Nov. 9, 1965 H. BRIDEN 3,216,510

DEVICES FOR APPLYING IMPACT FORCES

Filed Aug. 20, 1962 3 Sheets-Sheet 1

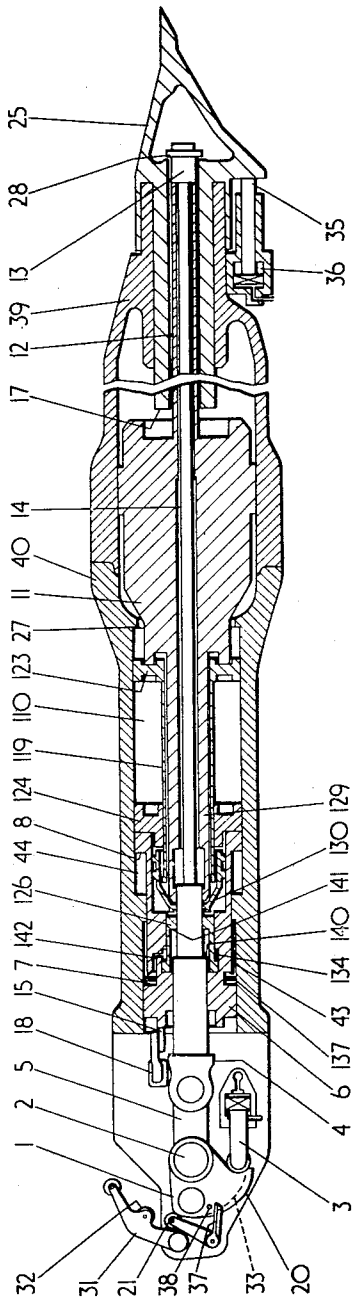


FIG. 1.

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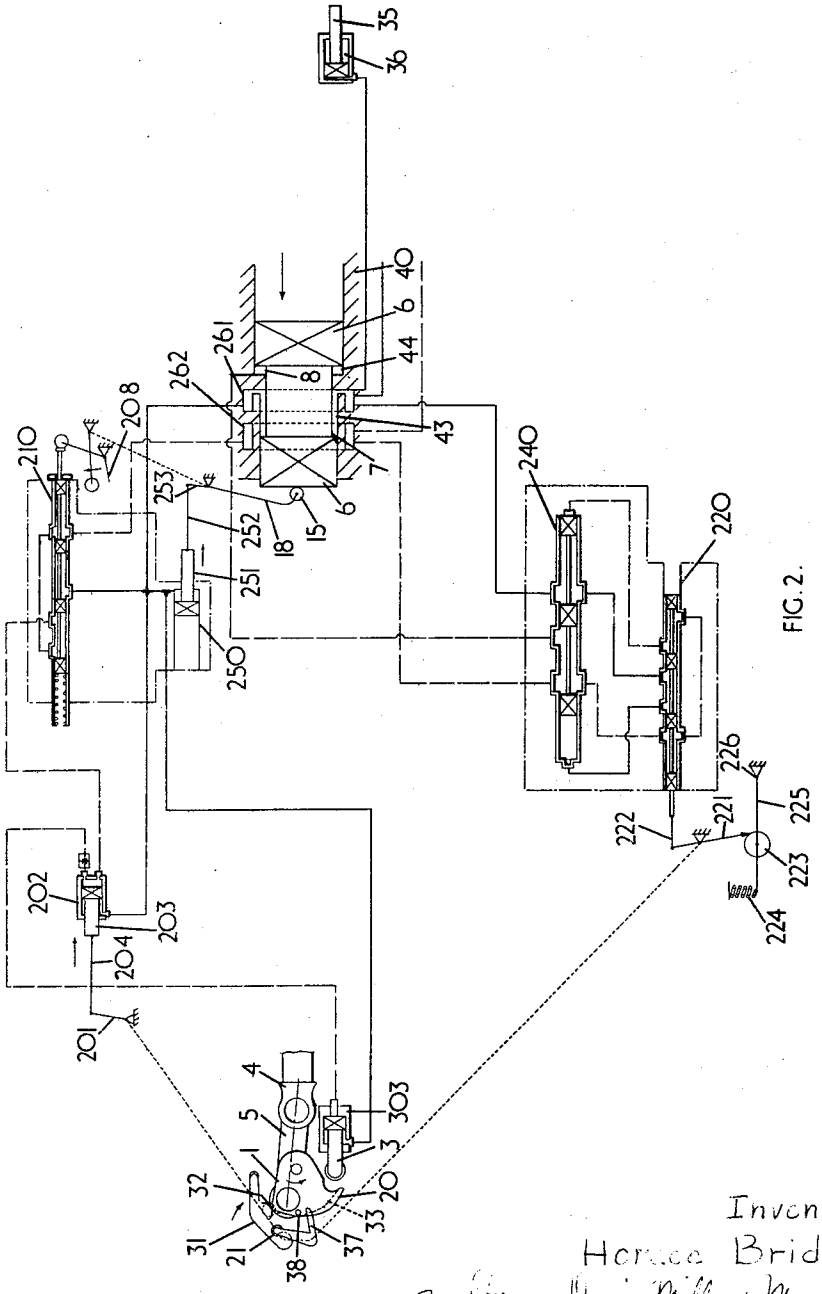


FIG. 2.

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DEVICES FOR APPLYING IMPACT FORCES

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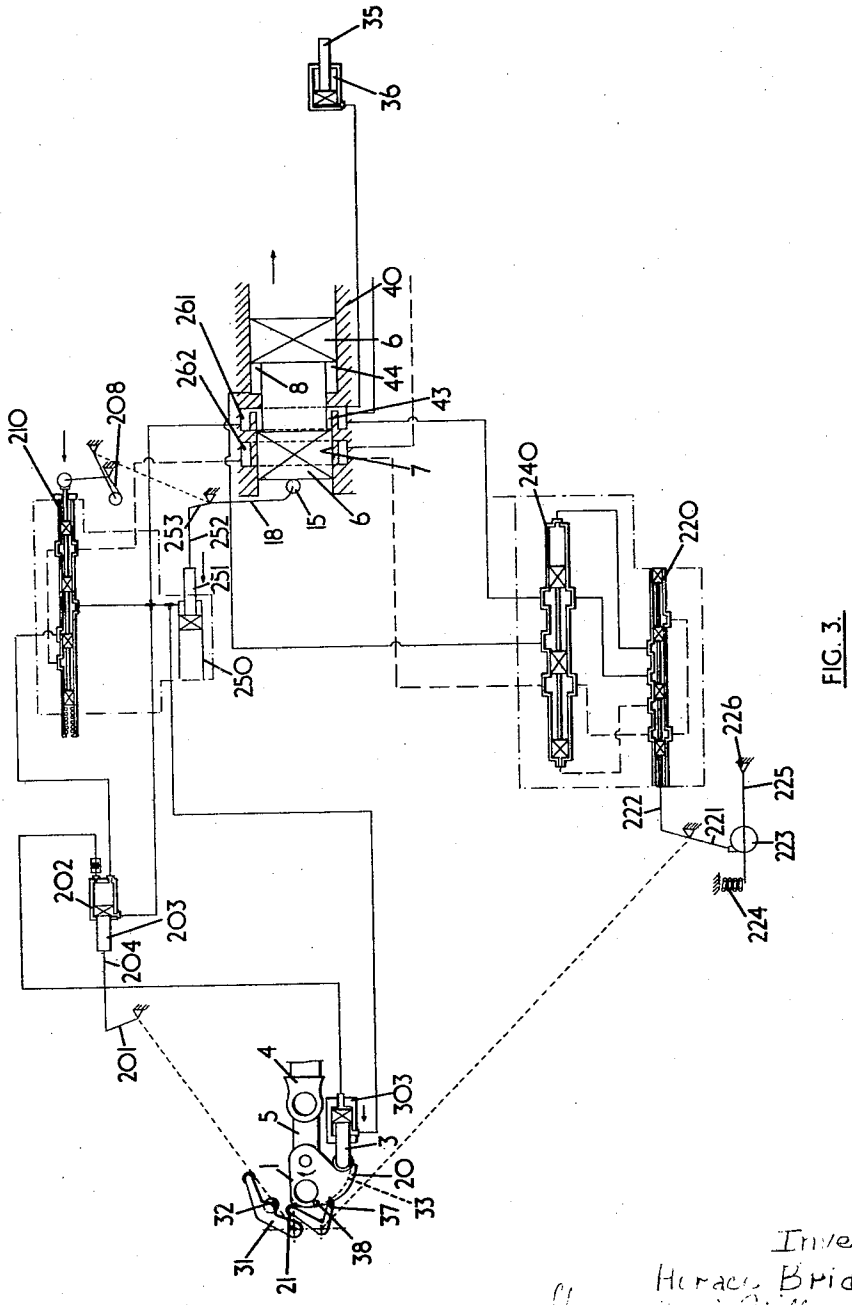


FIG. 3.

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DEVICES FOR APPLYING IMPACT FORCES

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4 Claims. (Cl. 173—15)

This invention relates to percussive mechanisms of the kind comprising a hammer and means for causing the hammer to automatically and repeatedly apply impact forces to a body. In a particular example, the present invention is intended to be mounted on a mineral mining plough and the mechanism then includes a plough cutter blade and is arranged to apply impact forces to the cutter blade during periods in which the blade is encountering resistance above a predetermined limit.

The invention is intended to provide an improved mechanism of the kind referred to, with more efficient conversion of the energy supplied into impact energy, and with improved means for absorption of the energy of moving parts.

According to the invention we provide percussive mechanism for applying impact forces to a body comprising a hammer operatively associated with two movable gas pistons between which is retained a quantity of compressed gas, the compressed gas acting, during operation, as a main spring which supplies energy to accelerate the hammer.

The invention is illustrated by way of example in the accompanying drawing, FIGURE 1 of which is a partly diagrammatic section of a mechanism in accordance with the invention with the mechanism in the position just before the release of the hammer.

In the drawings,

FIGURE 1 is a section through the mechanism,

FIGURE 2 is a diagrammatic representation of the hydraulic circuit in the condition when the mechanism is moving towards the locked position, and

FIGURE 3 is a diagrammatic representation of the hydraulic circuit in the condition when the mechanism is unlocking as the crank passes top dead centre to release the hammer.

In FIGURES 2 and 3, the convention has been adopted, for the purpose of simplification, of showing various valve operating lever systems, which are in fact physically connected to the levers **31**, **37** and the roller **15**, as being spaced from the levers **31**, **37** and the roller **15**. The dotted lines are linkages interconnecting the valve operating lever systems and the levers **31**, **37**, and **15**. The linkages are schematically illustrated and in practice they are such that rotation of the level **201**, for example, causes a corresponding rotation of lever **31** and urges the roller **32** to bear on cam surface **33** as will be hereinafter described. Hydraulic pipes carrying high pressure fluid are shown in unbroken lines and those carrying low pressure fluid are shown in long dashed lines in each of these two figures.

The illustrated mechanism comprises a mineral cutter blade **25** movably arranged in a nose casting **39** which is secured to one end of a central casting **40**, these two castings **39** and **40** being in this instance adapted to be mounted on a mining machine of the plough type and accommodating a piston and hammer assembly. A release unit is attached to the other end of the central casting and is protected by a cover (not shown).

Within the central casting **40** an inert gas is held under pressure in the space **110** enclosed by a forward gas piston **123**, a rear gas piston **124**, and inner gas tube

119, and a liner (not shown) fitted in the bore of the central casting. The two pistons **123** and **124** are of equal diameters.

The inner gas tube **119** and forward gas piston **123** are rigidly joined together, but the rear gas piston **124** can be moved along the inner gas tube **119** to compress the enclosed gas further. Stops on the rear (left-hand) end of the inner gas tube **119** limit the maximum separation of the gas pistons **123** and **124**.

In the release unit a crank **1** which pivots about an axis **2** is prevented from turning more than 2½° anticlockwise past top dead centre, by means of a roller on the rod of a release jack piston **3**. The piston **3** engages internal stops in a cylinder **303** at this position, and a cross-head **4** which is joined to the crank **1** by a connecting rod **5** is in consequence prevented from moving towards the right. A hammer **11** is slidable within the casting **39**. The rear end of the hammer co-operates with the piston **123**. The front end of the hammer has an extension tube **12** which engages with a nut **13** on the end of a rod **14** coupled at its other end to the cross head **14**. The position of the linkage **4**, **5**, **13**, **14** and crank **1** (shown in FIGURE 1) is herein referred to as the "locked position."

A main piston **6** is moved to-and-fro by fluid pressure obtained from hydraulic circuits to be described, in chambers **43** and **44** acting on its two annuli **7** and **8**. The smaller annulus **7** is subject at all times to high fluid pressure while the larger annulus **8** is subject to the pressure of fluid in the chamber **44** which is connected either to pressure or to exhaust by a main control valve **240** included in the hydraulic circuits shown in FIGURES 2 and 3.

With the crank **1** abutting the jack piston **3** and thus in its locked position, high pressure fluid from a source to be mentioned hereinafter is fed to the chamber **44** to act on the larger annulus **8** and the main piston **6** moves towards the right taking the rear gas piston **124** with it. The gas loads acting on the two gas pistons **123** and **124** are now no longer self balancing as they were when the piston **124** was tight against the stop at the left-hand end of the inner gas tube **119**, and the gas pressure acting on the rear face of the forward gas piston **123** is pressed against the hammer **11** with an increased pressure. The latter is restrained from moving by its extension tube **12** which engages with the nut **13** at the forward end of the linkage tie rod **14**, this rod, being joined at its other end to the cross-head **4**, is held locked against movement to the right by the crank **1**.

A roller **15**, see also FIGURES 2 and 3, carried on a resiliently loaded lever **18** pivoted to the centre casting bears on the left-hand end of the main piston **6**. The roller **15** detects any movement of the main piston **6** since if the latter moves to the right the resilient loading of the lever keeps the roller in contact with the piston. Hence the compression of the gas can be detected and when this compression reaches a predetermined amount, for example when the main piston has moved 1.75 inches, the lever **18** (as can be seen from FIGURES 2 and 3) acts through a further lever system including a bell crank lever **208** to cause the spool of a valve **210** to move to the left as is shown in FIGURE 3. This allows oil from the release valve **210** to pass to the release jack cylinder **303** via an auxiliary cylinder **202** (see FIGURE 3) and when high pressure oil is supplied to the cylinder **202** the piston **203** of the auxiliary cylinder is moved just prior to that of the release jack piston **3**, and acting through the auxiliary linkage **204**, **201**, lifts the roller **32** carried by the lever **31** clear of the crank **1** into the position shown in FIGURES 1 and 3 before the piston **3** starts to move. The high pressure oil ap-

plied to the release jack cylinder **303** is now able to move the piston **3** to the left. Further compression of the gas while the release jack piston **3** is extending is limited by the tail shaft **129** of the hammer **11** which engages with the main piston **6** through a conical thrust member **130** and a cushioning piston **126**. The cushioning piston **126** is slidable within a cylinder **134** formed within the main piston **6**. The cylinder **134** communicates with the chamber **43** through parts **142** (only one being shown). A flap valve **137** co-operates with the parts **142**, the valve has small calibrated apertures which provide controlled leakage paths. In the drawing these are conveniently represented by a space between the adjacent hatching lines. In this way relatively free flow past the value is possible in one direction, but only a restricted flow is possible in the opposite direction. The piston **126** is able to exert a force upon the rear piston **124**, through a conical thrust member **130**, the shaping of the thrust member being such as to accommodate the differences in diameters of the piston **126** and an annular abutment on the rear piston **124** and to provide different thrust areas at its opposite ends. When the release jack piston **3** moves far enough to push the crank **1** past its top dead centre it unlocks the linkage and leaves the cross-head **4** free to move the right.

The gas at its increased pressure acts on the forward gas piston **123** and accelerates it to the right taking the hammer **11**, the linkage tie rod **14**, nut **13**, cross head **4** and connecting rod **5** with it, the crank **1** being rotated in a clockwise direction. After moving a predetermined distance, for example 1.50 inches, the hammer **11** impacts on the end of the blade tail shaft at **17**.

As the crank **1** is rotated by the jack piston **3** a valve cam **20** which is integral with it moves a cam follower **21** which is arranged to act through a linkage system **221**, **222** to reverse the setting of a pilot valve **220** associated with a main control valve **240** thereby moving the piston valve **220** from the position shown in FIGURE 3 to the position shown in FIGURE 2. The main control valve **240** controls the admission of pressure fluid from the chamber **261** to the chamber **44** and from the latter to exhaust, thereby controlling the pressurisation of the piston **6**. This reversal of the pilot valve **220** setting causes the main control valve **240** to connect the chamber **44** to exhaust line through an annular distribution chamber **262**. An over-center device (parts **223–6**) and an arrestor device (not shown), which latter forms not of the present invention and therefore is not discribed, arrest and hold the pivlot valve **220** and its operating lever system **221** and **222** in this position. The over-centre device, shown diagrammatically, comprises a lever **225** pivoted at **226** carrying a latching surface schematically indicated at **223** which is adapted to be engaged by the end of lever **221** when the latter has been moved into the position shown in FIGURE 3, that is from one side to the other of the vertical plane passing through a predetermined position on the lever **221**. A spring **224** resiliently urges the lever **225** towards the lever **221**.

After impact the cross-head **4**, linkage tie rod **14** and nut **13** continue moving towards the right, taking the connecting rod **5** and crank **1** with them until a shoulder **140** on the cross-head **4** engages with stops **141** on a cushioning piston **126**. This cushioning piston **126** in turn moves towards the right, discharging oil from a cushioning cylinder **134** into the chamber **43** through ports **142** in the main piston **6**, and past a flap valve **137** which lifted off its seat and does not restrict this flow. From the chamber **43** the oil can flow back into the main pressure circuit through the valve **240**.

The movement of the cushioning piston **126** towards the right against the hydraulic forces exerted on it absorbs the energy of the moving linkage **1**, **4**, **5**, **13**, **14** and brings it to rest, meanwhile the same hydraulic forces tend to move the main piston **6** towards the right. These forces are less than the sum of the hydraulic forces acting on the annulus **7** and the gas loads acting through the rear gas piston **124** on to the main piston **6**, and the latter starts moving towards the left. The axial length of the conical thrust member **130** is such that the cushioning cylinder can complete its cushioning stroke before it contacts the member **130**.

When the cushioning piston **126** and the linkage have the same velocity as the main piston **6** the high pressure oil from the chamber **43** starts to flow back into the cushioning cylinder **134**. The flap valve **137** closes and the restricting orifices in the valve **137** restrict the rate of this oil flow so that the cushioning piston **126** and main cylinder **6** re-engage gently and the linkage **1**, **4**, **5**, **14**, **14** moves only slowly towards the left.

Should the coal or other body to which impact is applied absorb only p artof the energy of the blow, the movement of the blade **25** towards the right is restrained by a collar **28** on the nut **13** engaging with the blade **25**, the same nut **13** applying a similar restraint to the hammer **11** through the extension tube **12**. The inertia of the hammer **11** and blade **25** continues to accelerate the linkage **1**, **4**, **5**, **13**, **14** towards the right, thereby tending to impose undue forces upon the crank **1** and the connecting rod **5**. This is avoided by arranging that the physical properties and dimensions of the linkage tie rod **14** and hammer extension tube **12** are able to provide the necessary resilience at re-engagement of the hammer extension tube **12** with the collar **28** to protect the bearings of the crank **1** and connecting rod **5** against damage. As soon as this re-engagement takes place the cushioning piston **126** again provides the initial retardation as described above until the axial clearance of the conical thrust member **130** is taken up and piston **126** moves the member **130** to contact the rear gas piston **124** is moved towards the right away from the main piston **6**.

The net hydraulic force acting on the main piston **6** is now towards the right, the area of the annulus presented in the cushioning cylinder **134** being larger than the effective area of the annulus **7**, and the main piston is accelerated towards the right. During this accelerating period oil flows freely out of the cushioning cylinder **134** past the flap valve **137**, but as soon as the velocities of the main piston **6** and the other masses are equal, the flap valve **137** closes as flow reverses and is then restricted and the main piston **6** and the rear gas piston **124** reengage at a low relative speed.

All the moving parts are thus brought to rest, their energy being absorbed by the work done against the high pressure oil in the chamber **43** and cylinder **134**, by drawing oil from exhaust at high velocity through the main control valve **240** and the interconnecting ports into the chamber **44**, and against the gas load exerted on the rear gas piston **124**, the forward gas piston **123** being held meanwhile by fixed stops **27** in the casting **40**. The main piston **6** is now moved towards the left by the gas loads acting on the rear gas piston **124** and hydraulic forces acting on the annulus **7**, but the movement is heavily damped by the flow of oil out of the chamber **44**. When the main piston **6** reaches the position where release occurs, i.e. that shown in FIGURES 1 and 3, the rear gas piston **124** engages the stops on the inner gas tube **119** and now only the hydraulic forces move the main piston **6**.

From this position the cation is the same whether or not the blade has been fully arrested by its impact. The main piston **6** continues moving towards the left, taking the linkage **1**, **4**, **5**, **13**, **14**, hammer **11** and blade **25** with it until the blade **25** engages with the piston rod **35** of the sensing cylinder **36**. High pressure oil is fed at all times to this cylinder **36** and the dimensions of the cylinder and piston **36** and **35** and these of the annulus **7** are chosen so that the piston rod **35** can exert a greater force on the blade **25** acting towards the right than the oil acting on annulus **7** can exert towards the left, con-

sequently the impact cycle stops until the coal loading on the blade **25** exerts sufficient axial thrust to overcome this net force acting on the blade **25** towards the right.

The motion of the main piston **6** towards the left is detected by the roller **15**, and the setting of the release valve **210** is reversed by means of the lever system **18**, and **208** causing the release jack piston **3** to move the right as shown in FIGURE 2. The setting of the release valve **210** also causes the auxiliary cylinder **202** to act through its linkage **201**, **204** to bring the roller **32** on the lever **31** to bear on a second cam **33** integral with the crank **1**. As the crank **1** approaches its T.D.C. the turning moment exerted on it by the thrust of the connecting rod **5** decreases, but the shape of the cam **33** is such that the roller **32** exerts an increasing moment which drives the crank **1** over T.D.C. into contact with the release jack **3** and holds it there against any tendency to bounce back.

As the crank **1** locks in the position shown the hammer **11** is cushioned by the gas in the space **110**, and the main piston **6** is cushioned by the cushioning cylinder **134**, the cushioning piston **126** moving to discharge oil which absorbs the energy of these moving masses. The linkage mechanism **1**, **4**, **5**, **13**, **14** is again protected against the shock of re-engagement of the rebounding hammer **11** with the collar **28** (rebounding off the compressed gas between the gas pistons **123** and **124**) by the resilience of the linkage tie rod **14** and hammer extension tube **12**.

As the crank **1** moves anti-clockwise, a peg **38** engages with the lever **37** which operates the pilot valve **220**, this being set to move immediately after the crank has passed its T.D.C. position moving anticlockwise the main control valve **240** to the position shown in FIGURE 3 in which high pressure oil is fed to the chamber **44**. The cycle now continues as from the point at which high pressure oil is fed to the chamber **44** with the crank **1** locked, as hereinbefore described.

The roller **15** is resiliently loaded by a loading cylinder **250**, with a piston rod **251**, is continuously fed with high pressure oil and acts, through linkage **252** and **253**, to continuously urge the roller **15** into contact with the main piston **6** except during the period in which the piston **6** moves in consequence of the blade **25** not being arrested by impact. This ensures that movements of the piston **6** are detected as aforesaid. The annular chambers **261** and **262** are distribution chambers for the high pressure oil and low pressure oil respectively, and are connected as indicated to a high pressure supply and to exhaust.

The pilot valve **220** and the main control valve **240** may be fabricated in a single valve block, schematically represented by chain-dotted lines in FIGURES 2 and 3. The valve **210** and cylinder **250** may be similarly arranged.

In the arrangement of a percussive mechanism according to the invention on the body of a mineral mining plough one of whose blades is then constituted by the blade **25**, when this blade encounters resistance above a predetermined limit an impact of more than 2 inch-tons (and preferably approximately 12 inch-tons) is applied to the plough blade to break down resistant mineral. The frequency of such application is preferably less than 180 per minute and advantageously about 120 per minute. The ratio of the mass of the hammer to that of the cutter blade is preferably greater than 2:1 and may for example be 2½:1. A percussive plough as described in this paragraph has been found to have many advantages over prior known percussive ploughs, which differed from the present plough in giving only very much lighter impacts at a much higher frequency.

I claim:

1. A percussive mechanism for applying impact forces to a body, comprising a housing, a hammer disposed in said housing for movement in a predetermined direction to apply an impact force, means for locking the hammer against movement in said direction, a cylinder in said housing, a first piston slidably disposed in the cylinder and adapted to move said hammer in said direction, a second piston slidably disposed in said cylinder and spaced from said first piston to define a gas space therebetween for a quantity of a gas, means adapted to displace the second piston toward said first piston to reduce said gas space and pressurize any gas in said space to increase its stored energy, and release means connected to operate said locking means to allow the gas to expand to drive said first piston and the hammer in said direction.

2. The percussion mechanism of claim **1** and including means responsive to resistance to movement of said body, for actuating said release means to operate said locking means to release said hammer, thereby permitting the first piston to urge the hammer in said direction.

3. The mechanism of claim **1**, including a third piston for displacing said second piston, said third piston being slidably disposed in said cylinder and having an initial position and a first surface thereon adapted to be acted upon by hydraulic fluid to move said third piston from said initial position to exert a displacing force on said second piston, and a second surface on said third piston adapted to be acted upon by hydraulic fluid to return said third piston to said initial position, and a cushioning chamber within said third piston, a cushioning piston slidable in said cushioning chamber, and means for coupling a linkage to the cushioning piston whereby some of the kinetic energy of said linkage can be absorbed.

4. The percussion mechanism of claim **1** wherein said locking means includes a crank arranged to latch with a linkage when at a first position relative to a top dead center position, and to disengage from said linkage when in a second position relative to said top dead center position, and a hydraulic jack operatively disposed to move said crank from said first position to said second position, and a control valve controlling said jack, and said release means includes a lever system responsive to the location of said hammer and disposed to control the setting of the control valve.

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