Sept. 20, 1971 B. V. VOITSEKHOVSKY ET AL 3,605,916

HYDRAULIC HAMMER

Filed Nov. 18, 1969 3 Sheets-Sheet 1

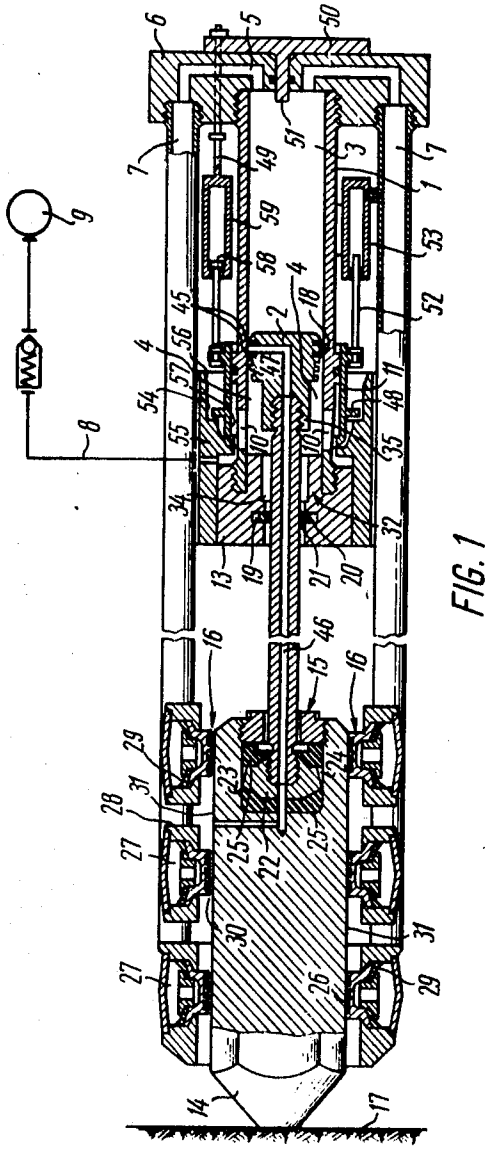


FIG. 1

HYDRAULIC HAMMER

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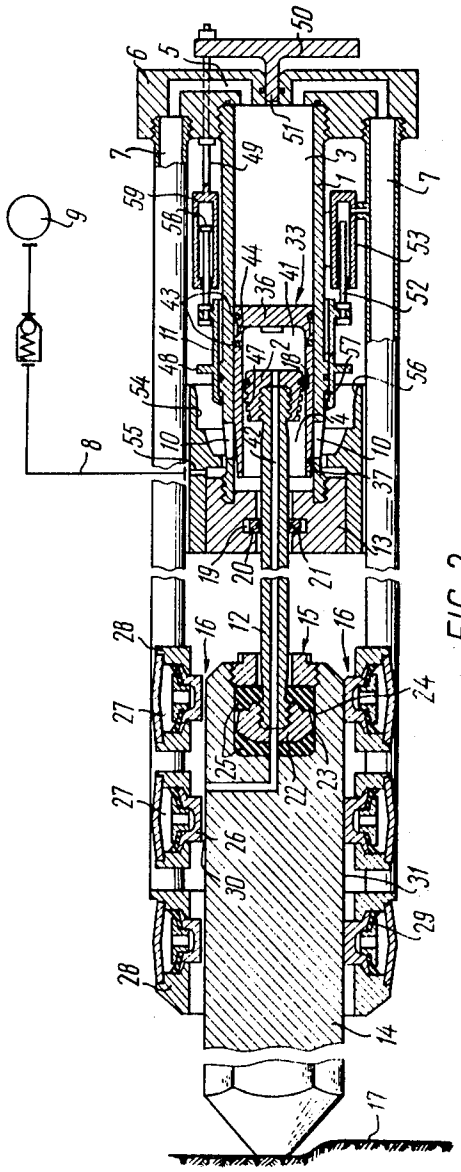


FIG. 2

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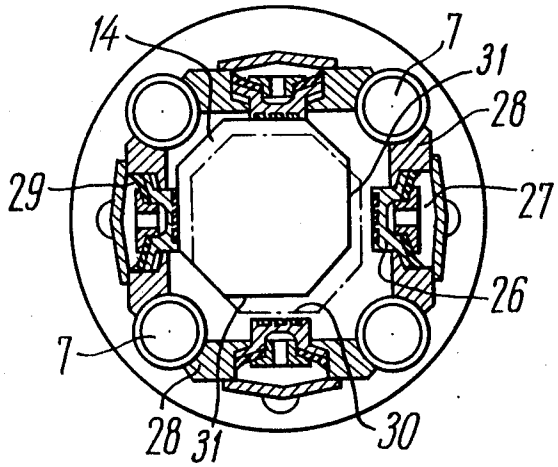


FIG. 3

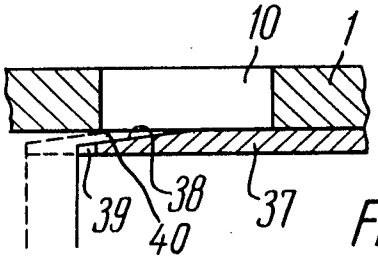


FIG. 4

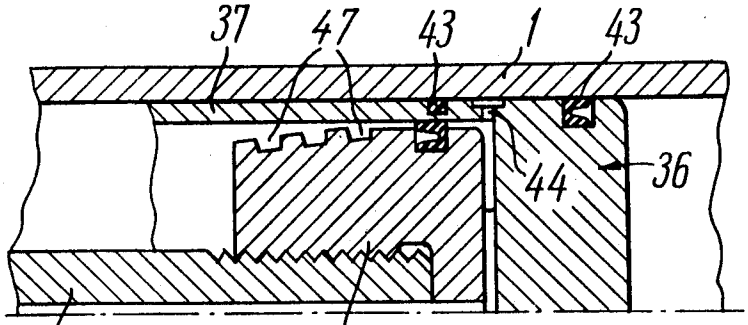


FIG. 5

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HYDRAULIC HAMMER

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U.S. Cl. 173—139 9 Claims

ABSTRACT OF THE DISCLOSURE

A hydraulic hammer for rock breaking has a cylinder accommodating a piston which is connected to the working member and performs the working stroke under the action of compressed gas, and the reverse stroke under the action of pressurized fluid, means being provided in the hammer permitting the piston to deflect together with the working member, from the cylinder axis under the effect of lateral forces arising as a result of the impact, produced by the working member against an uneven rock surface. Damping arrangements are provided to damp the residual energy of the working member during the impact.

The present invention relates to hydraulic hammers wherein the working stroke of the piston is effected by compressed gas, and the reverse stroke by pressurized fluid.

Widely known in the art are hydraulic hammers employed for mechanical working, which have a cylinder with a piston located therein and dividing the inner space thereof into two chambers, one of them being connected with a compressed gas vessel to accelerate the piston during the working stroke, and the other one communicating with a pressure fluid main to return the piston to its initial position during the reverse stroke. The piston is connected to the working member, through its piston rod, which working member is mounted in guides, the piston rod passing through the front end wall of the cylinder and being sealed therein.

As is known, hydraulic hammers develop high impact energy, owing to which attempts were made to use them for breaking rock. However, the prior art hydraulic hammers turned out to be unsuitable for this purpose for the following reasons. The rock, struck by the working member, generally has an uneven surface which during the impact causes lateral forces directed normal to the cylinder axis and producing destructive dynamic loads. Besides, the rock to be broken may be non-uniform in strength and may include voids, which causes entry of the working member, and hence, collision of the piston with the front wall of the cylinder.

The main object of the invention is to develop a hydraulic hammer suitable for rock breaking.

Another object of the invention is to develop a hydraulic hammer capable of damping the energy of the lateral rebound of the working member during its impact against a sloped (uneven) surface of the rock.

Still another object of the invention is to provide a means in the hydraulic hammer which will permit damping the impact energy in the case of free movement (entry) of the working member.

According to the invention, the piston rod is connected

to the working memebr through a hinge, and the guides for the working member are mounted on an elastic base and are movable in a direction normal to the axis of the working member while a damping arrangement is provided in the cylinder to prevent contact of the piston with the front end wall of the cylinder, the piston being so mounted in the cylinder that it can deflect together with the piston rod, at an angle to the cylinder axis.

It is preferable that the hinge connecting the piston rod to the worknig member have a disk with a projecting contact annular portion, said disk being located in a cylindrical space of the working memebr and fixed to the piston rod; and also a resilient element located in said space on either side of the disk.

The damping arrangement can be realized in different ways.

In one case it is formed by a space filled with fluid, and located in the front end wall of the cylinder said space being open from the piston side, and by a part of the piston, entering said space.

In another case, the damping arrangement comprises a sleeve located inside the cylinder and embracing the piston, this sleeve being movable with respect to both the piston and cylinder, and being capable of closing drain holes in the side wall of the second chamber of the cylinder in front of the piston, while the piston has on its side wall a narrow annular projection contacting the inner surface of the sleeve.

In this case it is expedient to provide an external tapered groove and through slots at the end face of the sleeve wall, said groove and slots being made in the sleeve wall, adjacent to the cylinder drain holes.

The piston may have depressions on the tapered part of its side.

In the preferred embodiment of the invention, the guides consist of several pistons located with clearance around the working member so that the axes of the pistons are perpendicular to axis of the working member axis, these pistons being mounted in chambers, filled with compressed gas, and rigidly fixed on the housing of the hammer.

The invention is further characterized in that the piston has a narrow annular projection, located on its side and contacting the inner surface of the cylinder; in the front end wall of the cylinder a transverse circular groove is made, in which a holder with a packing collar embracing the piston rod is movably mounted.

The assumed technical solution ensures reliable operation of the hammer when the working member thereof is affected by forces, varying in direction and magnitude.

The invention is further described by way of example with reference to the appended drawings, wherein:

FIG. 1 shows a sectional view of a proposed hydraulic hammer with a damping arrangement in one embodiment thereof;

FIG. 2 shows a sectional view of a hydraulic hammer with the damping arrangement in another embodiment thereof;

FIG. 3 is a section of the hydraulic hammer guides, taken along line III—III, showing the position of the working member with respect to the guides;

FIG. 4 is a partial enlarged view of the sleeve wall and the draining holes of the cylinder; and

FIG. 5 is a partial enlarged view of the piston and the sleeve inside the cylinder.

The hydraulic hammer shown in FIGS. 1 and 2 comprises cylinder **1** with piston **2** located therein and dividing the inner space of cylinder **1** into two chambers **3** and **4**.

Chamber **3** communicates with a pressurized gas vessel **7** through channels **5** made in a connecting washer **6**, consisting of several tubular receivers rigidly connected

to each other and to cylinder 1 and forming the housing of the hammer. Chamber 4 communicates with pump 9 through a pressurized fluid main.

Under the action of compressed air, piston 2 performs the working stroke in chamber 3, the reverse stroke being effected by the fluid fed into chamber 4. During the working stroke of piston 2, fluid is drained from chamber 4 through holes 10 in the side wall of cylinder 1, which holes are closed by gate 11.

Piston 2 is connected to the working member 14 by means of piston rod 12 passing through the front end wall 13, the rod 12 being connected to the working member by hinge 15.

The working member 14 is mounted in guides 16, and during the working stroke of piston 2 it acts on rock mass 17.

As shown in FIG. 1, piston 2 has a narrow annular projection 18 on its side wall, said projection contacting the inner surface of cylinder 1 and being required as a result of shaping piston 2 as a curved, and particularly a spherical body.

In the front wall 13 of cylinder 1 transverse circular groove 19 is provided with holder 20 movably placed therein and carrying an elastic packing collar 21 embracing piston rod 12. Owing to such a floating packing of piston rod 12, and the presence of projection 18 on the side of piston 2, the latter together with piston rod 12 can take a position at an angle to the axis of cylinder 1, which position is a result of distortion of working member 14 after striking the rock.

When lateral forces act on working member 14 during the impact, it tends to turn about its center of gravity, which, in case of rigid mounting of piston rod 12 could result in a breakage thereof.

To eliminate this, said hinge 15 is provided, comprising a cylindrical disk 22 attached to the end of piston rod 12 and having a narrow annular portion 23 contacting the inner surface of the wall of the cylindrical space 24 of the working member 14, wherein disk 22 is located.

The working member 14 is turned about portion 23, in order to return the working member to its initial position before the impact in space 24. Resilient elements 25 preferably made of elastic material are located on either side of disk 22.

Guides 16 consist of several pistons 26 (FIGS. 1 to 3) disposed around working member 14 in at least two rows normal to the axis of the working member, and mounted in chambers 27 filled with compressed gas and formed in plates 28 which are secured to the hammer housing. Pistons 26 are packed in chambers 27 with elastic packing collars 29.

Thus, pistons 26 rest on an elastic base, and their end faces are located on working member 14 with a clearance 30 about the sliding planes 31.

The mutual disposition of pistons 26 in each of the transverse rows is such that after the rebound of working member 14 in any direction normal to the axis of cylinder 1, the rebound energy is damped by compressed air in chambers 27. The position of pistons 26 in case of such a rebound is shown in FIG. 3.

The residual energy remaining in working member 14 after the impact, is damped by damping arrangement 32 or 33 located in cylinder 1, one embodiment of this arrangement being shown in FIG. 1, and another in FIGS. 2, 4, 5.

In the first embodiment the damping arrangement 32 (FIG. 1) includes space 34 in the front end wall 13 of cylinder 1, which space is filled with fluid and is open in the direction of piston 2, part 35 of piston 2 entering this space and acting on the fluid present therein.

In another embodiment, damping arrangement 33 (FIG. 2) comprises sleeve 36 located inside cylinder 1, embracing piston 2, and movable relative to either of them with a possibility of closing drain holes 10. In this case projection 18 of piston 2 contacts the inner surface of sleeve 36, but acts in the similar way.

The front part of wall 37 of sleeve 36 has an outer tapered groove 38 (FIG. 4) with through slots 39 therein, at the end face of wall 37.

The energy of the working member 14 in case of its idle stroke ("falling through" of the working member) is damped when sleeve 36 closes the drain holes 10, in this case fluid inside the sleeve acts through slots 39 on the sleeve end face, making it move towards chamber 3 relative to piston 2. The fluid pressure inside sleeve 36 will be maintained permanently during the working stroke irrespective of the rate of movement of piston 2 owing to the gradual change of the cross-sectional area of annular gap 40 (between groove 38 on wall 37 of sleeve 36 and the inner surface of cylinder 1) wherethrough the fluid flows from the space of sleeve 36 into holes 10.

Space 41 (FIG. 2) between piston 2 and sleeve 36 communicates with the atmosphere via channel 42, and the space between packing collars 43 of sleeve 36 communicates with the atmosphere by way of channel 44 in the sleeve wall 37, this channel being illustrated in greater detail in FIG. 5.

The same can be said about the hydraulic hammer shown in FIG. 1. Here the space between the packing collars 45 of piston 2 communicates with the atmosphere through channel 46.

In both cases this prevents fluid flowing from chamber 4 to chamber 3 of cylinder 1.

To preclude cavitation effects in chamber 4 in front of piston 2 in case of its abrupt braking at the moment of an impact by the working tool 14, recesses 47 having the form of grooves, particularly circular grooves, as shown in FIGS. 1, 2, 5 are made on a side of the tapered part of piston 2.

Gate 11 has a flange 48 (FIGS. 1, 2) and is connected with cross-piece 50 by means of sectional drawbars 49, the crosspiece adjoining the connecting washer 6 and having projection 51 protruding into chamber 3 of cylinder 1 and interacting with piston 2 or sleeve 36 at the end of the reverse stroke. Gate 11 is connected with plungers 52 of pneumtaic cylinders 53 communicating with the compressed gas vessel 7 and serving only for the displacement of gate 11 in order to close holes 10. Flange 48 is disposed in cylindrical groove 54 in member 55 entering tapered groove 56.

In gate 11 internal cylindrical groove 57 is formed whereby gate 11 is tightly pressed by the fluid against member 55 during the reverse stroke of piston 2.

The hammer shown in FIG. 1 operates as follows.

In the starting initial position, piston 2 is located in chamber 4 of cylinder 1 (it being of no importance whether part 35 of piston 2 enters space 34 or not), holes 10 are closed by gate 11, and cross-piece 50 is pressed to washer 6.

Fluid from pump 9 flows into chamber 4 and acts on piston 2 moving it together with working member 14 towards chamber 3 and expelling the remnants of compressed gas from the latter into vessel 7 via channels 5.

At the end of the reverse stroke, piston 2 acts on projection 51, thus moving cross-piece 50 and, through drawbars 49, gate 11, ensuring the initial displacement of the latter.

After the initial displacement of gate 11, and the initial opening of holes 10, fluid pressure in chamber 4 is dropped and piston 2 starts moving under the action of compressed gas in chamber 3 (working stroke) towards chamber 4, expelling fluid therefrom. The fluid, expelled from chamber 4 acts on the end face and flange 48 of gate 11, which overcoming the force of pneumatic cylinders 53 fully opens holes 10.

Sectional drawbars 49 permit gate 11 to move freely without any displacement of cross-piece 50 owing to the availability of slide 58 and guide frame 59.

When flange 48 passes tapered groove 56 of member 55, there starts a free drainage of fluid from chamber 4,

as a result of which piston **2** is freely accelerated by compressed gas in chamber **3**. As a result of striking against the rock mass **17** the working member **14** is abruptly braked, while the fluid continues to flow out of chamber **4** through holes **10**.

A vacuum void is formed now between piston **2** and the fluid. When the vacuum value is large, atmospheric pressure causes void closure, which results in a hydraulic impact and cavitation effects on the piston surface. The impact waves are damped by recesses **47** made on the side surface of piston **2**.

When the working member **14** enters voids in the rock mass **17**, the energy accumulated by this member is damped when part **35** of piston **2** enters space **34**. As a result the fluid is expelled under pressure from space **34** through the clearances between part **35** and the walls of space **34**. Thus, a rigid impact of piston **2** against wall **13** of cylinder **1** is avoided.

At the moment of the impact against the uneven surface of mass **17** the working member **14** under the action of lateral forces moves aside turning about annular portion **23** of disk **22**, straining resilient elements **25**.

The movement of working member **14** laterally causes the deflection of piston rod **12** with piston **2** from the axis of cylinder **1** at an angle thereto, and the displacement of holder **20** with the packing collar **21** in groove **19**. The energy of the rebound of the working member **14** laterally is damped by gas compression in chambers **27** by pistons **26**. Elastic collars **29** ensure the sealed condition of chambers **27** during distortions of pistons **26** under the action of the deflecting working member **14**.

When piston **2** is braked at the moment of impact, holes **10** are gradually closed by gate **11** under the action of pneumatic cylinders **53**.

After holes **10** are closed, the end face of gate **11** is pressed against member **55** by the fluid acting on the circular groove **57**, and piston **2** performs the reverse stroke.

The hammer shown in FIG. 2 operates in a similar way, except for its damping arrangement.

The working stroke of piston **2** is in this case arranged so that during the impact of working member **14** against mass **17**, sleeve **36** does not shut drain holes **10**. When working member **14** enters a void sleeve **36** shuts holes **10**, and the fluid is drained from sleeve **36** in front of piston **2** only through gap **40**.

Depending on the ratio of the forces acting on the annular end face and the blind end face of sleeve **36**, the latter will move towards chamber **3** or chamber **4**.

During such periodic ("floating") movement of sleeve **36** the cross-sectional area of gap **40** varies, thus maintaining a permanent fluid pressure inside sleeve **36** and a constant braking force. Damping arrangement **33** is more advantageous, than arrangement **32**, since during the action of arrangement **33** in the course of braking the compressed gas energy is not wasted, as there is no direct effect of compressed gas on piston **2**.

What we claim is:

1. A hydraulic hammer comprising: guides; a working member mounted in said guides; an elastic base whereon said guides are secured with a possibility of displacement normal to the axis of the working member; a cylinder; a compressed gas vessel; pressurized fluid mains; a piston mounted in said cylinder and dividing the inner space thereof into two chambers, one of which communicates with the compressed gas vessel to accelerate the piston, the second one being connected with the pressurized fluid mains to return the piston to its initial position after impact; a piston rod passing through the cylinder at the front end wall thereof, and connecting the piston with the working member, said piston being so mounted in the cylinder that it can deflect together with the piston rod, at an angle to the cylinder axis; a hinge connecting the piston rod to the working member, and a damping arrangement, located in the cylinder and serving to prevent impact of said piston with the front end wall of said cylinder.

2. A hydraulic hammer as claimed in claim **1**, wherein the hinge connecting the piston rod with the working member comprises a disk with a projecting contact annular portion, said disk being located in a cylindrical space provided inside the working member and being fastened to the piston rod, and resilient elements located in the space of the working member on either side of the disk.

3. A hydraulic hammer as claimed in claim **1**, wherein said damping arrangement is constituted by a space in the front end wall of the cylinder filled with fluid, said space being open from the piston side, and by a part of the piston entering said space.

4. A hydraulic hammer as claimed in claim **1** wherein said damping arrangement comprises a sleeve located inside the cylinder and embracing the piston, said sleeve being movable with respect to both the piston and cylinder, and being capable of closing drain holes in a side wall of the second chamber of the cylinder, the piston including an annular projection contacting the inner surface of the sleeve.

5. A hydraulic hammer as claimed in claim **4**, wherein the sleeve includes a wall having an external tapered groove and slots at the end face of the wall, said groove and slots being adjacent to the drain holes.

6. A hydraulic hammer as claimed in claim **4**, wherein said piston has a curved surface with recesses therein.

7. A hydraulic hammer as claimed in claim **1**, wherein said guides comprise several pistons located with a clearance around the working members and disposed perpendicular to the axis of the working member, the latter pistons being mounted in chambers filled with compressed gas and rigidly fixed on the housing of the hammer.

8. A hydraulic hammer as claimed in claim **1**, wherein said piston has a narrow annular projection contacting the inner surface of the cylinder.

9. A hydraulic hammer as claimed in claim **1** wherein in the front end wall of the cylinder there is a transverse circular groove, and a holder with a packing collar embracing the piston rod movably mounted in said groove.

References Cited

UNITED STATES PATENTS

2,854,962	10/1958	Bergman	173—139
2,929,361	3/1960	Reynolds et al.	173—139

JAMES A. LEPPINK, Primary Examiner