

Nov. 7, 1944.

F. S. KEAHEY, JR

2,362,075

ORDNANCE

Filed March 25, 1941

7 Sheets-Sheet 1

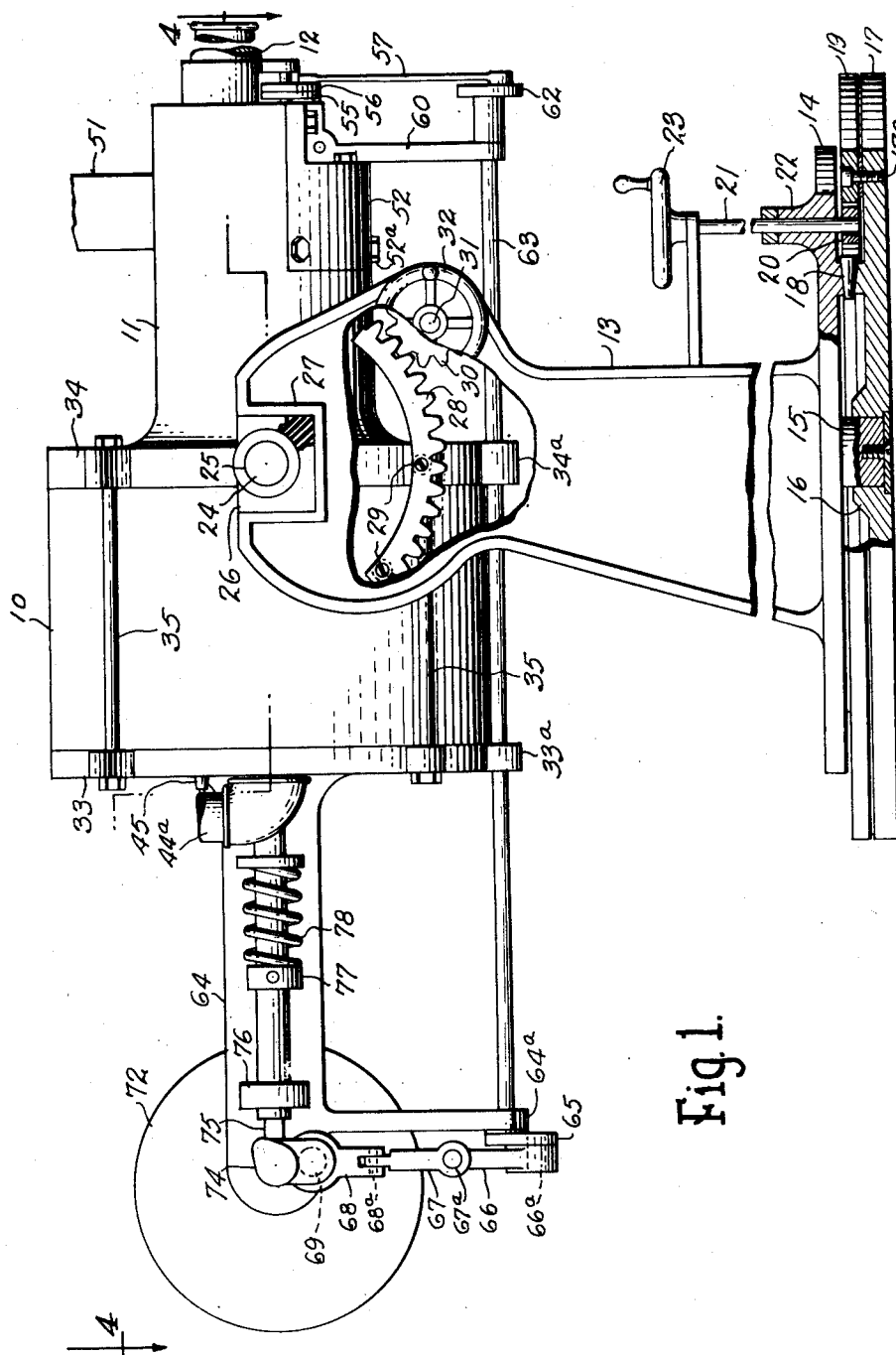


Fig. 1.

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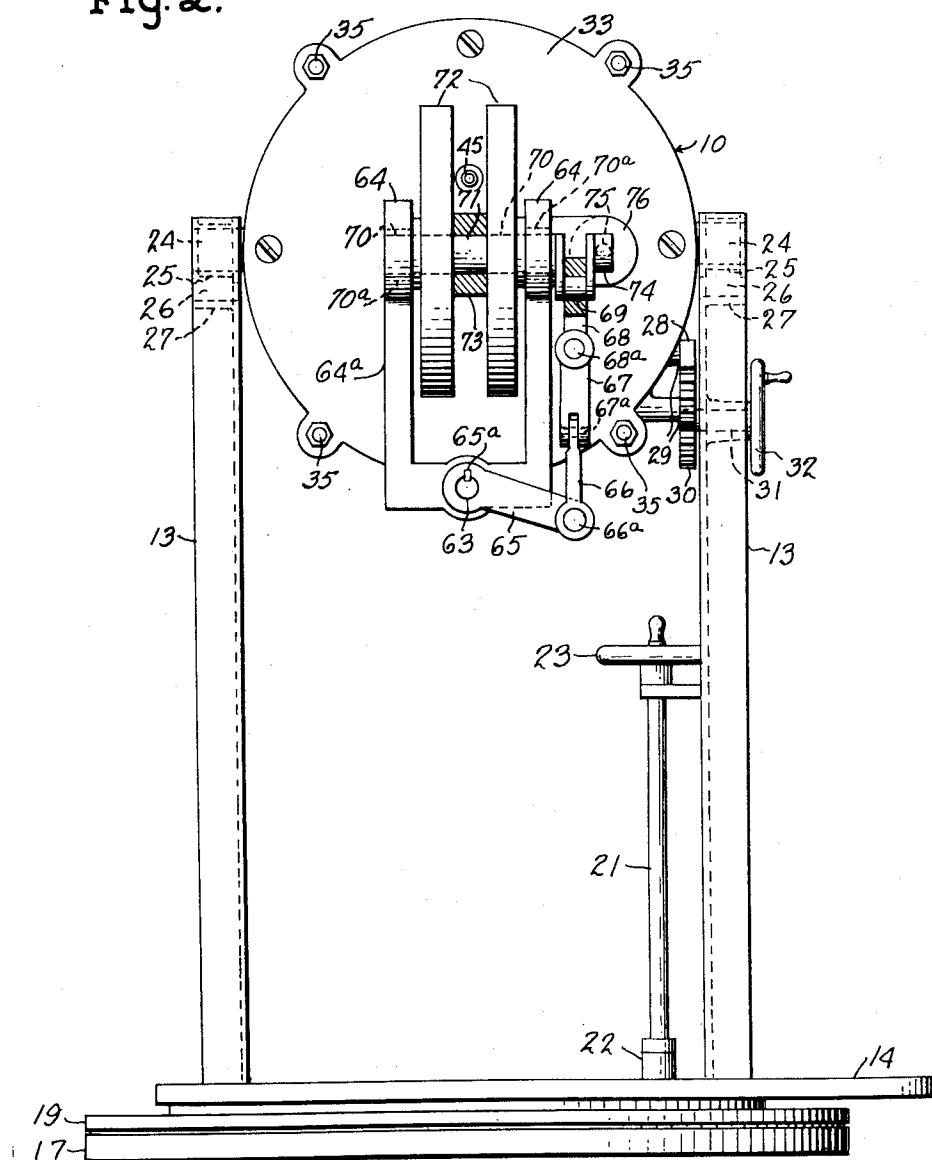
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Filed March 25, 1941

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Fig. 2.



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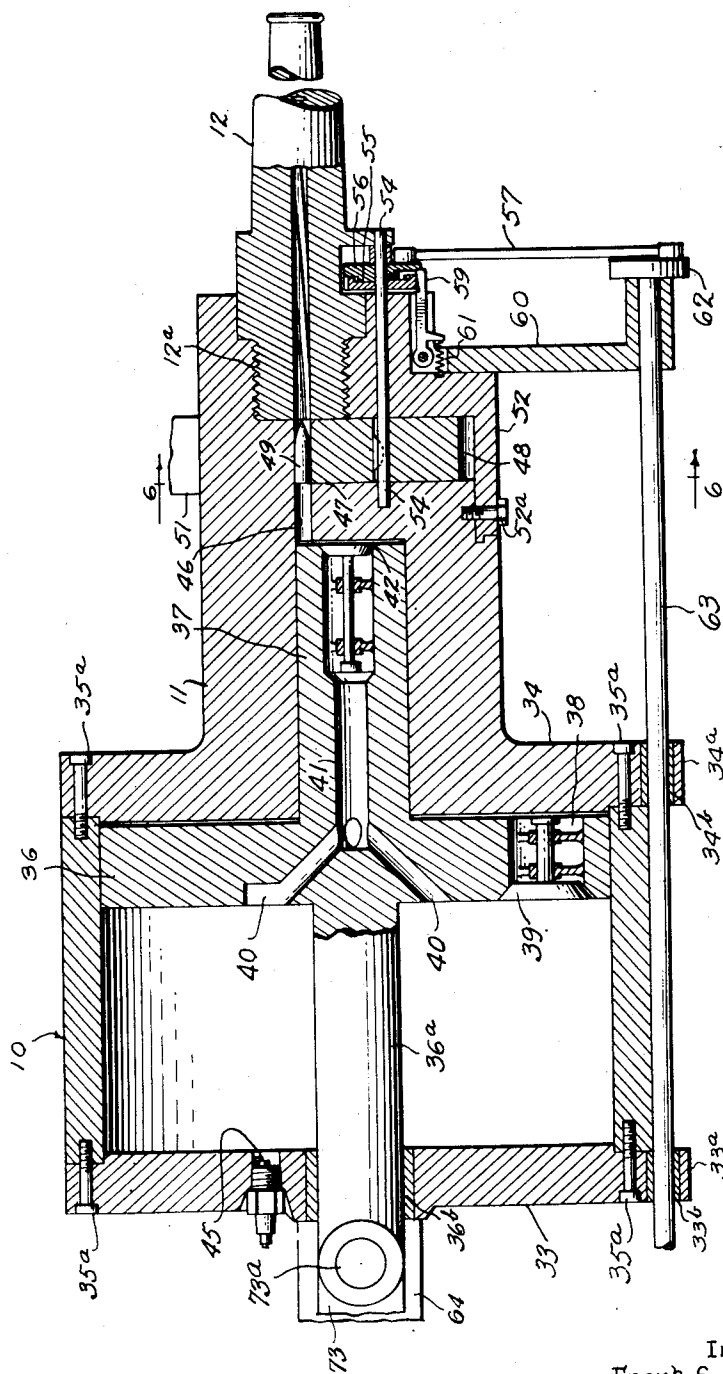
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Fig. 3.



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ORDNANCE

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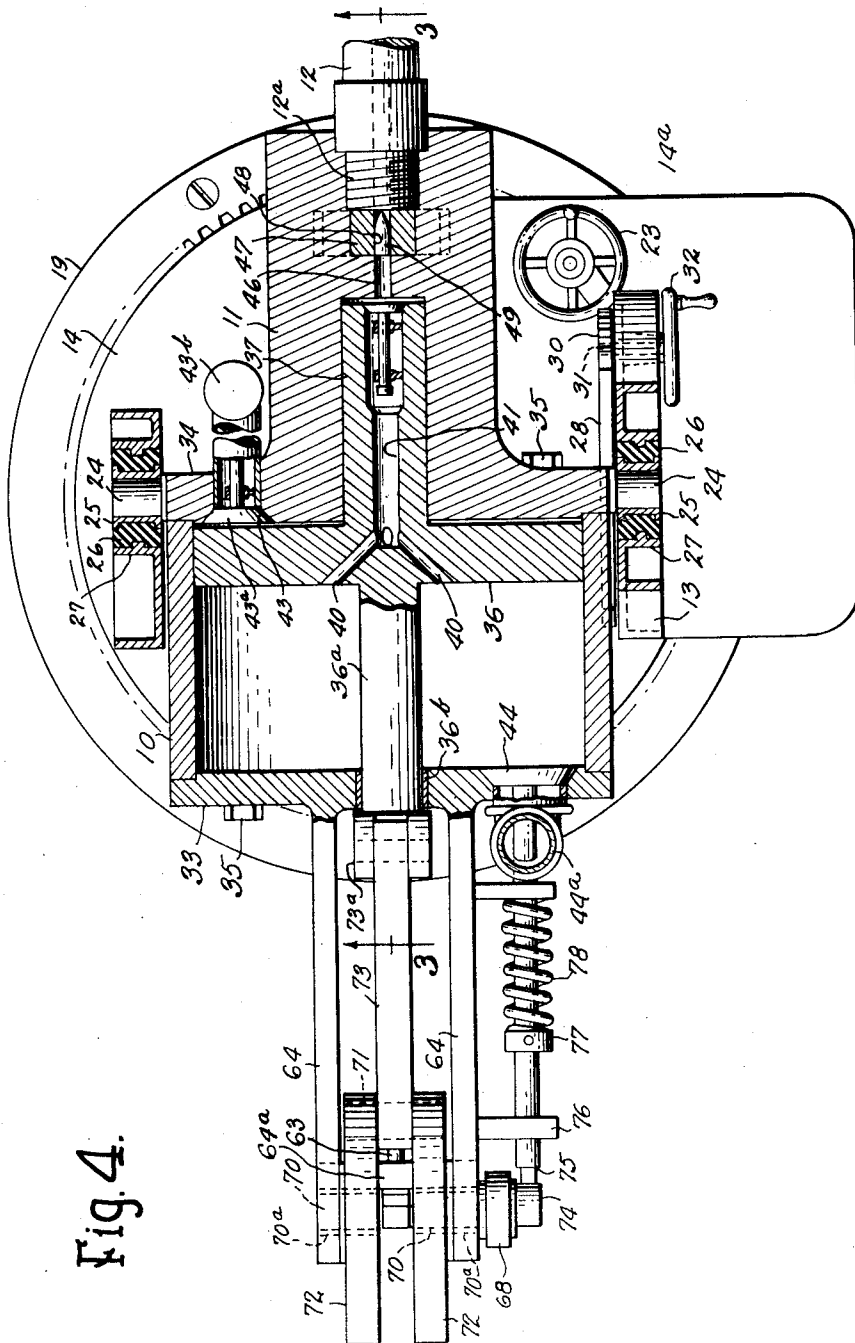


Fig. 4.

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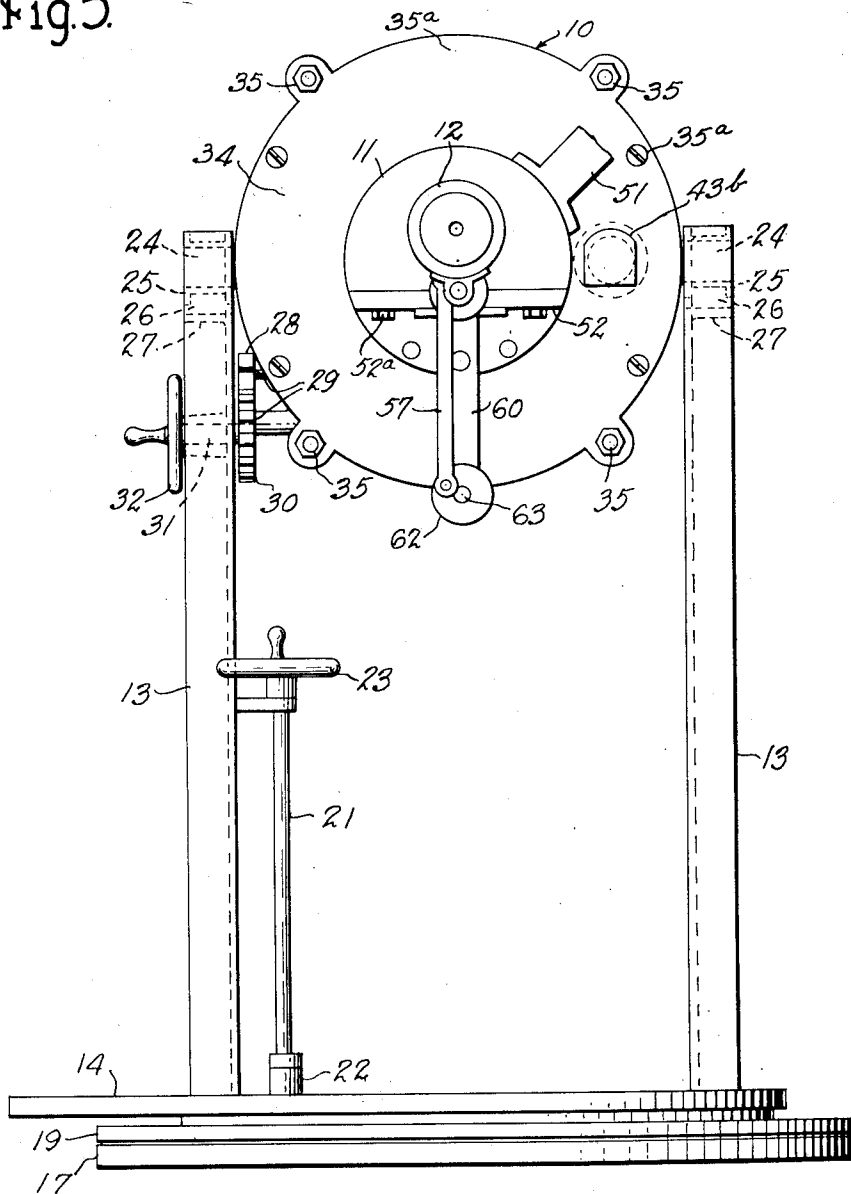
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Filed March 25, 1941

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Fig. 5.



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Filed March 25, 1941

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Filed March 25, 1941

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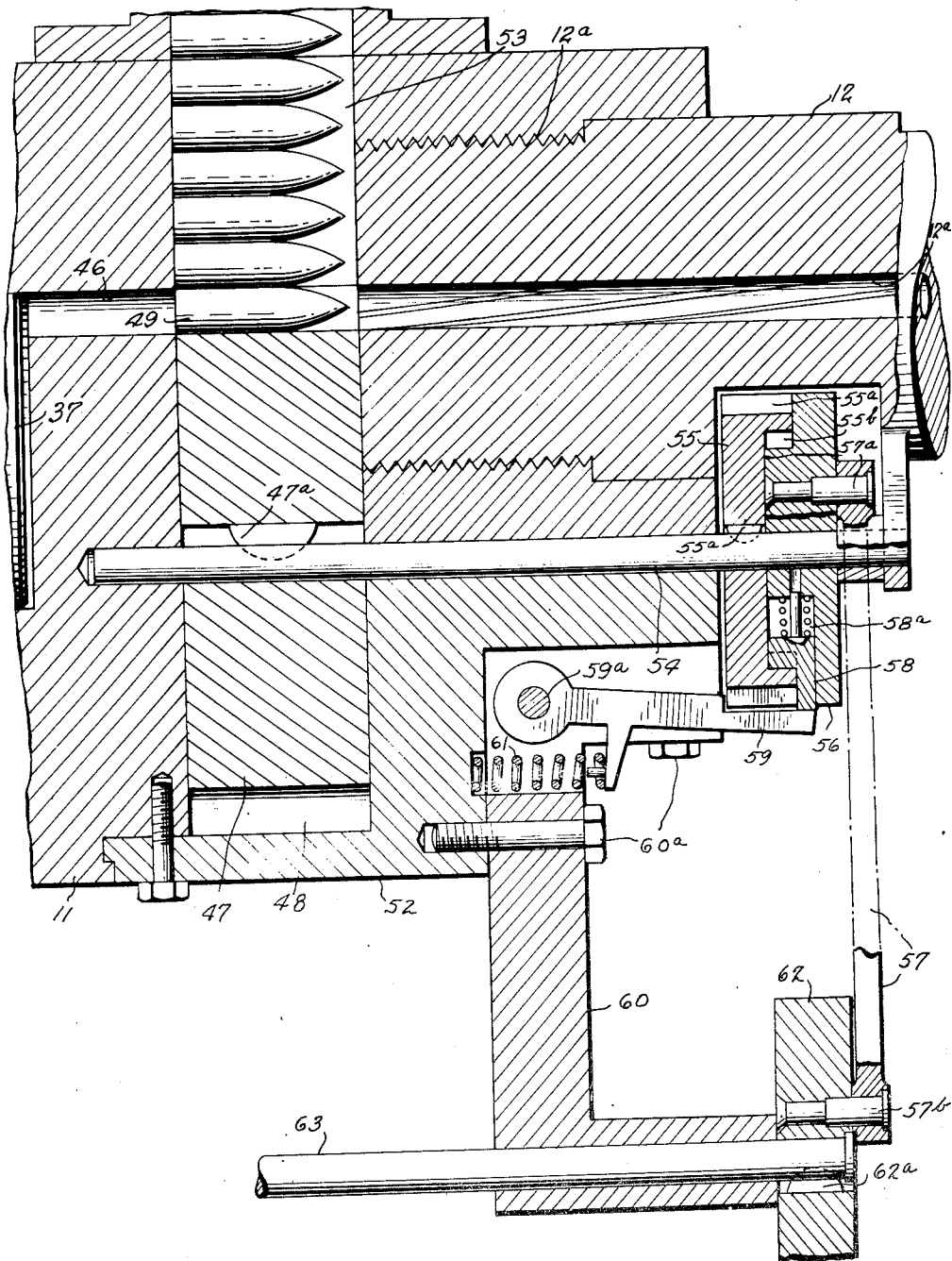


Fig. 7.

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## UNITED STATES PATENT OFFICE

2,362,075

## ORDNANCE

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Application March 25, 1941, Serial No. 385,126

13 Claims. (Cl. 89—7)

This invention relates to ordnance and has particular reference to a rapid fire, long range gun suitable for anti-aircraft work.

An object of the invention is to provide a weapon which employs the fundamental principles of the internal combustion engine, such as the Diesel type, or the conventional gasoline motor type, to the problem of projecting at high velocity, and with great rapidity, an extensive sequence of missiles intended to do effective work at high altitudes, or at great distances.

Although the embodiment of the invention as herein disclosed, relates to ordnance, in its broader aspects the invention may be employed to accomplish other useful work where extremely high pressures are a pre-requisite.

A further object of the invention is the provision of a gun which can be fired with such rapidity that in ordinary practice, a vertible column of missiles can be projected to high altitudes, in much the same manner as a column of water can be projected from a hose.

Another object of the invention is the provision of a machine gun of heavy caliber, the speed of which can be controlled in such manner as to produce a great variety of pressures and velocities, whereby great economies may be effected in its use on close range work.

Another object of the invention is the provision of a gun which develops constant or increased pressures in the barrel during the movement of the projectiles in the barrel.

Another object of the invention is the provision of a gun which has a comparatively low muzzle pressure.

A further object of the invention is to generally improve ordnance, particularly with reference to cost of construction, cost of operation, useful life and range.

Another object of the invention is the provision of a device which makes available for ordnance purposes the advantages and principles of the internal combustion engine, while at the same time employing pressures equal to or greater than the pressures of modern high explosives. Instead of a single high peak of pressure which falls rapidly as the bullet moves through the barrel, this gun maintains a high pressure throughout the passage because the piston follows the bullet holding the pressure at a high level.

The foregoing, and other objects and advantages of the invention will appear as the description proceeds, reference being made from time to time to the accompanying drawings, in which one

embodiment of the invention is illustrated, and in which drawings:

Fig. 1 is a side elevation, with parts broken away and other parts in section, showing a gun embodying my invention.

Fig. 2 is a rear elevation, partly in section, of the device illustrated in Fig. 1.

Fig. 3 is a longitudinal view in section, taken substantially on the line 3—3 of Fig. 4.

Fig. 4 is a top plan view, partly in section, taken substantially on the line 4—4 of Fig. 1.

Fig. 5 is a front elevation of the device, illustrated in Fig. 1.

Fig. 6 is an enlarged view, partly in section, taken substantially on the line 6—6 of Fig. 3, with parts broken away to show certain details.

Fig. 7 is an enlarged sectional view taken substantially on the line 7—7 of Fig. 6.

Fig. 8 is a fragmentary rear elevation of the oscillating plate comprising part of the loading mechanism.

Fig. 8A is a vertical section taken through the oscillating plate shown in Fig. 8.

Fig. 9 is a side elevation of the driving pawl shown in Figs. 6 and 7.

Fig. 10 is a front elevation of the driving pawl shown in Figs. 6 and 7.

My improved gun, in the simplest terms, comprises a two cycle internal combustion engine in which may be burned petroleum derivatives, alcohol or similar fuels. It has two cylinders; a large, low pressure cylinder, hereafter termed the major cylinder, in which the working pressures will approximate the pressures now employed in so-called internal combustion engines; and a smaller high pressure cylinder termed the minor cylinder, which receives its fuel charge from the major cylinder, when the latter is at its peak pressure, and builds up this pressure on its power stroke until the resulting pressure reaches 16,000 to 24,000 pounds per square inch.

While any desirable caliber is feasible, the gun herein disclosed is intended to shoot one inch diameter projectiles. This projectile is efficient for anti-aircraft use. With this caliber and these pressures the gun herein disclosed has a vertical range of 36,000 feet.

Referring now more particularly to the drawings, it will be understood that in the embodiment herein disclosed, my device consists generally of a major cylinder 10, a minor cylinder 11, and a rifle barrel 12, secured by threads 12a to the cylinder 11, which, together with the balancing mechanism, and loading mechanism hereinafter described, are mounted on suitable stanchions

13, which are cast integrally with the turn table 14, the latter being secured to a shaft 15, which is journaled in a suitable bearing member 16 formed in the bed plate 17. Roller bearings 18 are interposed between the bed plate 17 and the turn table 14.

The gun is rotated on its vertical axis by means of a ring gear 19 which is secured to the bed plate 17 by cap screws 17a, and is adapted to mesh with a pinion 20 which is keyed to the shaft 21, the latter being journaled for rotation in the boss 22, forming part of the turn table 14. The shaft 21 is rotated by the wheel 23, which may be manually or power operated.

The gun is mounted for rotation on its short horizontal axis by means of the trunnions 24, which are secured to each side of the cylinder 10, and journaled in suitable bearings 25, which are cushioned in thick blocks of live rubber 26, which are intended to serve as recoil blocks, as discussed in more complete detail later. The recoil blocks 26 are supported in suitable cradles 27, formed integral with the stanchions 13.

The elevation and depression of the gun barrel are controlled by means of a quadrant 28 which is secured to the cylinder 10 as at 29, and meshes with a pinion 30, which is keyed to the shaft 31, the latter being rotated by the wheel 32, either manually or by power.

The major cylinder 10 is provided with accurately fitted cylinder heads 33 and 34, which are held in place by a plurality of tie rods 35, and other suitable means such as cap screws 35a. The minor cylinder 11 is formed integrally with the cylinder head 34, and its walls are of sufficient thickness to withstand the extreme pressures developed therein.

Within the major cylinder 10 is a large piston 36, and within the minor cylinder 11, is a small piston 37. These pistons are integral with one another and reciprocate in unison. The area of the large piston 36 is substantially 21 times that of the area of the small piston 37.

In Fig. 3, it will be seen that the piston 36 is provided with a passageway 38, which is controlled by a valve 39, and a plurality of passageways 40 (Figs. 3 and 4), which communicate with a passageway 41, in the interior of the piston 37, the latter being controlled by the valve 42. The major cylinder 10 has a fuel intake valve 43 (Fig. 4), an exhaust valve 44 and a spark plug 45 (Fig. 3), although in employing the full Diesel principle the spark plug 45, may be dispensed with, and an injector substituted for the carburetor 43b (Figs. 4 and 5). The intake valve 43a and the exhaust valve 44 connect with suitable intake and exhaust means, which are standard practice in the Diesel or gasoline engine art. In this embodiment the intake means include a carburetor 43b (Figs. 4 and 5) and a throttle not shown. The large piston 36 is provided with a piston rod 36a which extends through a suitable bearing 36b in the cylinder head 33. The minor cylinder 11 can exhaust only through the passageway 46, which is in direct communication with the interior of the barrel 12, through the slots 48 of the projectile magazine 47, which forms part of the loading mechanism shown in Figs. 6 and 7.

The magazine 47 rotates in a close fitting chamber, the upper half of which is machined in the cylinder wall 11 and the lower half of which is machined in the hood 52, which is secured to the cylinder 11 by a plurality of cap screws 52a, making a gas tight chamber. This chamber has a communicating slot 53 through

which the bullets 49 are dropped from the hopper 51.

The magazine 47 is keyed, as at 47a, to a shaft 54, through which it is driven in synchronism, with the firing cycles of the gun. The shaft 54 is keyed into the ratchet plate 55, as at 55a. A second plate 56, rotating freely on the shaft 54, is oscillated by the connecting rod 57 in a clockwise direction 45 degrees, as viewed from the rear (Fig. 6) during a half cycle of the engine, during which half cycle comprising the compression stroke, the pistons 36 and 37 are receding from the position shown in Figs. 3 and 4. The plate 56 is oscillated in the opposite direction 45 degrees, during the next half cycle of the engine, in which the pistons 36 and 37 advance on the power stroke to the positions shown in Figs. 3 and 4. The plate 56 drives the plate 58 during the clockwise oscillation by means of a pawl 59 which engages the ratchet teeth 55b of the plate 55.

The plate 55 is securely locked by the key 59 in a predetermined position, with reference to the barrel bore 12a, during the firing half of the cycle to insure perfect alignment between the slots 48 of the magazine 47 and the bore 12a of the barrel. The key 59 is pivoted on the shaft 59a (Fig. 7) through the bifurcated casting 60 which is bolted to the hood 52 by a plurality of bolts 60a. A spring 61 in compression holds the key 59 in engagement with the rectangular locking slots 55c, which are machined in the outer periphery of plate 55 (Figs. 6 and 7) until the key 59 is forced out of engagement by the pawl 59, when the latter is driven outwardly by the spring 59a, which has power sufficient to overcome the compression of the spring 61. The connecting rod 57 is rotatably fixed to the plate 56 by a stud 57a and to the plate 62 by a stud 57b. The plate 62 is keyed as at 62a to the oscillating shaft 63 which is journaled in the casting 60. The shaft 63 passes through the bearings 34b and 33b (Fig. 3), which are mounted in the bosses 34a and 33a formed integrally with the cylinder heads 34 and 33, and also passes through the member 64a (Fig. 1) which is a downward extension of the bifurcated member 64, which is cast integrally with the cylinder head 33. An arm 65 is keyed, as at 64a, to the shaft 63 and oscillates the said shaft by power delivered through the connecting links 66, 67 and 68. Link 68 is in turn driven by the crank pin 69 which is formed integrally with the main shaft 70, which rotates in suitable bearings 70a, carried in the supporting arms of the bifurcated member. The shaft 70 carrying the twin eccentric flywheels 72 is rotated by a crank 71, which is driven by the main connecting rod 73, which in turn is connected by the pin 73a, to the piston rod 36a heretofore described.

A complete operating cycle will now be explained by reference to Figs. 3 and 4.

When the piston 36 arrives at the extreme advanced position shown in Figs. 3 and 4 and begins its receding movement, a fuel charge is drawn through the intake port 43 (Fig. 4), inasmuch as the valve 43a is free to open when the pressure in the cylinder 10, between the piston 36 and the cylinder head 34, becomes less than atmospheric. When the piston 36 completes its receding movement and begins its next advance movement, the valve 43a (Fig. 4) is forced closed by gas pressure causing the pre-compression of the fuel charge slightly above atmospheric pressure between the piston 36 and the cylinder head 34. When this pressure reaches a predetermined point it causes

the valve 39 (Fig. 3) to open, permitting the pre-compressed fuel charge to enter the firing chamber scavenging the burned charge out of the cylinder 10, in which is positioned the spark plug 45. The fresh charge of incoming gas is then compressed between the piston 36 and the cylinder head 33, a portion of the charge at the same time entering the cylinder 11, as explained below. The charge in the firing chamber of the cylinder 10 is then exploded by the spark plug 45 a few degrees before the piston 36 reaches the fully retracted position.

An additional portion of this burning charge from the firing chamber of the cylinder 10 passes through the channels 40 into the main channel 41 formed in piston 37 and then through the valve 42 into the cylinder 11, igniting and further increasing the pressure of the charge of fuel which had previously entered the cylinder 11 as explained herein above. The pressure in both the cylinders 10 and 11 will be about 1,000 to 1,500 pounds per square inch immediately after the firing of the charge, as in conventional internal combustion engines. The piston 36 driven by the burning charge of fuel toward the advanced position (Fig. 3) overcomes the counterforce of the piston 37, because of its greatly superior area. The charge in the cylinder 11 rapidly increases in pressure as the piston 37 advances which causes the valve 42 to close. As the piston 37 continues to advance the pressure in the cylinder 11 increases moving the bullet 49 slightly forward in the bore 12a of the barrel 12, until it comes in contact with the rifling of the barrel. When the pressure in the cylinder 11 reaches a predetermined peak value the bullet 49 is forced through the rifling and along the bore 12a of the barrel 12. One of the most effective characteristics of this gun is the maintenance of a propelling pressure behind the bullet which is practically uniform and only slightly lower than the peak pressure, because the advance of the piston 37 increases the pressure at about the same rate that the forward movement of the bullet tends to reduce it. This results in a propelling thrust greatly superior to that of powder guns without greatly exceeding the peak pressure of such powder guns. Thus a velocity much greater than is possible with powder guns is imparted to the bullet, giving it extremely long range and great striking power.

After the ejection of the bullet any remnants of gas in the cylinder 11 are exhausted through the barrel bore 12a and the gases of combustion in the cylinder 10 are exhausted through the valve 44 as explained hereinafter.

At the predetermined point where it is desired to exhaust the burned gases from the cylinder 10, through the exhaust valve 44, the cam 74, which is formed integrally with the main shaft 70, forces the valve stem 75 forward against the pressure of the compression spring 78 through suitable bearings not shown mounted in the bosses 76 and 77, formed integrally with the member 64. This opens the valve 44 permitting the burned charge of gas in the cylinder 10 to be exhausted, immediately after which the incoming charge of gas passing through the port 39 scavenges out the remnants of the burned charge of gas in the cylinder 10 as explained above. The valve 44 is then closed by the pressure of the spring 78 against the collar 77, inasmuch as the cam 74 will have rotated to such a position as to permit the valve stem 75 to return to the closing position.

The rate of fire or speed of the gun is adjust-

able by a conventional throttle not shown. As the effective pressure of the gas charge propelling the bullet varies with the speed or rate of fire, the velocity of the bullets and therefore the range of the gun are likewise variable, which permits adjustment as conditions warrant.

The rate of fire normally varies from 500 to 1000 shots per minute with a muzzle velocity of 5000 to 7000 feet per minute.

As stated above the live rubber blocks 28 are intended to serve as a recoil mechanism of great simplicity as contrasted to the recoil mechanisms conventionally employed with powder guns.

The operation of these rubber blocks is made fully effective by the supplementary effects of the reciprocating pistons 36 and 37, which recede as the bullet advances from the gun muzzle largely neutralizing the backward thrust or kick imparted to the gun by the bullet.

The movement of the pistons 36 and 37 tending to disturb the balance of the gun about the horizontal axis through the trunnions 24 is counterbalanced by the eccentric flywheels 72 which have their heavy sections disposed oppositely to the location of the crank 71.

A spring or power driven loading or feeding device not shown may be added if desired to force entry of the bullets 49 into the magazine 47 at a rate greater than that of a gravity operated hopper as illustrated.

Cooling means may also be employed with this device in certain applications although the construction of the device is such that in ordinary practice the scavenging action of the device as described will keep it relatively cool.

This gun may be mounted on a truck, car, boat or airplane or other suitable place. It will be understood that certain modifications may be made in practicing this invention, all of which are intended to be within the scope of the appended claims.

Having described my invention, what I claim and desire to secure by Letters Patent is:

1. In a gun of the character described, the combination of a large primary cylinder, a comparatively small secondary cylinder, a piston in said primary cylinder having an extension forming a piston for said secondary cylinder, an exhaust outlet for said secondary cylinder, means adapted to charge the said primary cylinder with an explosive mixture, and a controlled passageway connecting said primary and said secondary cylinders and arranged to permit the entrance of an explosive charge into said secondary cylinder from said primary cylinder.

2. The combination defined in claim 1, in which the controlled passageway between the primary and secondary cylinders is arranged to permit the entrance of part of the explosive charge into said secondary cylinder on the movement of said primary piston in one direction.

3. The combination defined in claim 1, in which the cylinders are in axial alignment and an increased compression of the explosive charge in the secondary cylinder is accomplished by the movement of the primary piston in one direction.

4. The combination defined in claim 1, in which the exhaust outlet of said secondary cylinder is in communication with the gun barrel.

5. The combination defined in claim 1, in which the exhaust outlet of said secondary cylinder is in communication with the gun barrel, and there are projectile feeding means associated with the gun barrel and said exhaust outlet.

6. The combination defined in claim 1, in

which the exhaust outlet of said secondary cylinder is in communication with the gun barrel, and there are projectile feeding means associated with the gun barrel and said exhaust outlet, the operation of said projectile feeding means being synchronized with the firing of the explosive charge in said secondary cylinder.

7. The combination defined in claim 1, including a piston rod to which is connected the said primary and secondary pistons, the said piston rod being connected on the exterior of the cylinders to a counter-balancing mechanism, adapted to dampen the recoil of said pistons.

8. The combination defined in claim 1, including a common piston rod to which the primary and secondary pistons are attached, the said common piston rod being connected on the exterior of the cylinders to a counter-balancing mechanism, adapted to dampen the recoil of said pistons, the said counter-balancing mechanism including one or more eccentric fly wheels.

9. The combination defined in claim 1, including projectile feeding means, the said exhaust outlet of said secondary cylinder being in communication with the gun barrel, and said projectile feeding means are associated with the said gun barrel and said exhaust outlet, the said projectile feeding means including a gas tight chamber, a cylindrical magazine rotatable in said chamber, projectile carrying openings in said magazine and means for indexing said openings with the said exhaust outlet and the bore of the gun barrel.

10. The combination defined in claim 1, in

which said controlled passageway between the two cylinders comprises an axial passageway through the primary and secondary pistons and a pressure valve in said passageway.

11. The combination defined in claim 1, in which the means to charge the primary cylinder include a passageway extending through said primary piston, and a pressure operated valve in said passageway.

12. In a gun of the character described, the combination of a large primary cylinder, a comparatively small secondary cylinder, a piston in said primary cylinder having an extension forming a piston for said secondary cylinder, an exhaust outlet for said secondary cylinder, intake, and exhaust means for said primary cylinder, and means communicating between said primary and said secondary cylinders and arranged to permit the direct entrance of an explosive charge into said secondary cylinder from said primary cylinder.

13. The method of projecting a missile which consists of compressing in a primary chamber, a mixture of combustible fuel and air to a pressure of not to exceed 1500 pounds per square inch, transferring some of said compressed mixture to a secondary chamber, exploding the mixture in said primary chamber and said secondary chamber, utilizing the resulting force of said explosion to further greatly compress the contents of said secondary chamber, and then releasing the products of combustion from said secondary chamber against a missile.

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