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CARTRIDGE-POWERED IMPACT TOOL

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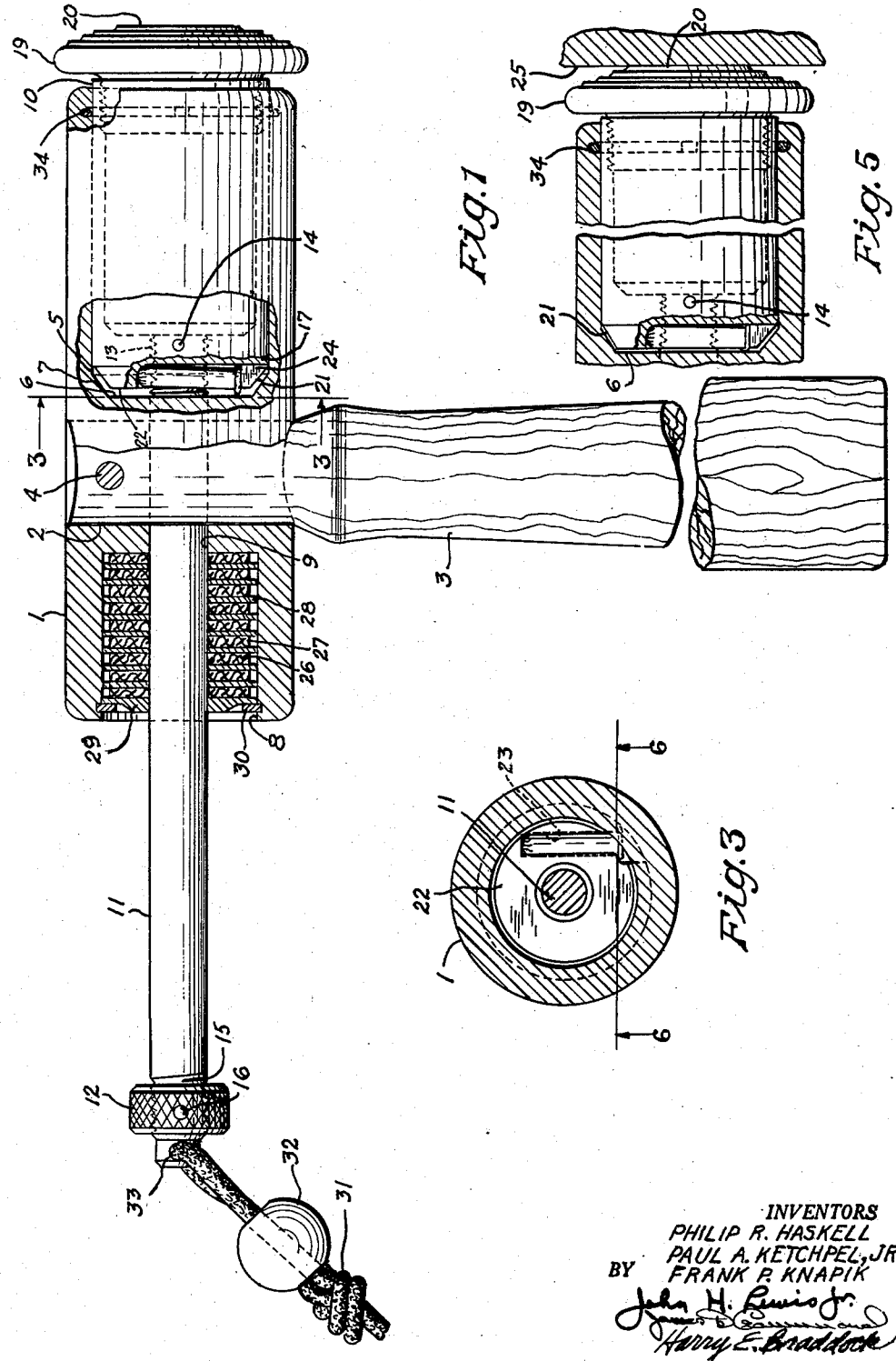


Fig. 1

Fig. 5

Fig. 3

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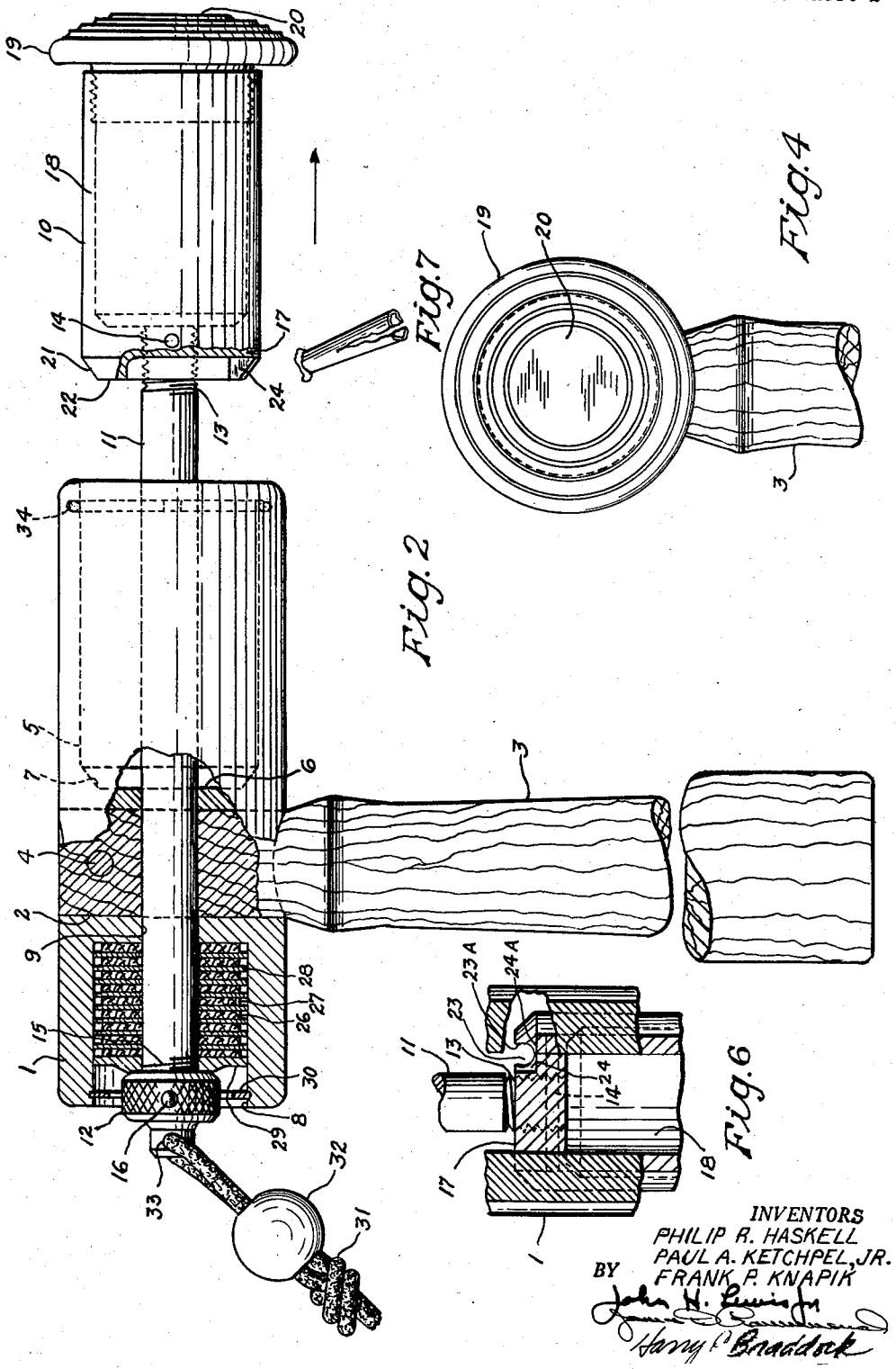


Fig. 2

Fig. 7

Fig. 6

Fig. 4

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CARTRIDGE-POWERED IMPACT TOOL

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13 Claims. (Cl. 81—52.35)

This invention relates to impact tools of the type which are manually swung against a work surface, and more particularly to an impact tool wherein the force of the impact blow is amplified by the explosion of a propellant powder cartridge within the tool at the moment of impact with a work surface.

In impact tools such as hammers, sledges, axes and the like, the primary limiting factor which determines the work performed by the tool is the strength of the operator. In the majority of uses to which manipulated impact tools are applied, the desired work is accomplished by a succession of blows, since human strength limitations make it impossible to accomplish the work by a single blow. Delivery of repeated blows depletes the operator's strength, with the result that both impact force and accuracy of blow delivery diminishes.

It is an important object of this invention to provide an impact tool in which a major portion of impacting force is derived from a propellant powder cartridge fired when the tool is lightly struck against the work surface, thus relieving the operator of heavy exertion, and permitting high accuracy of blow delivery.

It is an object of this invention to provide an impact tool wherein the impacting force delivered to the tool by the operator is supplemented or amplified by means in the tool for exploding a propellant powder cartridge and converting the energy therefrom into tool impact energy.

It is a further object of this invention to provide a manipulatable tool having a movable impact element, and means for exploding a propellant powder cartridge in proximity to the impact element when the tool is struck against a work surface by an operator to amplify or supplement the force of the blow.

It is a further object of this invention to provide a manipulatable impact tool having an impact assembly rectilinearly movable in a tool frame, and means for supporting a rimfire propellant powder cartridge in a confined combustion chamber defined between the assembly and tool frame with the rim of the cartridge abutting between the assembly and frame so that impact of the assembly against a work surface will cause the cartridge rim to be crushed to explode the cartridge, and the expanding gases of explosion will drive the assembly in impact with the work surface.

It is a further object of the invention to provide a manipulatable tool having a frame including a barrel and an impact assembly mounted for rectilinear movement in the frame, comprising a piston disposed for rectilinear movement in the barrel, and means for supporting a rimfire propellant powder cartridge with its rim in abutment between said piston and a portion of the frame forming an inner terminus of said barrel, when said piston is in firing position, so that the rim of the cartridge will be crushed to explode the cartridge when the impact assembly is struck against a work surface, and the piston will be driven against the work surface by the expanding gases from the cartridge.

It is a still further object of the invention to provide, in combination with the tool described in the preceding paragraph, means for de-accelerating and stopping the impact assembly without damage to the tool in the event that the impact assembly is not arrested by impact with the work surface.

The impact tool of this invention is in the form of a hand tool which may be swung, as a hammer or an axe is swung, against a work surface to be impacted. In general arrangement, the tool comprises a handle to which is fixed a tool frame. Within the tool frame is mounted a captive rectilinearly movable impact assembly which is designed to be propelled against the work surface by the explosion of a rimfire propellant powder cartridge. The rectilinearly movable impact assembly comprises a piston mounted for limited rectilinear movement in a barrel formed in the tool frame. An impact element is mounted on the piston and protrudes from the frame barrel for engagement with a work surface. A connecting rod rigidly fixed to the piston is journaled in a bore of the tool frame for rectilinear movement, and controls impacting movement of the piston by means of a stop on the connecting rod which engages a shock absorbing component in the tool frame when the piston moves from a firing position within the frame barrel, to a fired position in which the piston is protuberant from the frame.

Energy to drive the piston is derived from a conventional rimfire cartridge which is filled with propellant powder. A cartridge receiving bore is provided in the piston, and is so disposed that a cartridge in the bore has its rim in abutment with a portion of the tool frame, forming an inner terminus of the barrel, when the piston is in firing position. When the protruding impact element of the piston is struck against a work surface, by swinging the tool, the cartridge rim in abutment with the frame is crushed, as the frame continues to advance by inertia, igniting the priming compound therein, and exploding the propellant powder. The gases produced by the burning powder expand within the tool barrel, driving the piston with great force against the work surface. Since the tool frame is much heavier than the piston assembly, as will be hereinafter described, a substantial portion of the available cartridge energy is expended in moving the piston and is thus delivered as impact force on the work surface.

The foregoing and other objects will be made apparent in the detailed description of the tool and mode of operation which follows, especially when considered in connection with the accompanying drawings, wherein:

Fig. 1 is a side elevational view partly in section and with portions broken away to show the disposition of the elements of the tool in position for firing.

Fig. 2 is a view similar to Fig. 1, but shows the disposition of the tool elements immediately after firing.

Fig. 3 is a cross-sectional view taken on line 3—3 of Fig. 1.

Fig. 4 is an end view of the tool.

Fig. 5 is a fragmentary sectional view showing the position of the piston and frame of the tool at the instant of firing, the piston being shown in elevation with a portion broken away to show the cartridge.

Fig. 6 is a fragmentary sectional view on line 6—6 of Fig. 3, with a portion broken away to show details of the cartridge receiving bore.

Fig. 7 is a view showing a cartridge which has been fired in the tool.

With reference to the drawings, the tool comprises a tool frame 1 having a transverse bore 2. A handle 3 of any desired length is fixed in bore 2 by suitable means, such as the crosspin 4, shown. Forwardly of the handle, the frame is provided with a cylindrical barrel 5 which is adapted to receive a piston 10 to be hereinafter de-

scribed. At the rearward, inner terminus of barrel 5, a conical shoulder 7 is formed which joins the barrel and a lesser diameter planar end wall 6. Rearwardly of the handle 3, the frame 1 is provided with a cylindrical cavity 8, in which is mounted a shock absorbing component which will be described hereinafter. A cylindrical bore 9, of smaller diameter than barrel 5 or cavity 8 extends longitudinally through the frame and the mounted handle and communicates between barrel 5 and cavity 8.

An assembly, generally comprised of piston 10, connecting rod 11 and stop 12, is mounted for rectilinear movement relative to the hammer frame. Connecting rod 11 is slidably disposed in bore 9. Piston 10 is firmly mounted on connecting rod 11 by means of threads 13 and a crosspin 14 which extends transversely through both the piston and the connecting rod. Stop 12 is similarly fixed to connecting rod 11 by threads 15 and crosspin 16.

Piston 10, as best seen in Figs. 1 and 6, has a solid crown section 17 and a hollowed-out cylindrical body section 18. It is desirable to keep the weight of the piston and other elements of the rectilinearly movable piston assembly as low as is consistent with structural strength requirements, since the amount of kinetic energy which may be imparted to the piston by an exploding cartridge is inversely proportional to the mass of the movable piston assembly. Further, the forces developed by explosion of a propellant powder cartridge between the frame and the piston act on the frame as a recoil force and on the movable piston assembly as a propulsive force. If the weight of the movable piston assembly is low in relation to the weight of the frame, recoil of the frame on firing is reduced.

At the forward end of the cylindrical body section 18, an impact element 19 is mounted, by threaded connection as shown, or other convenient means. In the embodiment shown, the impact element is in the form of a circular pad having a concentrically ribbed striking face 20. While the impact element shown is admirably suited for those applications where it is desired to apply impact force to a fairly substantial area of a work surface, it will be obvious to those skilled in the art that the impact element may take other well known forms depending on the work to be accomplished.

As best shown in Figs. 1 and 5, the rearward exterior portion of the piston crown has a truncated conical form. The angularity of the conical surface 21 to the longitudinal axis of the rectilinearly movable piston assembly is greater than the angularity of the coaxial conical shoulder 7 of the frame. It will be seen that this construction prevents contact of shoulder 7 with surface 21 as the piston is moved rearwardly in the bore 5, and unless otherwise impeded, the piston can be moved rearwardly until the planar face 22 of the piston crown engages the end wall 6 of the frame 1.

Means are provided in the crown of piston 10 for supporting a rimfire propellant powder cartridge in such a manner that a portion of the rim of the cartridge projects above the planar face 22 of the piston. As best shown in Figs. 3 and 6, the cartridge supporting means comprises a bore 23 chordally disposed in the piston crown and a relief 24 adjacent the open end of bore 23. Bore 23 is of sufficient diameter to accept the body of a chosen rimfire cartridge, and is disposed in the piston crown in longitudinal intersecting relation with the planar face 22 of the piston. Relief 24 provides lateral clearance for the cartridge rim, permitting a cartridge to be inserted completely into bore 23, whereby the entire cartridge lies within the greater diameter of the piston. It will be seen that the base 24*a* of the relief is substantially coplanar with the bottom of bore 23. When a cartridge is inserted in bore 23, the cartridge rim rests on base 24*a*, angling the cartridge slightly from the axis of bore 23 and disposing the portion of the cartridge rim opposite base 24*a* above the planar face 22. The angulation of the cartridge from the axis of bore 23 causes the body of the inserted cartridge to wedge against the overhanging lip 23*a* of the bore, thus retaining the cartridge in place in the piston.

The cartridge receiving bore 23 is exposed for loading when the piston 10 is displaced out of barrel 5 by firing of the tool, or by manual pressure on the left-hand end of the connecting rod 11. In loading position, the rectilinearly movable piston assembly is disposed toward the right-hand extent of its movement as shown in Fig. 2.

After a cartridge is placed in bore 23 of the piston, it is necessary to move the piston assembly to the left-hand extent of its movement as shown in Fig. 1. To provide a means of moving the reciprocatory assembly to the firing position of Fig. 1, we have provided an opening 33 in connecting rod 11, through which is threaded a pull cord 31 provided with a ball grip 32. It will be seen that a manual pull on ball grip 32 will move the piston assembly to the left relative to frame 11, disposing the piston 10 within the barrel 5, in firing position.

Figs. 1 and 3 show the disposition of the piston 10 and cartridge within the barrel 5 when the tool is prepared to fire. In firing position, the barrel terminus defines a combustion chamber which is closed by the face 22 and the conical surface 21 of the piston rearwardly disposed in the barrel. It will be seen that the planar face 22 of the piston is slightly spaced from the end wall 6 by the rim of the cartridge. Referring to Fig. 3, it will be seen that the chordal disposition of the cartridge bore disposes a portion of the exposed rim of the cartridge under the conical shoulder 7. Any impact force which tends to move frame 1 forwardly with respect to the piston will first be resisted solely by the rim of the cartridge. The cartridge is made of brass or other relatively soft material which is easily deformed. When the impact element 19 is brought sharply against a work surface 25 (Fig. 5), by swinging the tool by handle 3, inertia of the substantial mass of the frame 1 will cause the frame to continue forward movement as the impact element and attached elements of the piston assembly are stopped. This results in the rim of the cartridge being distorted and folded over by impact of the advancing conical shoulder 7 and end wall 6, forming the barrel terminus, as shown in Fig. 5.

When the rim of the cartridge is folded over as described, the priming compound contained in the rim is ignited, initiating combustion of the propellant powder in the cartridge. The expanding gases of combustion split the cartridge case, which is unsupported at the planar face 22 of the piston, due to the longitudinal intersection of the planar face 22 by bore 23. An example of a cartridge case fired in the tool is shown in Fig. 7. Further expansion of the burning gases drives piston 10 forwardly, to the right, and impact element 19 imparts a substantial proportion of the kinetic energy derived from the firing cartridge to the work surface as a sudden impact. To more fully utilize the energy of the expanding gases, a seal 34 is mounted in an annular groove formed in the piston barrel. Seal 34 may be a conventional O-ring or piston ring having an internal diameter such that it circumferentially engages the piston 10, to prevent gas leakage. Seal 34, by its engagement with the piston, serves to frictionally retain the piston in place within barrel 5, in firing position, until the cartridge is fired.

The tool is provided with a shock absorbing component to arrest forward movement of the piston assembly on firing. This provision is necessary to prevent unhampered flight of the piston assembly from the tool and to reduce the mechanical strain which might be imposed on the tool in the event that the impact element glances from the work surface or penetrates the work surface. When the tool is supplied with an impact element having a striking surface of penetrating or cutting characteristics, the shock absorbing component performs the additional function of limiting the extent of penetration

of the impact element. In the embodiment shown, the shock absorbing component is mounted within cavity **8** of the tool frame, coaxial to connecting rod **11**, and is adapted to absorb the kinetic energy of the piston assembly when impacted and compressed by stop **12** at one extent of travel of the reciprocatory assembly. While various types of shock absorbers which dissipate energy in compression may be used, we prefer to employ the high efficiency type which is fully described and claimed in copending United States patent application of Philip R. Haskell et al., Serial Number 507,281, filed May 10, 1955, and entitled "Cartridge Powered Type Tool." Briefly described, to minimize the need for reference to that application, this component comprises a plurality of circular discs **26** of fabric woven from strands of a polymer compound, such as nylon, which discs are impregnated with elastic polymer **27** such as neoprene rubber. These discs are interleaved between thin metal discs **28**, and the laminated component so formed is mounted within cavity **8** by backing plate **29** and a retaining ring **30** which engages a circular groove in frame **1**. A central hole is provided in each of the impregnated fabric discs to accept connecting rod **11** in sliding relation thereto. The metal discs **28** have roughened surfaces which frictionally support the fabric layers. When the tool is fired, the piston and other elements of the piston assembly will be driven to the right in the direction of the arrow in Fig. 2. Unless forward movement of the piston assembly to the right is arrested by a work surface, the assembly will continue its travel until stop **12** engages the surface of backing plate **29** and the kinetic energy of the piston assembly is absorbed elastically by compression of the described shock absorbing component. In compression, the impregnated fabric discs **26** must expand radially, so each fabric disc is of slightly less diameter than the metal discs with which they are interleaved. The high efficiency of the described shock absorbing component derives from the fact that the elastic polymers such as neoprene have a satisfactorily low modulus of compression to permit effective storage of the energy imparted by the piston assembly, while the woven fabric and steel discs provide adequate reinforcement to prevent undue radial expansion of the synthetic polymer, preferably neoprene, under compressive loadings.

As before stated herein, we have found it desirable to keep the weight of the piston assembly low in relation to the weight of the frame and attached components. When a rifle cartridge is fired in the tool, the combustion gases act against both the tool frame and the piston assembly. If the piston assembly is light and the frame relatively heavy, the energy of the expanding gases of combustion will perform more useful work in moving the piston assembly against the work surface. Further, a relatively light piston assembly, by reason of its low inertia, will be decelerated and stopped more rapidly on impact with a work surface, resulting in greater energy of impact being applied to the primer of the cartridge by the advancing frame. Since rimfire cartridge primers are dependent on rapid deformation of the supporting cartridge rim for proper functioning, it will be seen that a high weight ratio between the frame and the piston assembly of the tool will materially aid cartridge ignition on impact.

The frame of the tool should be at least twice the weight of the piston assembly, and an even higher weight ratio of three-to-one is desirable to promote impact efficiency, reduce recoil, and secure reliable cartridge ignition. As an example, an actual tool constructed according to the invention was provided with a frame and handle weighing a total of 5.0 pounds and a piston assembly weighing 1.56 pounds, for a total tool weight of 6.56 pounds. The propellant powder cartridges used in this tool were normally primed .22 caliber rimfire cartridges loaded with 4.2 grains of uncoated, double-base powder having the high nitroglycerine content of 40%.

The powder was of fine flake-like granulation, approximately 325 cuts per inch from .038 grain, for fast burning. In actual tests with the given tool and cartridge it was found that reliable cartridge ignition was obtained when the tool was allowed to fall through a distance of 14 inches into impact with a solid work surface. Kinetic energy of impact at the work surface, on firing of the cartridge was found to be in excess of 300-foot pounds, and recoil of the tool from the work surface was moderate.

A cycle of operation of the tool will now be described. To load the tool, the operator grasps the handle **3** or frame **1** and manually moves the piston assembly in the direction of the arrow in Fig. 2, until the piston **10** is completely out of the frame barrel **5**. A propellant powder cartridge is inserted in the cartridge bore **23** and is firmly pushed into the bore until the overhanging lips **23***a* frictionally engage the cartridge. The operator then grasps the ball **32** on pull cord **31** and pulls the piston assembly to the left until the piston **10** is within frame barrel **5** and the rim of the cartridge is in abutment with the barrel terminus formed by the conical shoulder **7** and end wall **6** of the frame. The parts of the tool are now in the firing position shown in Fig. 1. To fire the tool, the operator simply swings the entire tool as one would a hammer, impacting the striking face **20** of the impact element **19** against the desired portion of the work surface. On impact, the piston assembly is decelerated or stopped, as the tool frame continues to move forward for a short distance, folding the rim of the cartridge and causing ignition of the primer. The combustion of the propellant drives the piston forwardly relative to the frame until the piston emerges from the frame barrel **5** and the propelling gases are vented to the atmosphere. In most cases, the escaping gases will drive the split cartridge case from bore **23** at low velocity so that the cartridge case falls harmlessly to the ground. If the cartridge case is not blown out of the tool by the escaping gases, it may be easily removed by the fingers, and the tool will be then ready for another loading and firing cycle.

It is contemplated that the impact tool of this invention will find a variety of useful applications in fields where it is desired to deliver extremely high values of impact loads with a hand-held tool, and it is further contemplated that modifications to the described invention may be made by one skilled in the art to adapt this invention to specific use applications, without departing from the invention as defined by the following claims.

We claim:

1. A work surface striking tool deriving impact energy from explosion therein of an impact sensitive propellant powder cartridge, comprising, a tool frame having a combustion chamber formed therein, a rectilinearly movable assembly on said frame, including a piston disposed in said combustion chamber and a work surface impacting element joined to said piston, support means on said piston for an impact sensitive propellant powder cartridge, said support means disposing said cartridge for abutment with the wall of said combustion chamber when said impacting element is struck against a work surface.

2. A work surface striking tool deriving impact energy from explosion therein of a primed propellant powder cartridge, comprising, a tool frame defining a barrel and an interior barrel terminus, an impact assembly comprising a piston rectinearly movable in said barrel into proximity with said barrel terminus, a work surface striking face on said piston protuberant from said barrel; means on said tool for supporting a cartridge with a primed end within said barrel, said supporting means disposing the primed end of a cartridge for abutment between said piston and said barrel terminus, a cartridge in said supporting means thereby being subjected to initiating impact by relative movement of said frame and said piston when said striking face is impacted against a work surface.

3. A rimfire propellant powder cartridge assisted impact tool comprising a tool frame defining a barrel and an interior barrel terminus, a piston rectilinearly movable in said barrel into proximity with said barrel terminus, said piston having a striking face protuberant from said barrel, means on said tool for supporting a rimfire propellant powder cartridge in abutment between said barrel terminus and said piston, with the rim of said cartridge disposed for impact by said barrel terminus.

4. An impacting tool in which a rimfire propellant powder cartridge is exploded on impact of the tool with a work surface, comprising a tool frame defining a tool barrel and an interior barrel terminus, a piston carried by said frame for rectilinear movement into said tool barrel, said piston having an end face disposed in opposition with the interior terminus of said barrel at one extent of piston rectilinear movement, rimfire cartridge support means in said end face of said piston, said means disposing a cartridge therein with its rim exposed for abutment with said barrel terminus as said piston approaches said one extent of movement, and an impact element carried by said piston in protruding relation to said barrel, whereby striking said impact element against a work surface will displace said piston toward said one extent of movement, thereby crushing the rim of a cartridge in said support means against said barrel terminus to initiate cartridge explosion.

5. A tool as set forth in claim 4, said cartridge supporting means comprising a cartridge receiving bore disposed in said end face of said piston.

6. A tool as set forth in claim 5, said cartridge receiving bore being chordally disposed in said piston in longitudinal intersecting relation to said piston end face.

7. A work surface striking tool deriving impact energy from a rimfire propellant powder cartridge fired within the tool, comprising, a tool frame defining a barrel and an interior barrel terminus, an impact assembly mounted for rectilinear movement in said frame, said impact assembly comprising a connecting rod journaled in said frame, a piston rectilinearly movable with said connecting rod into said barrel for abutment with said barrel terminus, and an impact element on said piston; means on said piston for supporting a rimfire propellant powder cartridge, said support means disposing a cartridge with its rim in abutment with said barrel terminus when said piston is within said barrel, whereby the rim of a cartridge in said support means will be distorted for firing by relative movement of said barrel terminus when said impact element is impacted against a work surface.

8. A tool according to claim 7, comprising a stop member on said connecting rod, and compressible shock absorbing means disposed between said stop member and said frame for engagement by said stop member.

9. A tool according to claim 8, said shock absorbing means comprising a plurality of compressible elastic discs mounted in a cavity of said frame and having aligned bores for passage of said connecting rod.

10. A work surface impacting tool in which impacting energy is derived from combustion of a rimfire propellant powder cartridge, comprising, a tool frame defining a barrel and an interior barel terminus; an impact assembly mounted for rectilinear movement in said frame and including a faced piston rectilinearly movable in said barrel, a work surface impacting element fixed to said piston and protuberant from said barrel, and shock absorbing means disposed between said assembly and said frame limiting movement of said assembly from a first position wherein said face of said piston is adjacent said barrel terminus to a second position wherein said piston face is exterior to said barrel, a rimfire cartridge receiving bore in said face of said piston, said bore exposing the rim of a cartridge therein for abutment with said barrel terminus on movement of said piston to said first position.

11. A work surface striking tool deriving impact energy from explosion of a rimfire propellant powder cartridge therein, comprising, a tool frame having a forwardly disposed barrel, an intermediate barrel terminus, a rearwardly disposed cavity coaxial with said barrel, and a bore connecting said barrel and said cavity; an impact assembly rectilinearly movable in said frame and comprising a connecting rod journaled in said bore, a piston mounted on a forward end of said connecting rod for movement into said barrel, and a stop member on the rearward end of said connecting rod; said piston having a forward striking face and a rearward crown; rimfire cartridge support means in said piston crown dimensioned to expose the rim of a cartridge therein for abutment with said barrel terminus on rearward movement of said assembly; and a shock absorbing component disposed in said frame cavity for engagement by said stop member on forward movement of said assembly.

12. A tool according to claim 11, said cartridge supporting means comprising a cartridge receiving bore transversely intersecting said piston crown, said bore having a maximum depth less than the rim diameter of the cartridge to be received therein.

13. A tool according to claim 12, said barrel terminus having a conical shoulder disposed to abut the rim of a cartridge in said cartridge receiving bore.

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