

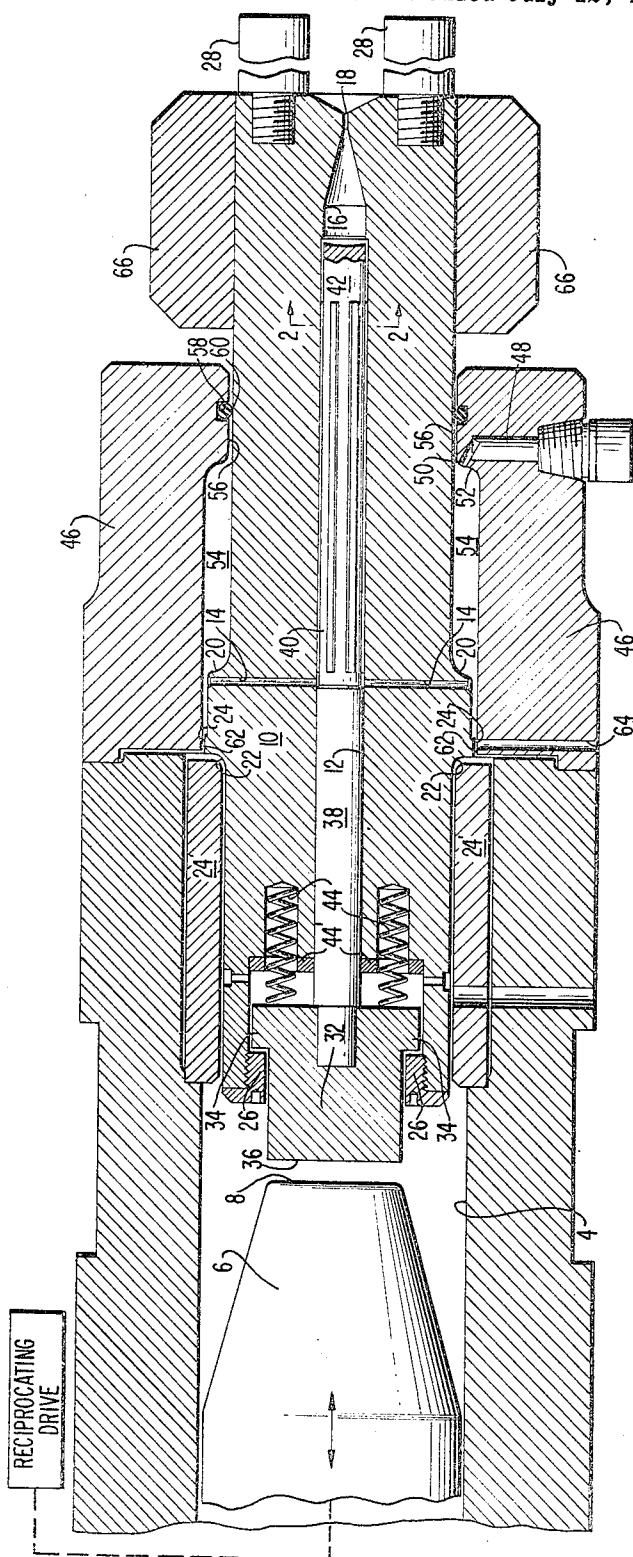
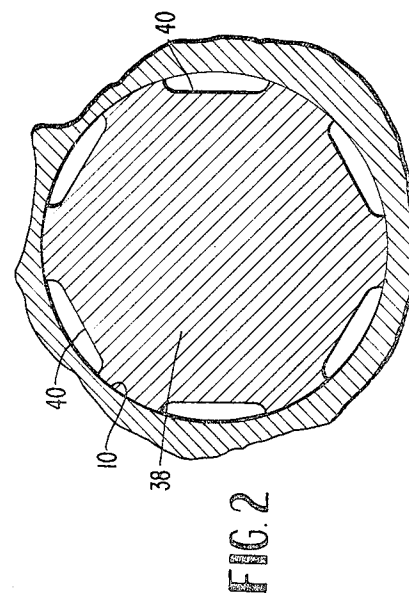
Jan. 20, 1970

W. C. COOLEY

3,490,696

HYPERVELOCITY PULSED JET HEAD ASSEMBLY

Filed July 12, 1968



FGZ

1

2

3,490,696

HYPERVELOCITY PULSED JET HEAD ASSEMBLY
William C. Cooley, Bethesda, Md., assignor to Exotech
Incorporated, Rockville, Md.

Continuation-in-part of application Ser. No. 612,945,
Jan. 31, 1967. This application July 12, 1968, Ser.
No. 744,488

Int. Cl. B05b 1/08, 17/04, 3/14

U.S. Cl. 239—101

10 Claims

ABSTRACT OF THE DISCLOSURE

A hypervelocity pulsed jet assembly utilizing a reciprocating impact piston within the bore of a main casing and a plunger assembly located at the end of the bore and having a chamber for receiving the plunger and a nozzle exit end. The chamber is charged with a fluid at which time the piston impacts the plunger which transmits the kinetic energy of the piston to the chamber exerting a high pressure on the fluid and converting the same into a high velocity jet along the axis of the nozzle. The cycle is repeated for automatic operation.

This is a continuation-in-part of application Ser. No. 612,945, filed Jan. 31, 1967.

This invention relates to a system for producing a high velocity jet pulse or successive jet pulses of liquid or gel at very high stagnation pressures (e.g., 50,000 to 500,000 p.s.i.) for purposes of cutting, fracturing, perforating or otherwise affecting various target materials, such as rocks, metals, minerals, concrete, wood, cloth, and a wide variety of other applications.

Pulsed jets of liquid have been achieved in the past by various methods, such as piston expulsion and also by the cumulation or shaped-charge principle. The piston expulsion theory is utilized in fuel injection devices and in the past has caused difficulties in piston sealing and leakage of pressures greater than 3,000 atm. The cumulation principle, and particularly the theory of explosive-shaped charges, has been used for production of metallic jets, but has not been extensively applied for production of liquid jets because of the complexity, expense and hazards in using explosive materials.

Accordingly, it is an object of this invention to provide a system which functions on the piston impact expulsion theory to produce repetitive pulsed jets of liquid with stagnation pressures greater than 100,000 p.s.i.

Another object of this invention is to provide a system for producing hypervelocity pulsed jets by repeated impact of a moving mass with a force transmitting member communicating with a nozzle chamber and having a liquid or gel charge therein and in which the transmitted forces are generated into high pressures in the nozzle chamber for ejecting a high velocity jet pulse.

It is another object of this invention to provide a system for producing hypervelocity jet pulses in a continuous and automatic manner in which the nozzle chamber is supplied with a liquid charge in a repetitive manner and controlled by the cyclic operation of the system.

It is another object of this invention to provide a system for producing a series of hypervelocity pulsed jets in which automatic starting and stopping the cyclic operation of the system is achieved by the relative position between the system and the target material being acted upon.

According to one embodiment utilizing the principles of this invention, there is provided a main cylindrical casing having mounted within the bore thereof a relatively heavy, low velocity piston or hammer head impact-

ing member. The hammer head or piston is adapted to be reciprocated along the axis of the bore by a suitable driving means which may be of the pneumatic, electrical, solid-explosive, liquid, monopropellant, bipropellant, internal combustion, steam, external combustion or some such other appropriate means for accelerating the mass. The kinetic energy of the impacting hammer head or piston is transmitted through a coaxially aligned anvil-plunger force transmitting element mounted for axial movement within a cylindrical housing to thereby exert a high pressure on a liquid or gel charge contained in a charge chamber having a nozzle exit end located at the forward end of the cylindrical housing. The initial motion of the plunger into the charge chamber forces out the liquid or gel charge through the nozzle end at extremely high velocities until the hammer head piston member has essentially come to rest. Upon retraction of the hammer head member, the force transmitting member, that is, the anvil-plunger, returns to its initial position thereby allowing a new charge of liquid to be admitted to the charge chamber, at which time the cycle is repeated.

Other objects and advantages will become apparent from a study of the following specification and drawings, in which:

FIG. 1 is a side elevational view of the hypervelocity jet system utilizing the principles of this invention; and

FIG. 2 is a cross-sectional view of the force transmitting member showing the fluted portions along which the liquid charge is transmitted into the charge chamber.

Referring now to FIG. 1, there is shown a main casing member 2 of generally cylindrical shape and having a guide bore 4. Mounted for reciprocable movement within the bore 4 is a hammer head or piston impact member 6 which is provided with a flat front impact surface 8. Mounted for reciprocable axial movement in the forward end of the casing 2 is a generally cylindrical housing 10 having an axial plunger-guide bore 12. Communicating with the bore 12 are a series of radially oriented passageways 14 for introducing a liquid into the bore, to be more fully explained below. At the forward end of the bore 12 there is provided a smaller diameter high pressure chamber section 16 terminating in a jet nozzle opening 18. The housing 10 is provided with a lower valve shoulder portion 20 and an upper shoulder portion 22, an outer guide shoulder portion 24, an annular retaining means 26 for the anvil-plunger to be described below, and stand-off legs 28 which rest on the target material during operation of the system.

An anvil-plunger member 30 is of generally cylindrical configuration and consists of an anvil portion 32 with a suitable annular shoulder portion 34 for cooperation with the shoulder portion 26 of the body housing 10 and retained thereby. The anvil portion 32 is provided with a flat striking surface 36 which is impacted upon by the flat surface 8 of the hammer head member 6 to be discussed below. The striking surface 36 may be covered with a resilient pad for the purpose of absorbing wear during the operation of the system. The plunger portion 38 of the anvil-plunger member 30 is affixed by suitable means within a recess provided in the anvil member 32. The plunger 38 is of cylindrical shape and closely fits within the plunger guide bore 12. The forward portion of the plunger 38 is fluted in an axial direction so as to permit passage of liquid from the passageways 14 to flow into the chamber 16 at the forward end of the bore 12. More specifically, as shown in FIG. 2, the plunger 38 is provided with an annular arrangement of fluted passageways 40. A nose section 42 of the plunger 38 is of a slightly smaller diameter and closely fits into the chamber 16 but with its end face positioned a short length away from the chamber entrance when the anvil-plunger 30

is in its return or start position. In this position, the fluted portion 40 will admit a charge of liquid into the chamber 16.

Between the anvil 32 and the body housing 10 there is provided an anvil-plunger return means in the form of one or more spring members 44, as shown (sunk in suitable recesses). The spring members may be metal springs, pneumatic springs, or the like. A buffer material 44' may be provided, as shown, surrounding the spring members and positioned between the body housing 10 and the anvil 32. Surrounding the body member 10 there is a body retainer and liquid manifold member 46 having one or more inlet ports 48 for admitting liquid or gel to a series of local feeding ports 50 located in a seat shoulder portion 52. The ports 50 communicate with an annular manifold space 54 which is created when the lower valve shoulder 20 of the body member 10 is displaced from the seat shoulder 52 of the body retainer 46 as shown in FIG. 1. In this position the upper shoulder 22 bears against a suitable corresponding shoulder of a retaining ring section 24' fixed within the bore 4 of the main casing and surrounding the upper or rear portion of the body member 10. The liquid filling the annular space 54 then is transmitted through the passageways 14 into the fluted sections 40 of the plunger 38 and thence into the chamber 16, as previously described. A lower guide bore 56 surrounds the body member 10 and is provided with an annular channel 58 having a sealing ring 60 retained therein which contacts the surface of the body member 10 to prevent undue leakage of liquid from the manifold space 54 between the body 10 and the bore 56. The retainer member 46 is provided at its upper portion with an upper guide bore 62 which closely fits around the outer guide portion 24 of the body member 10. One or more air bleed ports 64, positioned in the vicinity of the upper guide bore 62, connect the manifold space 54 with atmosphere. This arrangement allows any air in the manifold space to be bled or vented to atmosphere prior to operation of the system. Suitable mounting means (not shown) may be provided for affixing the body retainer member 46 to a suitable support which, in turn, is connected to the reciprocating drive assembly for driving the impact hammer head or piston member 6.

It should be noted that the construction of the high pressure section of the body 10 around the chamber 16 and nozzle 18 may be reinforced or strengthened by the provision of an annular metallic member 66 fitted onto the body member 10. It is contemplated, however, that any of a number of possible types of materials and methods may be used, including but not limited to one piece cylinder types, as shown, with or without auto-frettaging for high strength, multi-ring types with rings successively shrunk onto or expanded onto one another, ring-segment types, pin-segment types or multi-ring with intermediate fluid support pressure annulus types, nozzle inserts, and the like as known to those skilled in the art of high pressure technology.

The operation of the system is as follows: An appropriate supply of liquid charge is turned on for supplying the input port 48. In the "off" position, the assembly is first positioned so that the stand-off legs 28 do not rest on the target material. In this position the lower valve shoulder 20 of the body member 10 rests against the body retainer seat shoulder 52 of the body retainer member 46, and, as a result, the flow of liquid supplied to the inlet port 48 is shut off in the region of the local feeding ports 50 between the shoulders 20 and 52, thus conserving liquid prior to priming and operating the device.

For the "priming" position of the assembly, the operator next positions the stand-off legs 28 against the target material and then advances the rest of the assembly toward the target such that the body member 10 is moved axially to approximately mid-position within the body retainer member 46. In this position the separation of the valve and seat shoulders 20 and 52 permits a charge

of liquid under a suitable supply pressure to flow into the manifold space 54 and, by means of the radial passageways 14 and the fluted passages 40 of the plunger 38, into the chamber 16 and the nozzle 18. Since air in these respective volumes is undesirable during operation, any air initially present is either purged out by the flowing water or permitted to bleed out the bleed port 64 provided for this purpose as previously described. When a steady stream of liquid issues from the bleed port 64, the operator is ready to reposition the assembly into its operating position.

In the operating position, the operator advances the body retainer member 46 further in the direction of the target until the upper shoulder 22 of the body member 10 bears firmly against its corresponding shoulder of the ring section 24' in the guide bore 4 of the casing 2. In this position the body member 10 may interact with the piston head drive assembly control cycle by cutting off a suitable vent opening or the like located in the main casing 2 as shown in dotted lines. A suitable reciprocating drive assembly operating cycle is described in applicant's copending application Ser. No. 612,945, filed Jan. 31, 1967.

When the hammer or piston member 6 impacts on the anvil striker surface 36, the resultant axial motion of the plunger 38 which is affixed to the anvil 32 initially acts to cover the liquid feed passageways 14 and to close the passage between the front portion 42 and the chamber 16. This action stops the flow of liquid into or back from the chamber 16 during the remainder of the plunger stroke. As the plunger 38 is driven forward by the energy of the hammer acting on the anvil, the liquid in the chamber is rapidly compressed to a high pressure and ejected as a jet through the nozzle 18. The front face of the reduced portion 42, which may be a concave surface (e.g. spherical or conical), acts upon the liquid contained in the chamber 16, concentrating the reflected shock waves in the liquid so as to focus them toward the center line of the chamber and thereby increase the jet's stagnation pressure according to the principles described in applicant's copending application above-mentioned. The liquid in the chamber is then rapidly compressed to a high pressure and ejected as a jet through the nozzle 18. With proper proportioning of the hammer or piston weights, the anvil-plunger weight, nozzle chamber length and diameter, nozzle diameter and liquid properties, the hammer will come to a stop or bounce without the anvil 32 bottoming on the buffer members 44'. Essentially, then, all of the hammer kinetic energy is converted to energy in the liquid jet.

As the hammer is returned to its starting position, the spring members 44 return the anvil 32 rapidly back so that its shoulder 34 stops against the retaining shoulder portion 26 of the body member 10. In this position the liquid feed passageways 14 and the plunger nose portion 42 are open and liquid resumes its flow into the chamber 16 as previously described. The assembly is now ready for the next impact of hammer 6 and the cycle is repeated until the operator stops it by withdrawing the entire assembly from the target or until the stand-off legs 28 in some manner lose contact with the target. When the stand-off legs lose contact with the target or work piece, as by break-up of the target, the body member 10 is driven, either by the hammer or by its own weight, to a position in which it interreacts with the hammer assembly control cycle, for example, by closing or opening a vent opening in the hammer cylinder, as shown in dotted lines, to thereby stop the hammer's operating cycle and also to re-seat the valve shoulder 20 on the seat shoulder 52, the latter action shutting off further flow of liquid into the manifold space 54.

What is claimed is:

1. In a hypervelocity fluid jet head assembly for use with a main cylindrical casing having an impact piston head mounted for axial movement within the bore thereof, the combination comprising, a cylindrical housing

5

having an axial bore with a nozzle exit end, said housing being mounted for axial movement within said casing and extending in an axial direction therefrom, leg means surrounding said nozzle exit end and extending therefrom for resting on a target, an anvil plunger means positioned for reciprocating axial movement within said bore of said cylindrical housing, said plunger means having a rear end face extending into the bore of said main casing and a forward end face disposed in the vicinity of said nozzle exit end of said housing, said housing having an inlet port means communicating with said bore of said housing, means supplying a fluid material to said inlet port, means positioned on said plunger means for transmitting said fluid material from said inlet port to said nozzle exit end, and means for driving said piston member toward said end face of said plunger means whereby said piston member impacts said end face and drives said plunger means towards said nozzle exit end for generating a shock wave therein and converting said fluid material into a fluid jet along the axis of said nozzle.

2. In a hypervelocity fluid jet head assembly for use with a main casing having an impact piston member mounted for axial movement within the bore thereof, the combination comprising, a cylindrical housing mounted within the bore of said main casing and extending therefrom, said housing having a bore coaxial with the bore of said main casing and having a nozzle exit end, a plunger means mounted for axial movement within said bore of said housing, said plunger having a rear end face extending within the bore of said main casing, means for supplying a fluid material to said nozzle exit end, and means for driving said piston member toward said end face of said plunger means whereby said piston member impacts said end face and drives said plunger means toward said nozzle exit end for generating a shock wave therein and converting said fluid material into a fluid jet along the axis of said nozzle.

3. In a hypervelocity fluid jet head assembly for use with a main casing having an impact piston member mounted for axial movement within the bore thereof, the combination comprising, a housing mounted within the bore of said main casing and extending therefrom, said housing having a bore with a nozzle exit end, a plunger means positioned for axial movement within said bore of said housing, means supplying a fluid material to said nozzle exit end, and means for driving said impact piston member towards said plunger means, whereby said piston member impacts said plunger means to generate a shock wave in said nozzle exit end and converts said fluid material into a fluid jet along the axis of said nozzle.

6

4. In a hypervelocity fluid jet head assembly for use with a main casing having an impact piston member mounted for axial movement within the bore thereof, the combination comprising a plunger means mounted for axial movement within said bore of said casing, a chamber in said bore for receiving said plunger means having a nozzle exit end, means supplying a fluid material to said nozzle exit end, and means for driving said piston member toward said plunger means, whereby said piston member impacts said plunger means to generate a shock wave in said nozzle exit end and converts said fluid material into a fluid jet along the axis of said nozzle.

5. In an assembly according to claim 1, wherein there is further provided a means responsive to the axial position of said housing with respect to said casing for controlling said fluid material supply means.

6. In an assembly according to claim 1, wherein said means for transmitting said fluid material from said inlet port to said nozzle exit end is responsive to the axial position of said plunger means with respect to said inlet port.

7. In an assembly according to claim 6, wherein a means is provided between said plunger means and said housing for returning said plunger means to its initial position after impact by said piston head.

8. In an assembly according to claim 7, wherein a means is provided for driving said impact piston head in a reciprocating manner for periodically impacting said plunger means, whereby said means for transmitting said fluid material from said inlet port to said nozzle exit end is periodically interrupted.

9. In an assembly according to claim 1, wherein said means for driving said impact piston head is responsive to the axial position of said housing with respect to said casing.

10. In an assembly according to claim 9, wherein said axial position of said housing with respect to said casing is shifted in response to the withdrawal of said target from said leg means surrounding said nozzle exit end.

References Cited

UNITED STATES PATENTS

3,343,794 9/1967 Voitsekhovsky ----- 239—101

EVERETT W. KIRBY, Primary Examiner

U.S. Cl. X.R.

173—76, 424; 239—4, 102, 601