

[54] **MECHANICALLY ACTUATED WATER CANNON**[75] Inventors: **Delwin E. Cobb; Robert J. Sullivan**, both of Peoria, Ill.[73] Assignee: **Caterpillar Tractor Co.**, Peoria, Ill.[22] Filed: **Apr. 12, 1971**[21] Appl. No.: **133,261**[52] U.S. Cl. **239/101, 299/17**[51] Int. Cl. **B05b 1/08**[58] Field of Search **239/101, 102; 299/17**[56] **References Cited****UNITED STATES PATENTS**

3,539,104	11/1970	Cooley	239/102
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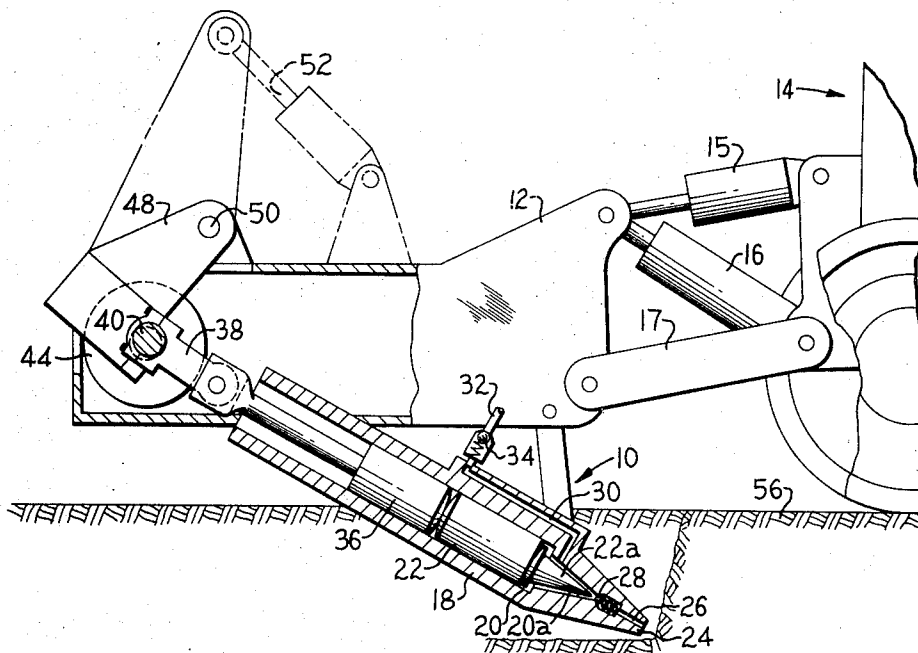
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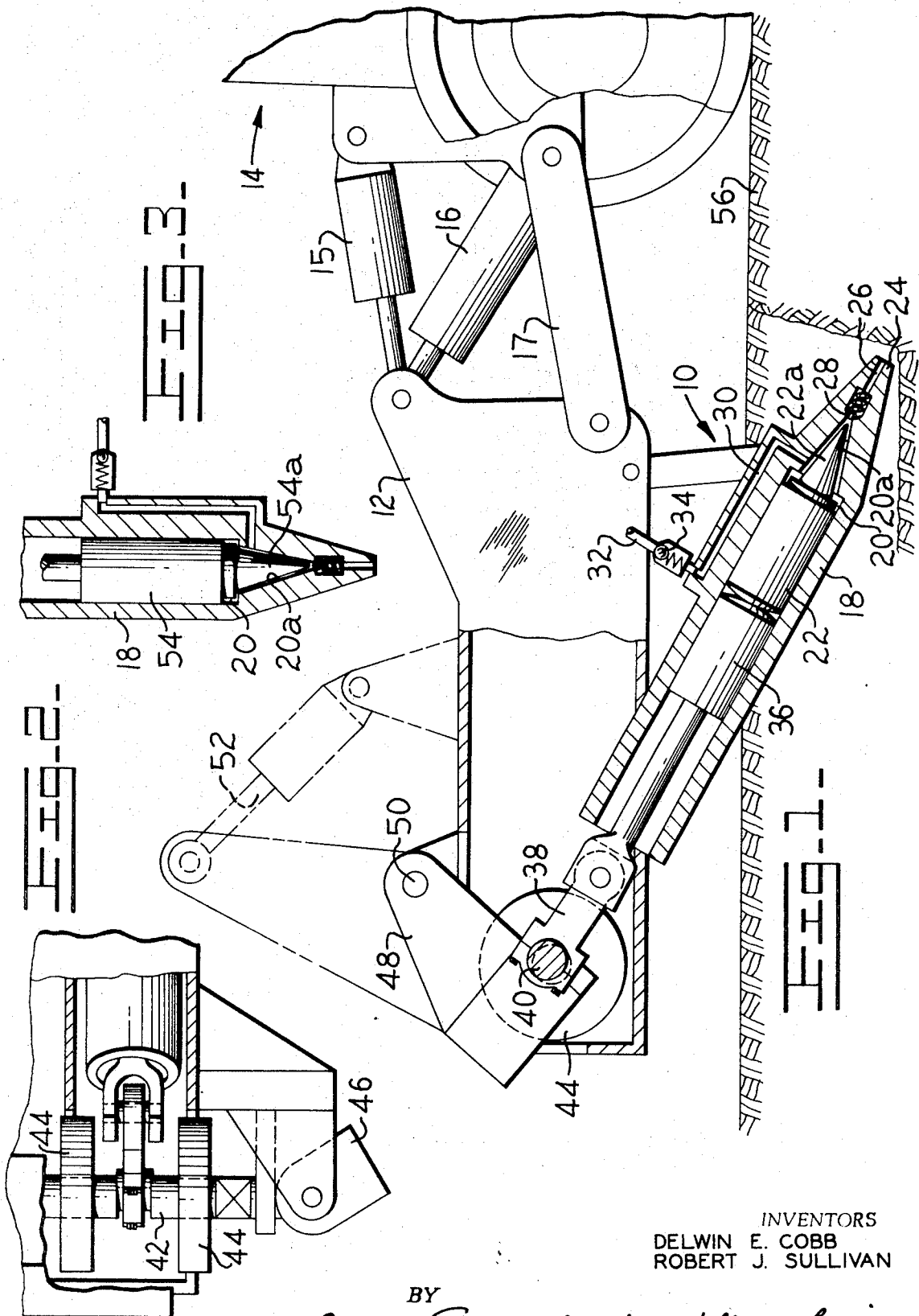
Primary Examiner—M. Henson Wood, Jr.*Assistant Examiner*—Michael Mar*Attorney*—Fryer, Tjensvold, Feix, Phillips & Lempio[57] **ABSTRACT**

An apparatus for creating high velocity jets of liquid for fracturing rock and like materials, said apparatus utilizing massive rotary flywheels for storing large amounts of kinetic energy. The kinetic energy is then delivered by a crank and link mechanism to a piston which forces quantities of liquid from a chamber through a nozzle at sufficient velocity to fracture selected materials.

7 Claims, 3 Drawing Figures

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MECHANICALLY ACTUATED WATER CANNON

BACKGROUND OF THE INVENTION

The present invention relates to a rock fracturing machine and pertains more particularly to an apparatus for mechanically developing high velocity liquid jets for fracturing such materials as rock and the like.

A considerable amount of hard rock and such material are excavated each year by the mining and construction industries. The most common method used for such excavation is that of blasting with dynamite and similar explosives. Although blasting has evolved to a highly sophisticated art, it has many serious and objectionable limitations. One major limitation is that it is not a continuous process. It is further objectionable in that it is noisy and potentially harmful to nearby structures. Blasting is generally noisy whether above or below ground and generally results in contamination of the atmosphere by dust and fumes.

Other conventional means of fracturing hard rock such as by tractor ground rippers, drills, saws, etc. results in extreme wear in the tips, bits or blades which engage the rock with a consequent high maintenance and replacement cost. Moreover, these methods are extremely slow and expensive.

Many exotic methods have been proposed for fracturing of rock and like material. Such methods include electron beams, electrical heating, laser, freezing, etc. Such methods have met with limited amounts of success but have been rejected by industry due to their high cost. Furthermore, many of these methods are dependent upon the chemical or electrical and other non-mechanical characteristics of the rock.

One of the most promising exotic techniques of fracturing rock is the water gun or water cannon. This technique utilizes high velocity pulsed water jets developing impact pressures of from 50,000 to 1 million psi, capable of shattering the hardest of rocks. The high velocity jet bores a hole and hydraulically explodes the rock. The major hindrance to exploitation of this technique of rock fracturing is the development of an efficient and continuous method of powering the water cannon. Numerous proposals to power the water cannon by such means as electricity, hydraulic and pneumatic means and other mechanical systems have failed to achieve commercial success. This failure has principally been due to the inefficiency of the system and the inability to develop an efficient rapid firing system which is practical and economical.

SUMMARY OF THE INVENTION

It is a primary object of the present invention to provide means for overcoming the above deficiencies of the prior art.

Another object of the present invention is to provide means for the efficient and practical application of a water cannon to the braking of hard rocks and the like.

A further object of the present invention is to provide efficient mechanical means for powering a water cannon.

A still further object of the present invention is to provide a multi-firing water cannon that is efficient and practical in the breaking and fracturing of rocks and like material.

In accordance with the present invention, a rotating flywheel is utilized to store large amounts of inertial

energy which is intermittently supplied at peak power periods for powering a water cannon. The energy from the flywheel is converted from a rotary motion to a linear motion which is supplied to a piston for extruding a charge of liquid such as water from a nozzle.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages of the present invention will become apparent from the following description when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a side elevational view partially in section of a preferred embodiment of the present invention;

FIG. 2 is a fragmentary top view of a portion of the apparatus illustrating the drive mechanism;

FIG. 3 is a sectional view of an alternate embodiment of the cannon mechanism.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, there is illustrated in FIG. 1 a preferred embodiment of the present invention in which a water cannon or gun generally designated by the numeral 10 which is mounted or carried on a suitable frame or support member 12. The support member 12 is operatively coupled to a suitable support or carrier vehicle, such as a tractor 14, by means of a suitable linkage which comprises a pair of hydraulic links 15 and 16 and a rigid link 17 operatively coupled to be effective to raise or lower the apparatus or change the angle of attack thereof. Such a linkage control is more fully disclosed in U.S. Pat. No. 3,503,456, issued Mar. 31, 1970, to D. J. Larsen. The hydraulic links 15 and 16 may be adjusted to vary the angle of the water of cannon 10 with respect to the material to be fractured as well as to adjust the height of the water cannon.

The water cannon comprises a cylinder 18 having a substantially cylindrical chamber 20 formed between a piston 22 and the forward end of the chamber. The chamber 20 formed at the forward end with a reduced portion 20a into which extends a correspondingly shaped portion 22a of piston 22. A nozzle 24 is carried on the forward end of the cylinder and has an orifice 26 in communication with the chamber 20. A check valve 28 is provided between the chamber 20 and orifice 26 to prevent leakage. An inlet port 30 is provided for introducing a charge of water or other suitable liquid into chamber 20. The inlet port 30 is connected by means of a conduit 32 to a suitable source of supply of water or other suitable liquid. A check valve 34 prevents back-up of the pressurized water to the source.

The piston 22 is free within cylinder 18 and abuts against a second cylinder or a ram 36 which is connected by a connecting rod 38 to the throw 40 of a crankshaft 42. The crankshaft 42 is rotatably carried in suitable bearing carried by frame or housing member 12. A suitable number of flywheels 44 are carried on shaft 42 for storing large amounts of energy. The crankshaft is operatively coupled to a suitable drive motor such as a hydraulic motor 46. It is recognized that the flywheels 42 can be made larger or smaller or their number increased or reduced to accommodate varying job conditions and other variables associated with the water cannon. The crankshaft and flywheel as-

sembly are supported from the housing 12 by suitable carrier means 48 which is pivotally connected at 50 to the support member 12. This carrier is pivoted to permit free recoil about pivot 50 in response to the hydraulic pressure in the chamber 20. The mass of the carrier and the stiffness of any restraining springs 52 which may be optional must be selected or adjusted to limit the hydraulic pressure and machine stresses to a safe level.

Suitable vent means must be provided for piston 36 to prevent air from being trapped between this piston and piston 22. Such vent means may take the form of grooves in either one of piston 36 or the walls of cylinder 18 or in the form of an opening in piston 36.

An alternate embodiment of the invention is shown in FIG. 3 in which a single piston 54 is connected directly to the crankshaft. With this embodiment, care must be taken to see that no gas is trapped between the water and chamber 20 and the piston 54. This may be controlled by the manner in which the water is injected into the chamber 20 to assure that the chamber remains full. Alternately, the piston and cylinder may be oriented vertically with the nozzle adapted to be aimed in different directions. The chamber 20 includes a reduced portion herein illustrated at 20a as being substantially conical in shape. A corresponding portion 22a is formed on the piston 22 for extending into this reduced portion during extrusions of the water pumped from the chamber. A like extension 54a may be provided from the piston 54 as shown in FIG. 3. This construction contributes to a more rapid rise in water pressure within the chamber.

Operation of the crankshaft or of the system by rotation by crankshaft 40 reciprocates piston 36 within cylinder 18. As the piston 36 is retracted, water is injected through inlet 30 into chamber 20 forcing piston 22 to the retractive position. As the piston 36 moves rapidly forward, it impinges against piston 22 accelerating it rapidly forward against the charge of water contained in chamber 20 and extruding it under very high pressure through orifice 26 into contact with the formation 56. As the piston 36 then moves backward on the second stroke, a charge of water is drawn into the chamber 20 through the inlet 30 in readiness for a second stroke.

Pressures on the order of 50,000 psi and upwards to as high as 1,000,000 psi can be produced with such a mechanism as the present invention with a proper drive means. A 100 horsepower system, for example, if losses were neglected, could deliver a jet against a target face with an instantaneous jet ranging up to 10,000 horsepower according to reported tests. These tests indicate that the force that is applied to the rock face should be at least 10 times higher than the rock compressive strength for adequate fracture and that the nozzle of the water cannon should come to within 30 to 70 orifice diameters away from the rock to be fractured.

As is apparent, any number of cannons 10 may be supported from the support means 12 for operation by crankshaft 42. The rapid pressurization during extrusion of water from the cannon requires more horsepower than is practical to provide with a drive motor. Therefore, masses in a form of flywheels 44 sufficient to store sufficient energy to meet the intermittent peak

demands of the system are provided. The work that is performed during extrusion of the water from the cannon is of an intermittent nature during a small part of the time it takes for the drive shaft 42 to make a complete revolution. During the greater part of the revolution of the drive shaft, the motor power is used to accelerate the speed of the flywheel. The energy thus stored in the flywheel is given out during the part of the revolution when the work is done at the expense of its velocity. As the velocity of the flywheel changes, the energy is given up in proportion to the differential between the square of its initial and final speeds and is equal to the difference in the energy which it would give out if brought to a full stop and that energy which is still stored in it at the reduced velocity.

Thus, it is seen that the intermittent nature of the power demand of the water cannon is met in a practical manner by the flywheel energy storage means of the present invention. This proposed apparatus thus provides a simple and efficient means for supplying adequate power in the form of an inertial flywheel system to supply the sufficiently high pressures required for fracturing rock and the like materials by means of a water cannon. The subject invention permits a continuous rock disintegration process with no problem of wear of tips, cutters, bits, which ordinarily would contact the rock. The water jets induced by the present invention provide a means for applying very high power per unit face area which permits a rapid fracture rate not dependent upon chemical, electrical or other characteristics of the rock to be disintegrated.

While the present invention has been described with reference to particular embodiments, it is to be understood that many modifications and changes may be made in the apparatus of the present invention without departing from the scope thereof as defined in the appended claims.

What is claimed is:

1. An apparatus for generating a high pressure jet of liquid, said apparatus comprising:
 - means for storing a substantial amount of inertial energy;
 - a cylindrical chamber for containing a charge of liquid;
 - a nozzle in communication with said chamber;
 - a piston reciprocally mounted in said chamber; and,
 - means comprising a crank and connecting rod for applying said inertial energy to said piston to thereby extrude said liquid from said chamber through said nozzle.
2. The apparatus of claim 1 wherein said means for storing inertial energy comprises a rotatable flywheel.
3. The apparatus of claim 1 wherein said connecting rod is connected to a ram; and,
- said ram being reciprocally mounted for intermittent engagement with said piston.
4. The apparatus of claim 1 wherein said crankshaft is mounted to permit rebound thereof with respect to said nozzle.
5. The apparatus of claim 1 wherein said chamber includes a reduced portion; and,
- said piston includes a portion extending into said reduced portion during extrusion of said liquid from said nozzle.
6. An apparatus for creating a high pressure water jet, said apparatus comprising:

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support means for supporting and positioning said
apparatus from a mobile vehicle;
a crankshaft rotatably mounted on said support
means;
a flywheel supported for rotation with said 5
crankshaft;
a motor operatively connected for driving said
crankshaft;
a cylindrical chamber for containing a charge of
water;
a source of water for said chamber;

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a nozzle in communication with said chamber;
a ram mounted in said chamber; and,
a link connecting said crankshaft to said ram and
operative to force said ram against said charge of
water to force same from said nozzle at a high
velocity.

7. The apparatus of claim 6 comprising means per-
mitting said crankshaft to rebound with respect to said
nozzle.

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