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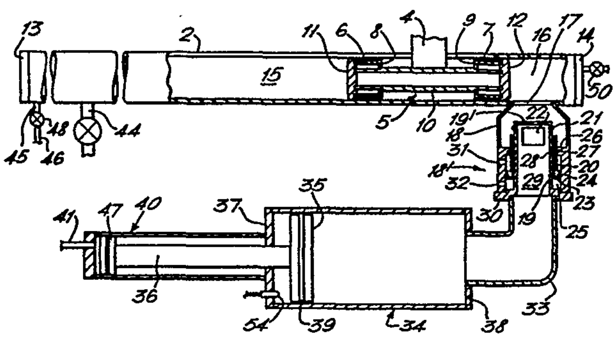
(54) **Air launcher.**

(57) An air launcher has a charge reservoir (34) with a displacement member (35). On opening of a firing valve (18'), charge pressure air is admitted to the barrel (2) of the air launcher for propelling the main piston (5). As charge air flows into the barrel space (16), the displacement member (35) is driven by an actuator (40) to maintain the charge air pressure substantially constant, whereby acceleration of the main piston (5) is substantially constant.



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AIR LAUNCHER

Background of the Invention

The present invention relates to an air launcher.

As used herein, the term "air launcher" means a compressed gas operated gun comprising a barrel, a firing valve at the breach end of the barrel and a compressed gas charge reservoir connected to the breach end of the barrel via the firing valve, from which reservoir compressed gas is delivered to the barrel when the valve is opened for "firing" the gun. Usually the compressed gas will be air, but other gases may be used.

Usually the pressure of the gas propelling a projectile along the barrel of the gun will drop as the gas expands with movement of the projectile towards the muzzle end of the barrel. Provided no pressure losses are experienced in the valve, the expansion will be substantially adiabatic:

$$\text{Pressure x Volume}^{\gamma} = \text{Constant.}$$

Such expansion results in the acceleration given to the projectile being initially high on opening of the valve and falling thereafter, the acceleration being substantially proportional to the pressure. For some projectiles it is desirable to provide a constant acceleration. For instance, if a projectile can withstand a certain acceleration only, it can be accelerated to a higher speed if the acceleration is maintained throughout the passage of the projectile along the barrel than if the acceleration initially reaches the certain value as a peak and subsequently drops.

Substantially constant acceleration can be achieved by maintaining the pressure of the compressed gas substantially constant. A large charge reservoir can provide a more constant acceleration than a small charge reservoir, since the change in volume experienced by the gas in the reservoir and in the barrel as the projectile moves down the barrel is less. However an air launcher with a large reservoir makes less efficient use of its gas charge since all the gas is vented to atmosphere after the projectile has left the barrel.

The object of the invention is to provide an improved air launcher giving a constant, or at least substantially maintained, acceleration to a projectile on firing.

The Invention

An air launcher of the invention has a charge reservoir having a variable volume and includes a displacement member adapted to reduce the volume of the charge reservoir on firing of the air launcher and an actuator for driving the displacement member in such manner on firing.

Conventional air launchers are constructed with their charge reservoirs circumferentially disposed around their firing valve. This arrangement is possible in the present invention, with the displacement member being an annular piston forming one end wall of the charge reservoir. However, the arrangement is inconvenient in that annular pistons are complex. An alternative is to provide the piston in a circular cylindrical secondary charge reservoir connected to the main charge reservoir surrounding the valve. However, this arrangement can be improved upon by adopting the arrangement of the preferred embodiment wherein substantially the entire charge reservoir is provided separately from the barrel of the air launcher. This has the advantage of enabling the reservoir to be compactly positioned alongside the barrel. The valve may still be provided in the breach of the gun. However, again it is preferred to provide the valve separately from the barrel in a passage connecting the reservoir to the barrel. This has the advantage of enabling the valve to be of a relatively compact length and diameter.

Although it is envisaged as possible that the displacement member may be a diaphragm, it is preferably a piston acting in the circular cylindrical reservoir.

The actuator may be a hydraulic piston-and-cylinder unit. Alternatively, as is preferred, it may be a pneumatic piston-and-cylinder unit. The pneumatic pressure driving the actuator may be similar to that of the compressed gas charge in the charge reservoir provided the initial volume of the actuator and its pressure gas storage is larger than that of the reservoir. However, the said pneumatic pressure is preferably considerably larger than that of the reservoir, whereby the piston in the actuator can be considerably smaller than the piston in the reservoir. Thus the swept volume in the actuator is smaller at least where there is a one-to-one mechanical advantage between the two pistons. This has the advantage that the change of volume in the actuator is small in comparison with the change in volume of the reservoir per se (excluding the associated barrel volume). Thus if for example the initial charge reservoir volume is comparable to the initial actuator and storage volume, the change in volume in the actuator and storage will be a small proportion of its original volume giving a substantially constant actuator force producing a substantially constant reservoir pressure with a swept volume preferably corresponding to the major part of the original reservoir volume.

Where the charge reservoir pressure is comparatively low and the ratio of the charge reservoir pressure to the actuator pressure (in accordance with the respective piston area ratios) is such as to permit it, the actuator pressure may be kept constant by utilising pressure gas whose pressure has been dropped from the storage gas pressure to a constant pressure in a pressure regulator interposed between the storage and the actuator.

Where a high charge reservoir pressure is required such that a pressure regulator cannot be used; or where sufficient flow cannot be obtained through the pressure regulator to obtain a constant actuator pressure; or only a small storage volume is available in comparison with the charge reservoir volume, loss of actuator pressure during travel can be compensated for by providing a variable mechanical advantage between the actuator piston and the reservoir piston. Conveniently such a variable mechanical advantage may be provided by systems of levers. Preferably the mechanical advantage of the actuator piston with respect to the reservoir piston increases substantially in proportion to the distance travelled by the actuator piston raised to the power of y; whereby the loss of pressure in the actuator is compensated for to provide a constant pressure in the reservoir.

Preferably the diameter of the reservoir is substantially larger than the diameter of the barrel whereby the barrel can be comparatively long - for acceleration of the projectile over a longer time and distance to a higher speed - with respect to the length of the reservoir and the stroke of its piston.

In order to decrease the travel of the reservoir piston, a plurality of shorter stroke reservoir pistons may be provided ganged together to a single actuator.

Typically the pressure ratio between the reservoir and the actuator may be between 10 : 1 and 40 : 1.

Two significant advantages of an air launcher of the invention are firstly that it permits the use of a comparatively small charge reservoir volume and secondly it permits the use of a comparatively short barrel for a given maximum acceleration and "muzzle" velocity.

The Drawings

To help understanding of the invention, various specific embodiments thereof will now be described by way of example and with reference to the accompanying drawings in which:-

Figure 1 is a perspective view of a first air launcher of the invention;

Figure 2 is a cross-sectional view of the breach end of the air launcher of Figure 1;

Figure 3 is a pneumatic circuit diagram of the air launcher of Figures 1 and 2;

Figure 4 is a cross-sectional view of a braking cannister which may be incorporated as an alternative to the braking arrangement shown in the air launcher of Figure 2;

Figure 5 is a cross-sectional view of an alternative firing valve for the air launcher of Figure 1;

Figure 6 is a diagrammatic cross-sectional view of another air launcher of the invention; and

Figure 7 is a diagrammatic cross-sectional view of an alternative charge reservoir and accummulator arrangement for the air launcher of Figure 2.

First Embodiment of the Invention

Referring first to Figures 1 and 2, the air launcher 1 there shown has a barrel 2 having a so-called slotted cylinder through the slot 3 of which a tongue 4 extends from a piston 5 for propelling a projectile. (The slotted cylinder is a device known in itself having a pair of strips (not shown) which normally close the slot in a pressure-tight manner. One of the strips passes above the level of the barrel wall and the other passes below the level of the barrel wall at the tongue to allow the tongue to extend out of the barrel wall and travel along the barrel. The barrel remains sealingly closed by the strips on both sides of the barrel.)

The piston 5 is of composite structure carrying front and rear seals 6,7 on respective flanged annular members 8,9 captive to a central tubular member 10 by end caps 11,12. The tongue 4 is secured to the tubular member 10. The barrel 2 has front and rear sealing end closure caps 13,14, whereby the barrel spaces 15,16 on either side of the piston

5 are sealed.

Adjacent the rear end cap 14 of the barrel a charge air port 17 is provided for admitting charge pressurized gas preferably air to the barrel space 16 behind the piston 5. At the port 17 a valve housing 18 is sealingly fixed to the barrel. The housing 18 is generally cylindrical and accommodates a cylindrical inner member 19 having a closed free end 19'. Between the inner member 19 and the housing 18 is slidingly accommodated a sleeve valve member 20, which is shown in Figure 2 in its open position. When the valve member 20 is moved forwards towards the barrel 2, its forward end co-operates with an annular seal 21 to close ports 22 in the member 20 and hence close the valve, generally designated 18'. When the valve member 20 is moved back, the ports 22 are opened.

The valve member 20 has a rear flange 23, having a seal 24, which co-operates with an annular space 25 between the members 18 and 19 in the manner of a piston-and-cylinder unit. An inwards extending flange 26 of the housing 18 defines a forward end of the space 25 and carries a seal 27 which in conjunction with an oppositely positioned seal 28 in the inner member 19 seals the valve piston-and-cylinder from the interior 29 of the valve housing 18. A flange 30 in the rear end of inner member 19 is sealingly secured to the housing 18 to define the rear end of the space 25. Ports 31 and 32 in the housing 18 to the space 25 on opposite sides of the piston flange 23 allow admission of pressure air to either end of the space 25 for moving the valve member 20. It should be noted that the valve 18' is pressure balanced in that the pressure across the valve member 20 provides negligible resistance to movement thereof, especially when the pressure within the valve member is higher and the valve is being opened, and hence opens very quickly with negligible subsequent pressure drop thereacross. Early in the process of opening of the valve 18', the charge reservoir pressure acts on the top face 20' of the valve sleeve to accelerate the process of opening of the valve 18'.

Via the inner member 19, the valve is sealingly connected to a bend 33; itself sealingly connected to a charge reservoir 34. The reservoir is circular cylindrical and has a piston 35 with a rod 36 passing out of end plate 37 of the reservoir opposite from the end plate 38 connected to the bend 33. The piston 35 is sealed via its seal 39 to the charge reservoir. Accordingly, with the valve 18' open charge air is captive between the piston 35 in the reservoir 34 and the piston 5 in the barrel 2.

Attached to the end plate 37 of the reservoir 34 is an actuator 40 in the form of a high pressure piston-and-cylinder unit whose piston 47 is connected to the opposite end of the rod 36 from the charge reservoir piston 35. Via a port 41, the working space of the actuator 40 is connected to a comparatively large high pressure air storage 42, with interposition of a pressure reducing regulator valve 43 for passing air at a constant pressure from the reservoir 42 to the actuator 40, see Figure 3.

At a position close to the front end cap 13 of barrel 2, the latter is provided with a closable port 44 to the ambient. Between the port 44 and the end cap 13 a further port 45 is provided with a pipe 46 connecting it to a pressure air storage reservoir 42. A valve 48 is provided in the pipe 46.

Typical diameters of the pistons are as follows:-

Main piston 5	7.87 in	(200mm)
Charge reservoir piston 35	15.75 in	(400mm)
Actuator piston 47	3.94 in	(100mm)

Typical strokes of the pistons:-

Main piston 5	20ft	(6 metres)
Charge reservoir piston 35	3ft 3in	(1 metre)

Above the barrel a track 60 is provided for a trolley 61 fast with the piston 5 via its tongue 4. A projectile to be launched can be mounted on the trolley.

Operation of the First Embodiment

Operation of the air launcher of Figures 1 and 2 will now be described with reference to Figure 3, which shows the device actually firing. The valve 18' is open allowing charge air to pass from the reservoir 34 into the space 16 behind the piston 5 thereby driving the latter along the barrel. High pressure air from the storage 42, typically at 4,500 psi (30 MN/m^2), drops pressure to 2,400 psi (16MN/m^2) in the regulator 43 and acts on the piston 47 of the actuator 40. Due to the area ratio of this piston 47 and the piston 35 of the charge air reservoir 34, the charge air pressure therein is maintained at 1,500 psi (1MN/m^2).

During travel of the piston 5 in the barrel 2, the port 44 is maintained open, whereby the pressure in front of the piston remains at ambient pressure at least until the piston 5 passes the port 44. At this point the piston, and the attached trolley 48, will have attained maximum launch velocity. As soon as the port 44 is passed, pressure builds up in front of the piston 5 to brake it, whilst the charge pressure driving the piston is dumped to ambient through the port 44 - with the result that the pistons 35 and 47 stop at the end of their travel. Meanwhile, the main piston 5 is brought to rest by the build up of pressure in front of itself. Once it has stopped, it rebounds until it has returned to the vicinity of the port 44.

The air launcher is then ready for recharging. Two actions are involved which can occur simultaneously, but are essentially independent. Initially the valve 18' is closed with use of a servo valve 49. Then in the first action, the port 44 is closed, and the valve 48 is opened to admit pressure air from the storage 42 to the barrel space 15. Valve 48 is ganged to valve 50 in the breach end cap 14 to vent the barrel space 16 to ambient. The piston 5 is thus driven back down the barrel. When it reaches the breach end, the valves 48,50 are closed and the port 44 is opened again ready for the next firing.

In the second action, after closure of the valve 18', a bleed 51 from the actuator working space 52 is opened via valve 53 to admit charge pressure air to the reservoir 34. Due to the area ratios of the pistons, the quantity of air required to charge the relatively low pressure reservoir 34 is approximately that contained in the relatively high pressure actuator working space 52. When the pistons 35,47 have returned, to the left in Figure 3, a trip 54 closes the bleed valve 53. An isolating valve 55 is ganged to the bleed valve 53 to isolate the actuator space 52 from the storage 42 during this charging transfer action. When the bleed valve 53 is closed the isolating valve 55 is opened. Any short-fall in charge air for the reservoir 34 can be made up direct from the storage 42 on line 56 via a valve 57. It is by these latter that the reservoir is charged for a first charging of the air launcher.

First Variant of the First Embodiment

Referring now to Figure 4, an alternative to the braking arrangement at the muzzle end of the Figure 1 air launcher will now be described. In the Figure 1 air launcher, the air trapped for braking the piston 5 is compressed from ambient pressure, and a relatively long compression stroke is required. In the Figure 4 arrangement the compression/ braking stroke is reduced by utilising a brake which is initially pressurized to a high pressure, typically 1,000 psi (67 MN/m^2).

At the "muzzle" end of the barrel 71 a braking cannister 72 is provided in the form of a stepped cylinder 73 having a large diameter portion 74 and a small diameter portion 75. The left hand end 76 of the cannister is fast with the barrel end cap 77 with a cannister charging bore 78 passing through both components 76,77. Captive within the large diameter portion 74 of the cannister is a piston 79 having a tapered periphery engageable in the mouth of the small diameter portion 73 at the step 80 between the portions. A light spring 81 urges the piston into engagement with the step. The piston 79 has a small drilling 82 typically 0.020in. (0.5mm.) through it. The free end of the small diameter portion has a lip 83 captivating a light weight small piston 84.

The main piston 85 of the air launcher has a hollow construction 86 whereby the small diameter portion of the braking cannister can extend into it. The front seal 87 of the piston 85 is provided about the mouth of the hollow 86. A rod 88 extends axially of the hollow to its mouth.

In use, the free end of the rod 88 abuts the light weight piston 84, when the piston 85 has traversed the greater part of the length of the barrel. As the piston is moved down the small diameter portion 75 of the cylinder 73 the high pressure of gas introduced into the cannister via the bore 78 acts on the piston 84 to brake the main piston 85. The tapered piston 79 is forced out of its seat at the step 80. When the main piston 85 has been braked to a halt the majority of the gas has been expelled from the small diameter portion 75. Pressure in the cannister forces back the main piston. However its speed of rebound is restrained by the tapered piston 79 moving into sealing engagement with the seat 80 whereby pressure gas must pass through the small drilling 82 to drive back the main piston 85. The small diameter of the drilling 82 is such as to control the speed of rebound. In other respects, the operation of an air launcher including this brake is as described with reference to Figure 3.

Second Variant of the First Embodiment

Referring now to Figure 5, the valve 18" there shown is an alternative to the valve 18' of Figure 2 having a housing 518. The upper, free end of the sleeve 520 of the valve has a radially inwards directed flange 520a. The upper free end of an inner member 519 fixed to the housing 518 has a radially outwards directed flange 519a, extending in line with the closed end 519' thereof. In the closed position of the valve, the sleeve flange 520a is below the inner member flange 519a, i.e. the sleeve flange 520 is positioned in the opening direction thereof from the inner member flange 519a. Set in the inner member flange 519a is a face seal 521 against which the sleeve flange 520a abuts in the closed position of the valve 18". The diameter of the seal 521 is smaller than the internal diameter of the sleeve, such that the charge pressure air, having passed through the ports 522, acts on the inside of the flange 520a (see arrow P) radially outwardly of the seal 521. Thus the charge pressure air acts to close the valve 18".

On admission of firing pressure via valve 531 a higher pressure is required than in the Figure 2 arrangement. This is advantageous in avoiding misfiring. Once the firing pressure acting on the sleeve's piston 524 overcomes the charge pressure on the flange 520a, the valve opens. The charge pressure then acts on the opposite side of the flange 520a, i.e. on the side previously abutting the seal 521, and accelerates the sleeve 520 towards its open position.

Second Embodiment of the Invention

Turning now to Figure 6, the air launcher 101 there shown, has a barrel 102 having at its breach end a sleeve valve 103 of the type which opens virtually instantaneously to give substantially no pressure drop between the barrel and an annular charge reservoir 104, arranged peripherally of the sleeve valve 104. The reservoir 104 has a charge gas displacement piston 105 sealingly arranged therein. The piston 105 has seals 106,107 sealingly engaging the radially outer and inner internal surfaces of the charge reservoir. Movement of the piston along the reservoir alters its volume.

The piston 105 is mechanically connected by a rod 108 to a piston-and-cylinder unit 109 pneumatically connected with the interposition of a valve 110 to a high pressure gas store 111. The valve 110 may be ganged to open simultaneously with the valve 103. Alternatively the valve 110 may be permanently open or even omitted, in either of which latter cases the ratio of pressures in the reservoir 104 and the gas store 111 is dictated by the area ratio of the annular piston 105 and the piston 112 in the piston and cylinder unit provided neither piston is against a stop.

On charging of the reservoir 104 with the valve 103 closed, the pistons displace allowing the reservoir to reach its maximum volume. On opening of the valve 103 and firing of the air launcher, charge gas moves into the barrel to propel the projectile. A small reduction of pressure in the reservoir allows the piston 112 to drive the piston 105 to displace charge gas into the barrel. Since the swept volume of the piston-and-cylinder unit 109 is small in comparison with its store 111 and bore losses in the piping connecting these components are small, the pressure on the piston 112 remains substantially constant whereby the force on the charge gas from the piston 105 remains substantially constant as does the pressure in the charge gas and hence also does the acceleration of the projectile 113 in the barrel 102. Figure 5 shows the projectile approximately half way along the barrel with the pistons at mid stroke.

As an alternative to the unit 109 extending out behind the barrel 102, the unit could be arranged in front of the charge reservoir either with the connecting rod passing through the reservoir or the piston 105 arranged at the front end of the reservoir.

With a reservoir charge pressure of 5 bar and an outer diameter of 500 mm and an inner diameter of 300 mm, the piston 112 may have a diameter of 44.7 mm to enable a storage pressure of 100 bar to balance the pistons. Such ratios give a swept volume ratio of 20 : 1.

Third Embodiment of the Invention

Turning now to Figure 7, the charge reservoir and accumulator arrangement there shown includes two features, namely an increasing mechanical advantage of the actuator over the charge reservoir piston and a duplication of charge reservoir pistons whereby a greater displacement can be achieved for a given movement. The first of these features enables not only a higher charge reservoir pressure to be obtained but also a more constant one. The second feature enables a comparatively short reservoir piston stroke to be utilized.

The barrel and valve for the air launcher including the arrangement of Figure 6 can be as described with respect to Figures 1 and 2 and will not be described in detail. A branched duct 201 leads to the firing valve 202 from twin charge reservoirs 203,204 provided in line beneath the barrel 205. Each charge reservoir has its piston 206,207 connected to a common connecting rod 208. The connecting rod passes sealingly through the front reservoir 203 to the rear reservoir 204 with the piston 206 carried medially of the piston rod. The forward end of the piston rod carries a roller 209 which bears against a lever 210 pivotally connected at one end 211 to the supporting framework 212 of the air launcher and at the other end 213 to the piston rod 214 of the actuator 215. The cylinder end 216 of the actuator 215 is also pivotally connected to the framework 212.

Figure 6 shows the actuator and charge reservoir with their pistons in mid-stroke. As the actuator extends in the general direction of arrow 217, the end 213 of the lever 210 describes a circular arc 218, whereby the moment arm 219 of the actuator about the lever end 211 increases, with decrease in the angle α between the actuator and the lever 210 towards 90°. The consequence is that as the pressure in the actuator storage 220 falls on expansion of its pressure air the mechanical advantage thereof over the pistons 206,207 increases so that charge reservoir pressure can be maintained substantially constant during travel of the pistons on firing of the air launcher. The provision of the two charge reservoirs provides twice the displacement of charge air into the barrel for a given piston displacement. This enables the individual charge reservoir diameters and/or strokes to be kept comparatively smaller than would be the case if a single charge reservoir alone were employed, as in the Figures 1 and 2 embodiment.

The operating cycle of this air launcher is similar to that of the embodiment of Figures 1 and 2 as described with reference to Figure 3 as regards firing and return of the main piston after firing. For recharging of the charge reservoir, charge gas is introduced directly into the charge reservoirs for displacing their pistons and returning the actuator to its initial position. No valve is provided between the actuator and its storage 220.

The invention is not intended to be restricted to the details of the above-described embodiments.

For instance the barrel may be another form of rodless cylinder, i.e. a cable cylinder, or indeed a rodded cylinder, as opposed to a slotted cylinder. The firing valve, such as 18',18",103,202, may be included in the barrel as such at its breach end, or in an axial extension of the barrel at its breach end, or in any duct leading directly to the breach end of the barrel. All these arrangements are intended to be included within the term "at the breach end of the barrel" as used in the second paragraph of this specification and in the claims.

CLAIMS

1. An air launcher comprising a barrel (2; 71; 205), a firing valve (18'; 103; 202) at the breach end of the barrel (2; 71; 205) and a compressed gas charge reservoir (34; 104; 203,204) connected to the breach end of the barrel (2; 71; 205) via the firing valve (18'; 103; 202), from which reservoir (34; 104; 203,204) compressed gas is delivered to the barrel (2; 71; 205) when the valve (18; 103; 202) is opened for firing the air launcher, characterized in that a displacement member (35; 106; 206,207) is displaceably provided in the charge reservoir (34; 104; 203,204) for displacing charge gas from the charge reservoir (34; 104; 203,204) by reducing the storage volume thereof on firing of the air launcher and that an actuator (40; 109 205) drivingly connected to the said displacement member (35; 106; 206,207) is provided for driving the displacement member (35; 106; 206,207) to reduce the said volume on firing.

2. An air launcher as claimed in claim 1, wherein the actuator (40; 109; 205) comprises a pressure gas piston-and-cylinder unit having a piston (47; 112) mechanically connected to the displacement member (35; 106; 206,207) and an associated pressure gas reservoir (42; 111; 220) pneumatically connected to the said actuator, the pressure gas from the said associated reservoir (42; 111; 220) acting on the piston (47; 112) of the said actuator to displace the said displacement member (35; 106; 206,207) on firing of the air launcher.

3. An air launcher as claimed in claim 2, wherein a pressure reducing valve (43) is provided between the said piston-and-cylinder unit (40) and the said associated reservoir (42).

4. An air launcher as claimed in claim 3, including a bleed (51) leading from the working space of the actuator (40) to the charge reservoir (34) for transferring pressure

gas from the actuator (40) to the charge reservoir (34) after firing the air launcher, a stop valve (53) in the bleed (51), a stop valve (55) in series with the pressure reducing valve (43) and a trip (54) actuated by the displacement member (35) for closing the two stop valves (53,55) which are ganged together and openable together for transferring pressure gas from the working space of the actuator (40) to the charge reservoir (34) for charging it.

5. An air launcher as claimed in claim 2 wherein the pneumatic pressure connection between the said piston-and-cylinder unit (109; 205) and its associated reservoir (111; 220) is permanently open whereby on charging of the charge reservoir (104; 203; 204) the displacement member (105; 206,207) displaces the piston of the said piston-and-cylinder unit against the pressure of the associated-reservoir pressure gas.

6. An air launcher as claimed in any preceding claim wherein the actuator (42; 111) is directly connected to the displacement member (35; 105) with a one-to-one mechanical advantage.

7. An air launcher as claimed in any one of claims 1 to 5, wherein the actuator (217) is connected to the displacement member (206,207) at a greater than one-to-one mechanical advantage.

8. An air launcher as claimed in claim 7, wherein the said connection is such that the said mechanical advantage increases with displacement of the displacement member (206,207).

9. An air launcher as claimed in claim 8, the said connection includes a lever (210) pivotally connected at one end (211) to framework (212) of the air launcher and at the other end (213) to a piston rod (214) of the actuator (215), the actuator (215) is pivotally connected to the framework (212) and the displacement member (206,207) is pivotally connected to the lever (210), the geometry of the connection

being such that the axis of the actuator (215) and the axis of lever (210) are at an angle greater than 90° at least initially on firing and that this angle decreases with displacement of the displacement member (206,207) whereby the mechanical advantage of the actuator (215) over the displacement member (206,207) increases with displacement.

10. An air launcher as claimed in claim 9, wherein the displacement member (206,207) is a piston having an axially guided piston rod (208), which is pivotally connected to the lever (210) via a roller (209) rolling on the lever (210).

11. An air launcher as claimed in any preceding claim, wherein a plurality of compressed gas charge reservoirs (203,204) are provided having their displacement members (206,207) ganged together for displacement by the actuator (215).

12. An air launcher as claimed in any preceding claim, wherein the firing valve (18'; 202) is a sleeve valve (18'; 202) in a valve housing (18) extending substantially perpendicularly from the barrel (2; 205) at its breach end, a sleeve (20) of the valve being displaceable in the direction of extent of the valve housing.

13. An air launcher as claimed in claim 12, wherein the charge reservoir (34; 203,204) is circular cylindrical with its axis parallel to that of the barrel (2; 205) and spaced therefrom, the breach end (38) of the reservoir (34; 203,204) being sealingly connected to the valve housing (18) and a piston rod (36; 208) from a piston (35; 206,207) constituting the displacement member extending from the other end (37) of the reservoir.

14. An air launcher as claimed in any preceding claim, wherein the barrel is an elongate cylinder (2; 71; 205) including a closure (13) closing its forward or muzzle end, a main piston (5) is provided in the barrel and a main piston braking arrangement is arranged at the forward end of the barrel.

15. An air launcher as claimed in claim 14, wherein the braking arrangement comprises the end closure (13), a port (44) in the barrel (2) spaced from its forward end, and a peripheral seal (6) on the main piston (5) sealing it to the barrel (2), the arrangement being such that, on passing the port (44) whilst travelling along the barrel (2) after firing of the air launcher, the main piston (5) traps air between itself and the end closure (13), which air becomes pressurized for braking the main piston (5).

16. An air launcher as claimed in claim 14, wherein the braking arrangement comprises a cannister (72) fixed in the barrel (71) at its forward end (77) and having a cylinder (73) closed at a forward end (76) and a piston (84) captive in the cylinder (73) at its rear end (83) which end is directed towards the breach end of the barrel (71), the cylinder (73) being parallel with the barrel (71); and a rod (88) attached to the main piston (85) and extending towards the forward end (77) of the barrel (71); the arrangement being such that after firing of the air launcher as the main piston (85) approaches the forward end (77) of the barrel (71) the rod (88) abuts the cannister piston (84), which piston had been held at the rear end (83) of the cannister cylinder (73) by pressurized gas therein, and drives the cannister piston (84) in against the pressure of the gas until the main piston (85) is braked.

17. An air launcher as claimed in claim 16, wherein the cannister cylinder (73) is stepped and includes a second piston (79) in a large diameter, front end portion (74), with the first cannister piston (84) being in a small diameter portion (75) which is at the rear end (83) of the cannister (73), and a spring (81) urging the second piston (79) into sealing engagement with a step (80) between the said portions (74,75), the second piston (79) having a small drilling (82) passing therethrough, the arrangement being such that on displacement of the first piston (84), the

second piston (79) is displaced from its seat (80) and on return of the pistons (84,79), the spring (81) seats the second piston (79) whereby the pressure gas returning from the large diameter portion (74) of the cylinder (73) to the small portion (75) does so slowly through the small drilling (82) and the main piston (85) is returned slowly.

18. An air launcher as claimed in claim 17 wherein the main piston (85) has a hollow front end (86) with the rod (88) extending axially thereof and the small diameter portion (75) of the cylinder (73) is sized to pass into the hollow front end (86) of the main piston (85).

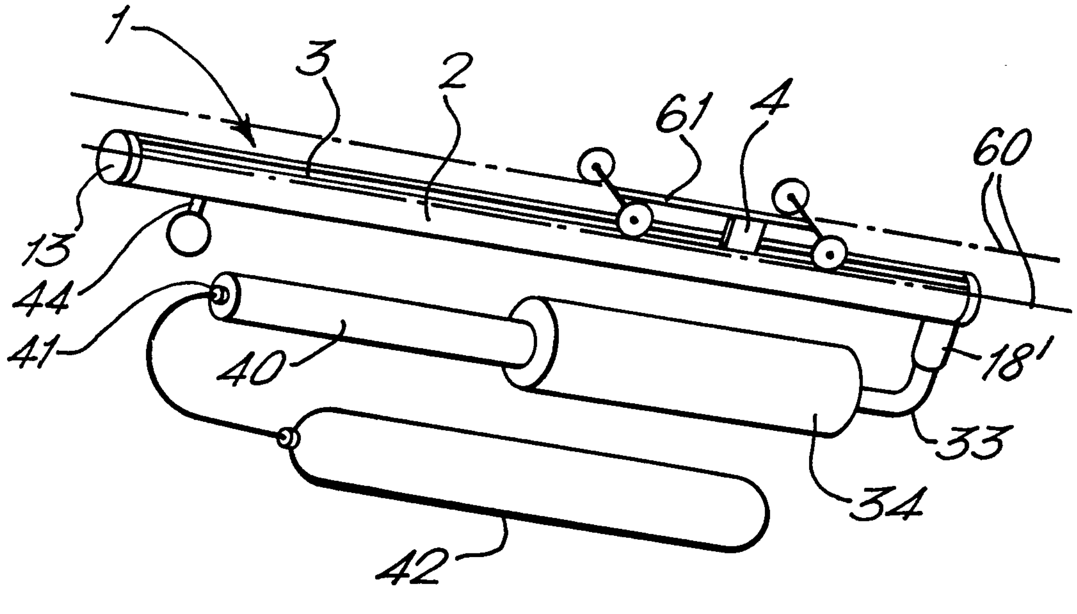
19. An air launcher as claimed in any preceding claim, wherein the firing valve (18',18") comprises a housing (18; 518) open to the barrel; an inner circular cylindrical member (19; 519) fixed in the housing (18; 518), open to the charge reservoir, and having a closed free end (19'; 519'); ports (22; 522) in said inner cylindrical member; a sleeve (20; 520) circularly surrounding the inner cylindrical member (19; 519) and therealong from a closed position wherein the sleeve (20; 520) covers the ports (22; 522) to an open position wherein the sleeve exposes the ports; a seal (21; 521) for sealing together the respective free ends of the inner member (19; 519) and the sleeve (20; 520) when the sleeve is in its closed position; and means (24,25,31; 531) for moving the sleeve to its open position for firing; the arrangement being such that after initial opening of the valve (18'; 18") pressure of compressed gas from the charge reservoir acts on the sleeve (20; 520) at its end (20'; 520') to accelerate it towards its open position.

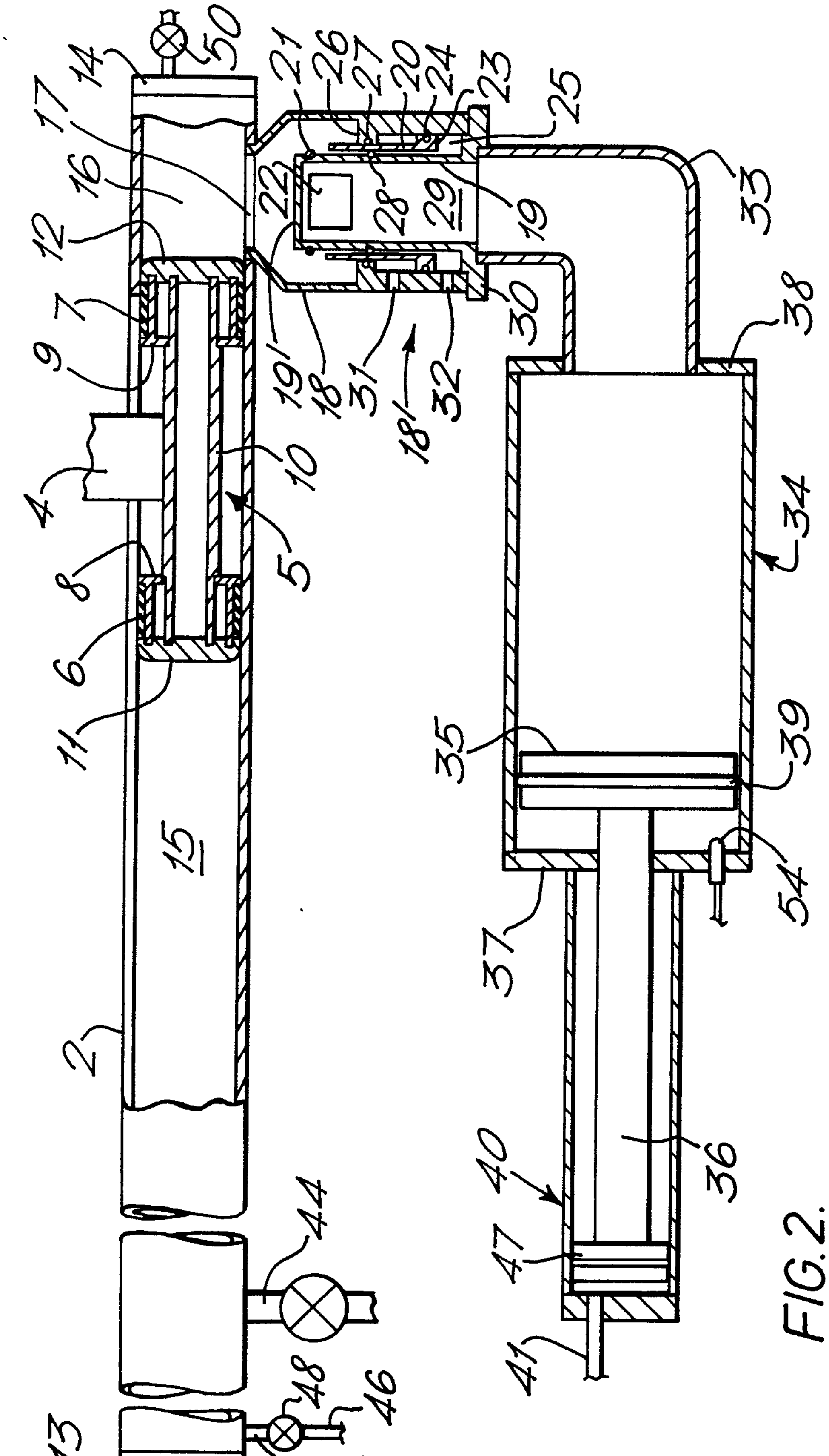
20. An air launcher as claimed in claim 19, wherein the seal (21) is an annular seal (21) mounted on the inner member (19) and acting to seal the annular space between the inner member (19) and the sleeve (20) when the sleeve is in its closed position.

21. An air launcher as claimed in claim 20, wherein

the inner member (519) has a radially outwards extending flange (519a) at its free end; wherein the sleeve (520) has a radially inwards extending flange (520a) at its free end, the flange (520a) on the sleeve (520) being positioned in the opening direction thereof from the flange (519a) on the inner member (519); and including a circular face seal (521) mounted on the flange (519a) of the inner member (519) opposite the flange (520a) of the sleeve (520) at a smaller diameter than the internal diameter of the sleeve (520) for sealing the sleeve (520) to the inner member (519) at the flanges (519a; 520a) when the sleeve is in its closed position with pressure of compressed gas from the reservoir acting to hold the valve (18") closed.

FIG.1.




50
14
17
16
12
7
9
4
8
6
11
15
2
44
48
46
13
45
21
26
27
20
24
23
25
22
28
29
19
33
19'
18
31
18'
32
30
10
5
38
34
35
39
54
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36
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47
41

FIG.2.

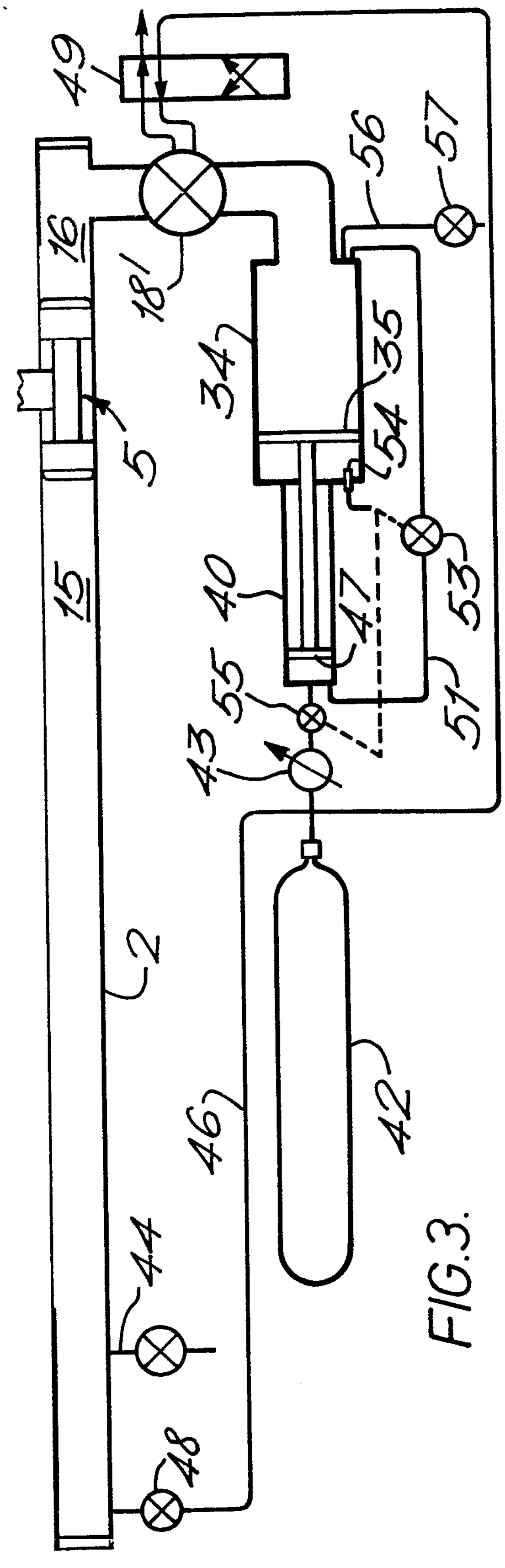
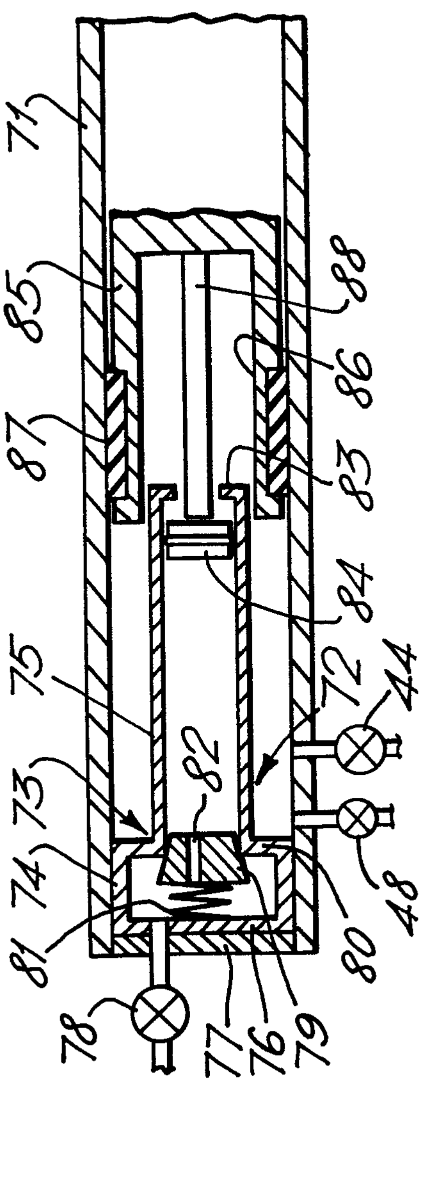

49
16
18'
34
35
54
56
57
5
15
40
47
53
55
51
43
2
46
42
44
48

FIG.3.


71
85
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86
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83
84
75
72
44
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74
82
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81
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76
79

FIG.4.

FIG.5.

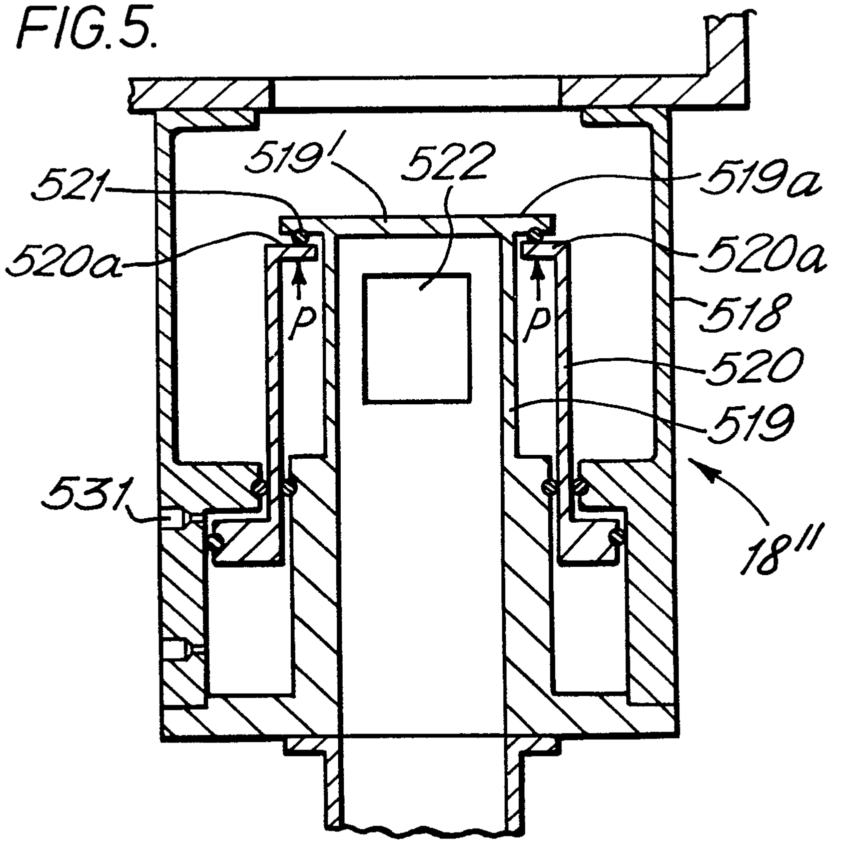
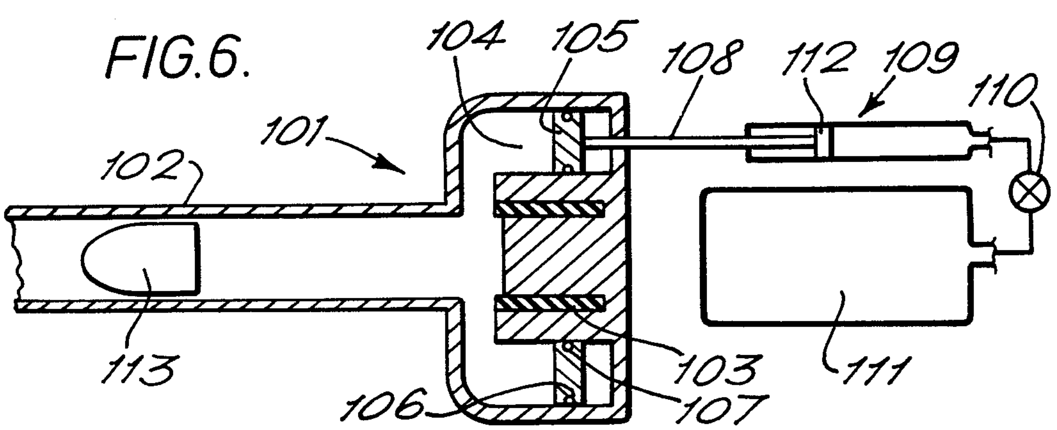

519'
522
521
519a
520a
520a
P
P
518
520
519
531
18''

FIG.6.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105
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112
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111
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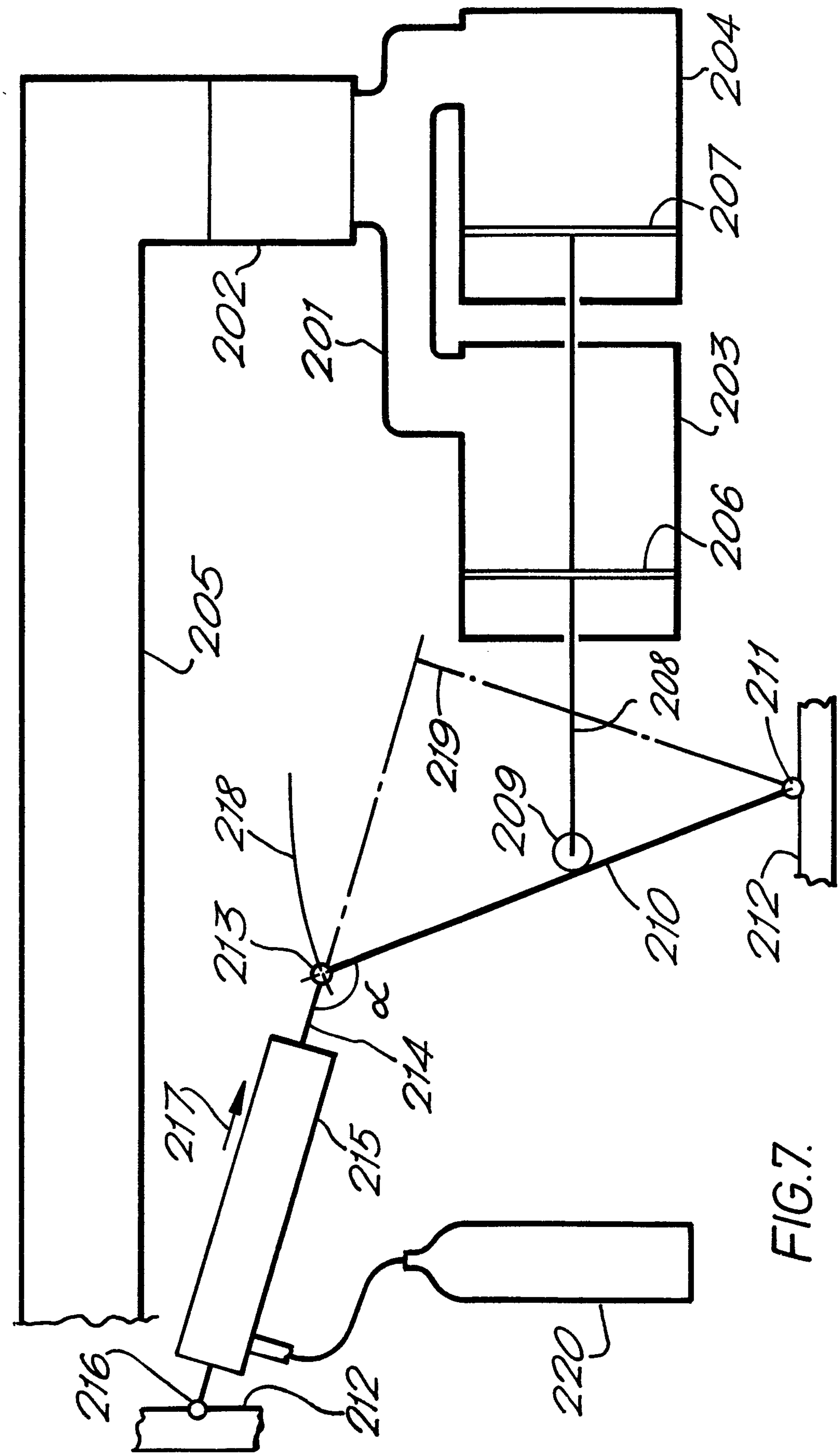
107


201
202
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220
212
α

FIG.7.