted opposite each other and on opposite sides of said brake shoe, in the path of the latter portion of travel of said element, means for movably mounting said pairs of shoes on the support for said launching means mounted on said support for simultaneously actuating said pairs of shoes to produce braking stress on opposite sides of said first named braking shoe in the latter portion of its travel.

22. In combination with airplane launching means and a support therefor, of a brake member secured to a moving element of said means, brake shoes mounted opposite each other and on opposite sides of said brake member, in the path of the latter portion of travel of said element, means for movably mounting said shoes on the support for said launching means, supplemental shoes on the sides of said brake-shoes, and means for actuating said shoes to produce braking stress on opposite sides of said braking member in the latter portion of its travel.

23. In combination with airplane launching means having a support, of a brake shoe secured to a moving element of said means, additional brake shoes mounted opposite each other and on opposite sides of said brake shoe, in the path of the latter portion of travel of said element, means for movably mounting said additional shoes on the support for said launching means, and a plurality of means mounted on said support and disposed in the direction of the extent of said shoes for simultaneously actuating said additional shoes to produce braking stress on opposite sides of said braking shoe.

24. In combination with airplane launching means and a support therefor, of a brake member secured to a moving element of said means, brake shoes mounted opposite each other and on opposite sides of said brake member in the path of the latter portion of travel of said element, means for movably mounting said shoes on the support for said launching means, the ends of said shoes approached by said brake member being provided with a beveled mouth, and means for actuating said shoes to produce braking stress on opposite sides of said braking member in the latter portion of its travel.

25. In an airplane launching mechanism, a base, launching means, means for swiveling said launching means to said base and having an opening through its neutral axis, means independent of said launching means for supplying power, means for storing said power, means for mounting said storing means on said swiveled launching means, means extending into said opening and flexibly connecting said power supply and said power storage means, and means for transforming said stored power into launching movement of said airplane.

26. In an airplane launching mechanism, a base, launching means, means for swiveling said launching means to said base and having an opening through its neutral axis, means for storing a power medium, means for mounting said storing means on said swiveled launching means, means for passing a power medium into and out of said opening and to said storing means, and means for transforming said stored power medium into launching movement of said airplane.

27. In an airplane launching mechanism, a car, means for removably securing said plane upon said car, means for securing said car from movement, means for generating a pressure to be applied to said car, means for applying some of said pressure to said secured car, means for successively applying further pressure to said car and releasing by said further pressure said means for securing said car, means for accelerating said pressure upon said car, means for decelerating said car in the latter portion of its travel, and means for releasing said plane from said car.

28. In an airplane launching mechanism, a car, means for removably securing said plane upon said car, means for securing said car from movement, means for generating a pressure to be applied to said car, means for applying some of said pressure to said secured car, and means for successively applying further pressure to said car

and releasing by said further pressure said means for securing said car.

29. In an airplane launching mechanism, a car, means for removably securing said plane upon said car, means for securing said car from movement, means for generating a pressure to be applied to said car, means for applying some of said pressure to said secured car, means for successively applying further pressure to said car and releasing by said further pressure said means for securing said car, and means for accelerating said pressure upon said car.

30. In combination with a pneumatic launching catapult having a track, a launching car upon the track, pneumatic means for moving the car along the track, and a storage tank for supplying air to the pneumatic driving means, means for locking said car in initial position on said track, separate pneumatic means for releasing said locking means, and a single pneumatic means for controlling the movements of each of said pneumatic means.

31. In combination with a pneumatic launching catapult having a track, a launching car upon the track, pneumatic means for moving the car along the track, and a storage tank for supplying air to the pneumatic driving means and a single pneumatic means for controlling the movements of the driving means, said means consisting of a single valve comprising a casting having a plurality of passages therein one passage of which is connected to the storage tank another passage of which is connected to the pneumatic driving means, a valve seat between these passages, a valve within the casting, means for manually seating the valve against the valve seat, pneumatic means for holding the valve against the seat, means for disconnecting the manual means from the valve, means for releasing the pneumatic means for the instantaneous flow of air from the storage tank through the interconnected passages, and means for automatically maintaining an approximately even pressure within the pneumatic driving means as the car moves along the track.

32. In combination in a pneumatic launching catapult a track, a launching car upon the track, a draft cable connected with the car, motion transmitting mechanism including a cylinder and a piston, for transmitting motion to the draft cable, a storage tank for compressed air, a pneumatic valve between the storage tank for compressed air, a pneumatic valve between the storage tank and the cylinder, means for locking the car in starting position, pneumatic means for releasing the locking means and a single manually operated valve for operating the releasing means and for operating the pneumatic valve between the storage tank and the cylinder.

33. In combination in a pneumatic launching catapult, a track, a launching car upon the track, a draft cable connected with the car, motion transmitting mechanism including a cylinder and a piston for transmitting motion to the draft cable, a storage tank for compressed air, a pneumatic valve between the storage tank and the cylinder, means for locking the car in starting position, pneumatic means for releasing the locking means pneumatic means for maintaining said means in an operative condition, and a single manually operated valve for placing the releasing means in an operative condition, and for operating the pneumatic valve between the storage tank and the cylinder.

HOLDEN C. RICHARDSON.
WILLIAM M. FELLERS.