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Thrust-Impact Rock-Splitter

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Clark et al.

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[54] **THRUST-IMPACT ROCK-SPLITTER**

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[73] Assignee: **The Curators of the University of Missouri**, Columbia, Mo.

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[51] **Int. Cl.**[2] **E21C 37/02**

[52] **U.S. Cl.** **299/22**; 299/15

[58] **Field of Search** 299/15, 20–22

[56] **References Cited**

U.S. PATENT DOCUMENTS

1,884,946 10/1932 Wineman .... 299/22 X

3,488,093 1/1970 Darda 299/22

Primary Examiner—Ernest R. Purser

Attorney, Agent, or Firm—Ray E. Snyder

[57] **ABSTRACT**

A rock splitting tool having elongate laterally expanding metal pressure bars or feathers and an axial sliding wedge or spreader for radially separating the feathers, the wedge being driven by the combined and superimposed forces of a hydraulic thrust servomotor and an impact hammer. The driving paths for transmitting forces to the wedge are coaxial and partially in series and partially in parallel.

3 Claims, 2 Drawing Figures

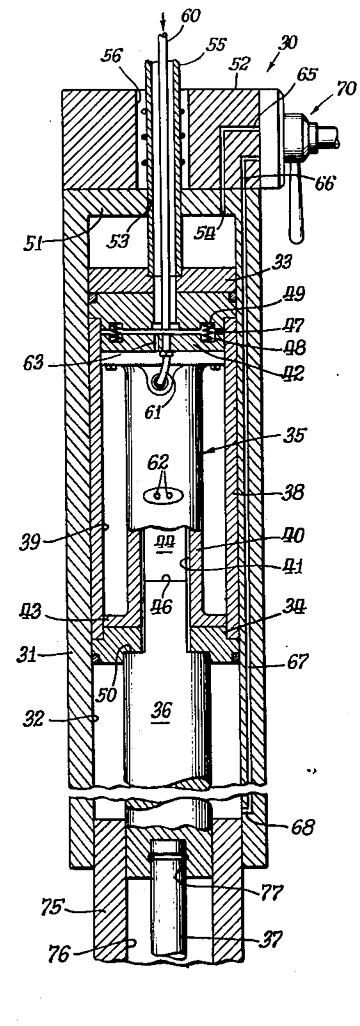

Fig. 1.

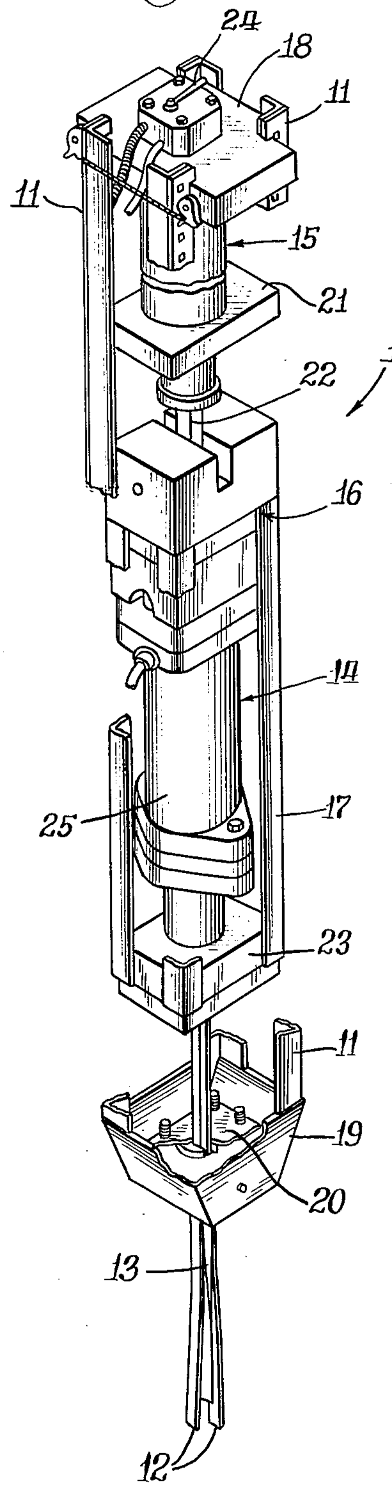
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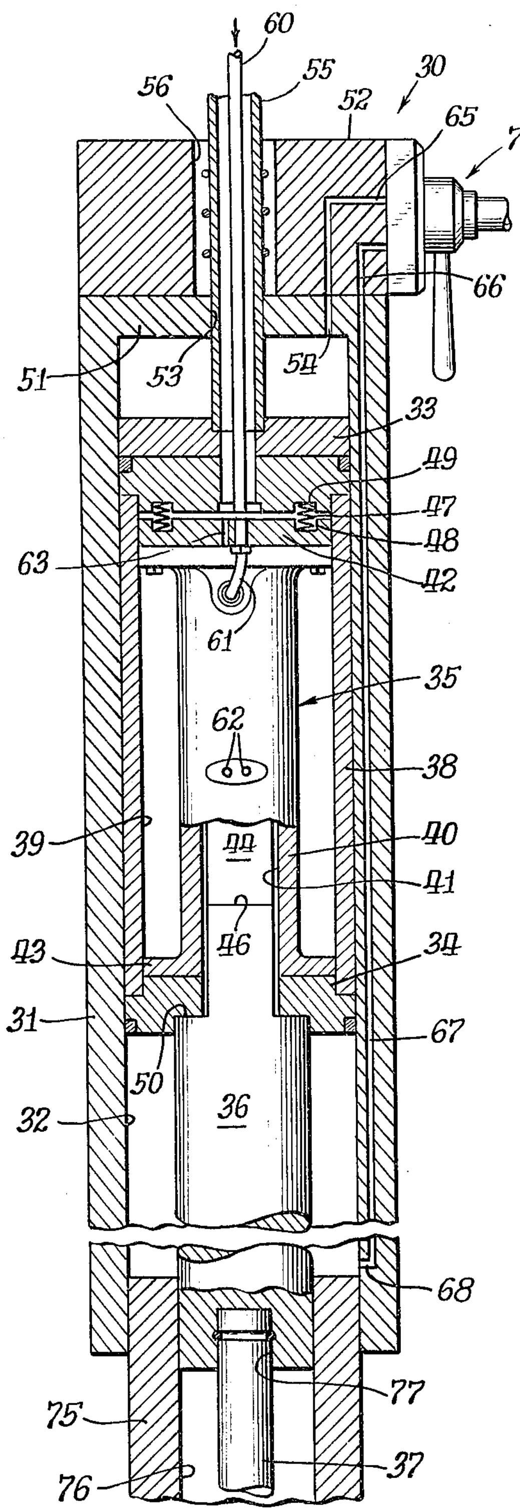
Fig. 2.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THRUST-IMPACT ROCK-SPLITTER

BACKGROUND OF THE INVENTION

The invention described herein was made in part in the course of work under a grant or award from the National Science Foundation.

1. Field of the Invention

This invention relates generally to the field of Mining or in Situ Disintegration of Hard Material, and more particularly to Expansible Breaking Down Devices having fluid pressed pistons and wedges.

2. Description of the Prior Art

Pressure breakers or rock-splitters are well known in the art and are exemplified by the patents to Darda:

U.S. Pat. No. 3,414,328 Hydraulically Actuated Tool for the Mechanical Breaking of Rocks by Means of a Wedge Slidable through Insert Pieces

U.S. Pat. No. 3,488,093 Pressure Breaker

U.S. Pat. No. 3,791,698 Hydraulically Operated Apparatus for Mechanical Splitting of Rock and the Like

Each of the above patents shows a rock-splitter of the general type involved in the present invention. The splitters each have two or more elongate, wedge-like pressure bars or feathers adapted to be inserted into a pre-drilled hole in a rock or other hard substance, and an elongate central sliding wedge or spreader adapted to be driven axially between the feathers. The driving force for the spreader is most commonly provided by a hydraulic piston which is actuated by high fluid pressure. The total force acting axially on the spreader is the product of the fluid pressure times the area of the piston, and this force is transformed into a radial force and is multiplied manyfold by the mechanical advantage of the feather-spreader configuration. The feathers at first move radially to the diameter of the pre-dilled hole and the radial force generated by the pressure bars then builds up until it is of sufficient magnitude to cause the rock to fracture.

Impact hammers or drills are also well known in the art. Such drills most commonly comprise in elongate cylinder and a heavy metal piston disposed to move longitudinally within the cylinder. Air or other fluid under pressure is supplied from a suitable compressor source and is admitted by suitable valves into the cylinder to cause the piston to oscillate therein. The momentum of the piston is imparted as an impact force against an anvil disposed in the working end of the cylinder. The anvil in turn drives a drill or wedge against a rock or paving to fracture the same. The impact force imparted to the rock may have a peak value in excess of 50,000 lbs.

A U.S. Pat. to Amtsberg, No. No. 3,796,271 teaches a triple coaxial hammer comprised of three hammer elements in telescopic relation for driving a rock drill. Amtsberg's hammer is hydraulically movable on a work stroke, and is returnable by hydraulic force supplemented by force of pressure air. This arrangement provides a relatively wide impact pulse against the drill. It is not used in conjunction with a rock splitter and does not combine the hydraulic and pneumatic forces for driving the drill.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an improved rock splitting tool that effectively combines the steady force from a hydraulic servomotor with the superimposed oscillating force of an impact hammer for driving an axially slidable wedge between two or more pressure bars.

The combined tool of the present invention has been found to operate for its intended purpose at speeds up to five times as fast as pressure breakers employing a hydraulic servomotor alone.

The composite tool of the present invention may be designed for use as a unitary hand-held tool, carried by a back-hoe or similar mounting, or incorporated into larger machines such as tunnelling machines. In the latter application, it is comtemplated that this tool may totally eliminate blasting as a means of tunnelling or mining through hard rock.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a rock-splitting tool driven by a combined hydraulic thrust servomotor and an impact hammer; and

FIG. **2** is a longitudinal cross-sectional view of an integral tool combining the hydraulic thrust motor and an impact hammer in a unitary housing.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The thrust-impact rock-splitting tool of the present invention is designated generally in FIG. **1** by the numeral **10** and is seen to comprise: a main mounting frame **11**, a pair of pressure bars or feathers **12**, an axially sliding wedge or spreader **13**, an impact hammer **14**, and a hydraulic thrust servomotor **15**, a load division block **16**, and a thrust frame **17**.

The frame **11** includes an upper end reaction block **18** and a tapered pivoting feather block **19** at its lower end. The feathers **12** are attached to the feather block **19** and are held in place by a spring loaded feather retaining plate **20**.

The hydraulic servomotor **15** is attached to and abuts against the reaction block **18** and is also held in place by a mounting plate **21** attached to the frame **11**. The thrust of the servomotor **15** is transmitted downward as shown through a connecting rod **22** which acts against the load division block **16**. The block **16** is attached to and serves as an upper end of the thrust frame **17**. A lower end or block **23** of the thrust frame **17** is connected to the upper end of the wedge or spreader **13**. Nearly all of the total force generated by the servomotor **15** is transmitted to the wedge **13** through a path comprising the connecting rod **22**, load block **16**, frame **17**, and lower block **23** to the wedge **13**. In a typical embodiment, the servomotor **15** has a piston (not shown) that is several square inches in area, and the fluid operating pressure is several thousand psi so that the total force developed may approach or exceed 100,000 lbs. A arcuately movable valve **24** is mounted on the upper end of the servomotor **15** and is effective to apply or release fluid pressure for operating the servomotor **15**.

The impact hammer **14** may be of the compressed air driven type and is mounted longitudinally within the thrust frame **17**. The hammer **14** has an external housing **25** and its upper end reacts against the load division block **16**. Springs or other resilient means (not shown) are disposed between the upper end of the housing **25** and the load block to preload the hammer **14** by approximately 200 lbs. The lower end of the housing **25** abuts against the block **23**. The hammer **14** contains an internal oscillating piston and anvil (not shown) adapted to impart an intermittent impact force against the wedge

13. This intermittent force is additive to and combined with the steady thrust force imparted to the wedge **13** through the thrust frame **17**.

In operation, the rock-splitting tool **10** functions as follows:

The rock to be split is pre-drilled to a diameter and depth convenient to receive the feathers **12** and wedge **13** when extended. The frame **11** is oriented coaxially with the pre-drilled hole and the feathers **12** and a portion of the wedge **13** are inserted into the hole. The valve **24** is actuated to direct fluid under pressure to the servomotor **15** advancing the thrust rod **22**. The movement of the rod **22** advances the frame **17** and the wedge **13** expanding the feathers **12** radially to the diameter of the hole. Thereafter, the servomotor continues to apply a steady force on the wedge **13** tending to expand the diameter of the hole. The impact hammer **14** is then actuated adding and superimposing an intermittent impact force on the wedge **13**. The combined forces have peak magnitudes sufficient to fracture any rock structure wherein adequate relief or room for lateral displacement is available.

In practice, the combined rock-splitting tool **10** just described has been found effective to operate at speeds up to five times as fast as either component acting alone. It is believed that this result can be attributed to the effects of the frictional forces involved, as follows:

The feathers **12**, once expanded to the diameter of the pre-drilled hole, bear against the interior rock walls and are held relatively stationary by the forces of friction. These frictional forces are large and are substantially equal to the thrust force developed by the servomotor **15** and a portion of the force developed by the impact hammer **14**. Most of the reaction force from the hammer **14** is absorbed by the inertia of the apparatus **10**. That the forces of friction at the feathers are large is apparent from the fact that the mounting carriage for the tool **10** is incapable of absorbing the reaction force of many thousands of pounds generated by the servomotor **15**. These frictional forces also create huge normal forces and hence huge static frictional forces between the interior surfaces of the feathers **12** and the wedge **13**. It is a well known principle of physics that rolling or sliding friction is less than static friction. It is therefore surmised that the almost instantaneous impact forces generated by the hammer **14** are sufficient to overcome the static friction between the wedge **13** and feathers **12** and convert this to sliding friction, allowing the wedge **13** to advance at a significantly increased rate.

Referring now to FIG. 2, there is illustrated a view of an improved rock-splitting tool **30** which incorporates a hydraulic servomotor and impact hammer into an integral unit. The tool **30** comprises a generally cylindrical external housing **31** formed with an internal cylindrical bore **32**, a hydraulic pressure apply piston **33** and a hydraulic return piston **34** disposed within the bore **32**, an impact hammer **35** disposed longitudinally and sandwiched between pistons **33** and **34**, a cylindrical anvil **36**, and a power output shaft **37**, which may be a wedge or adapted to be coupled directly to a wedge.

The pistons **33** and **34** are disposed to slide longitudinally within the bore **32** and are interconnected by means of a rigid cylindrical sleeve **38**. The inner wall of the sleeve **38** defines a cylindrical chamber **39** which contains the impact hammer **35**.

The impact hammer **35** has a generally cylindrical external housing **40** formed with an internal cylindrical bore **41**, an upper end wall **42**, a lower end wall **43**, and a heavy metal piston **44** disposed to oscillate longitudinally within the bore **41**. The piston **44** is adapted to impact against an upper end **46** of the anvil **36**. Springs **47** are disposed under compression within recesses **48** and **49** formed in the upper end wall **42** and lower side of piston **33**, respectively. The springs **47** pre-load or bias the housing **40** against the piston **34**. The amount of preload may be approximately 200 lbs. The piston **34** in turn bears against a cylindrical shoulder **50** formed on the anvil **36**.

The upper end of the housing **31** is formed with an end wall **51** and a control block **52** is mounted on top of the wall **51**. The end wall **51** is formed with an axial central bore **53** and a high pressure fluid inlet port **54**. A connecting shaft in the form of a cylindrical sleeve **55** is attached to the piston **33** and disposed to slide axially through the bore **53** and through a bore **56** formed in the control block **52**. A compressed air conduit **60** extends through the sleeve **55** and is connected to an inlet port **61** formed in the housing **40** of the air hammer **35**. The housing **40** is also formed with air exhaust ports **62** which vent into the chamber **39**. The chamber **39**, in turn, is vented through an exhaust port **63** formed through the upper end wall **42** and opening into the interior of sleeve **55** for venting to atmosphere.

The control block **52** is formed with a high pressure fluid conduit **65** connected to the inlet port **54**. The block **52** is also formed with a low pressure fluid conduit **66**. The conduit **66** joins with a conduit **67** formed in the housing **31** and opening into the cylinder **32** through a port **68**. The port **68** is located at a point near the bottom of the cylinder **32** and beneath the piston **34**. A control valve **70** mounted on the block **52** is operable to direct high pressure fluid through the port **54** to actuate the piston **33** and at the same time vent any accumulated fluid beneath the piston **34** through the port **68**. The control valve **70** is also operable to direct low pressure fluid through the port **68** to return upward the piston **34** and at the same time vent any accumulated fluid from above the piston **33** through the port **54**.

The lower end of the housing **31** is fitted with an internal cylindrical sleeve **75** rigidly mounted within the lower end of the cylindrical bore **32**. The interior wall of the cylindrical sleeve **75** defines a cylinder **76** for the longitudinal movement of the anvil **36**. The upper end of the power output shaft **37** is attached within a recess **77** formed in the under side of the anvil **36**.

In operation, the hydraulic-pneumatic rock-splitting tool **30** functions as follows:

The tool **30** is oriented to drive a wedge **37** between two or move feathers disposed within a pre-drilled hole in a rock. The valve **70** is turned to a pressure apply position and is effective to direct high pressure fluid from a source (not shown) through a conduit **65** and port **54** into the upper end of the cylinder **32**. The fluid pressure acts against the top of piston **33** forcing it downward as shown. The total force developed by the piston **33** is transmitted through the sleeve **38** and piston **34** to the anvil **36**. The anvil **36**, in turn, transmits this steady force to the wedge **37** as the anvil **36** slides downward through the cylinder **76**. Once the feathers have expanded to the diameter of the pre-drilled hole, the force continues to build up as previously described. Any residual fluid that may have been present in the lower end of the cylinder **32** is vented through the port **68** as the piston **34** descends.

The impact hammer **35** is then actuated by introducing high pressure air from a source (not shown) through the conduit **60** to the inlet port **61**. The air is properly valved within the housing **40** so as to cause the piston **44** to move up and down within the cylinder **41**. The momentum of the piston **44** on its downward stroke is imparted at impact to the upper end **46** of the anvil **36**. This impact force is superimposed upon the steady force applied by the piston **33** and is transmitted directly through the anvil **36** to the wedge **37**. The combined forces are of sufficient magnitude to fracture any type of rock structure wherein adequate lateral relief is available.

Once the rock has been split, the air pressure is cut off to the impact hammer **35** and the control valve **70** is turned to its low pressure apply position. In this position, the valve **70** is effective to direct low pressure fluid through the conduits **66** and **67** and port **68** into the lower end of the cylinder **32**. This fluid pressure acts against the lower side of the piston **34** forcing it upward and raising the air hammer **35** and upper piston **33**. Any accumulated fluid in the upper cylinder **32** is vented through the port **54** and conduit **65**. The tool **30** is then restored to its original position and is ready to repeat the cycle.

It should be noted that the combined tool of the present invention is able to accomplish its intended function with a relatively small total size and weight, and with relatively moderate working pressures. Either tool alone, presumably, could perform the function, if such individual tools were of sufficient size and the materials of sufficient strength. Such tools would become very heavy and cumbersome to work with, which would reduce their maneuverability and overall efficiency.

Other types of impact hammers, such as hydraulically or electrically actuated tools might be used in place of the air hammer shown and described. In addition, it is to be understood that many changes and modifications might be made without departing from the spirit of the invention.

The invention is not to be considered as limited to the embodiments shown and described, except in-so-far as the claims may be so limited.

We claim:

1. A rock-splitting tool having two or more elongate pressure bars and an axially driven central wedge for radially separating the pressure bars, and comprising:

a hydraulically actuated thrust servomotor having a power output shaft for providing a steady output force;

means defining a first force transmission path including an anvil connecting said power output shaft with the wedge;

an impact hammer having a housing and an internal oscillating piston adapted to impart impact forces to said anvil by the momentum of said piston thereby defining a second force transmission path through said anvil to the wedge; and

resilient means disposed between said impact hammer housing and said thrust servomotor for pre-loading said impact hammer housing through said anvil against the wedge.

2. The rock-splitting tool of claim **1** wherein said first and second force transmission paths are in parallel and coaxial with the wedge.

3. The rock-splitting tool of claim **2** wherein: said first and second force transmission paths are partially in series by an amount equal to the pre-load provided by said resilient means.

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