Dec. 18, 1956 W. H. CLINE, JR 2,774,334

RECIPROCATING PRIME MOVER

Filed May 1, 1953 2 Sheets-Sheet 1

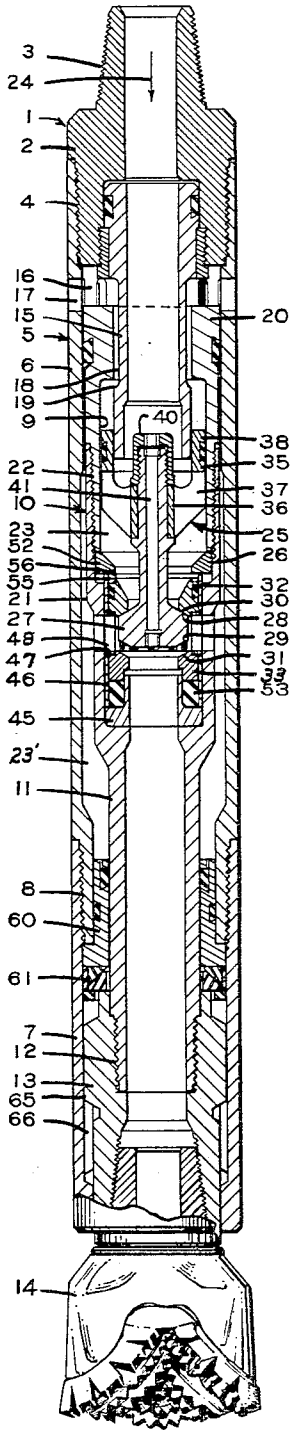


Fig. 1

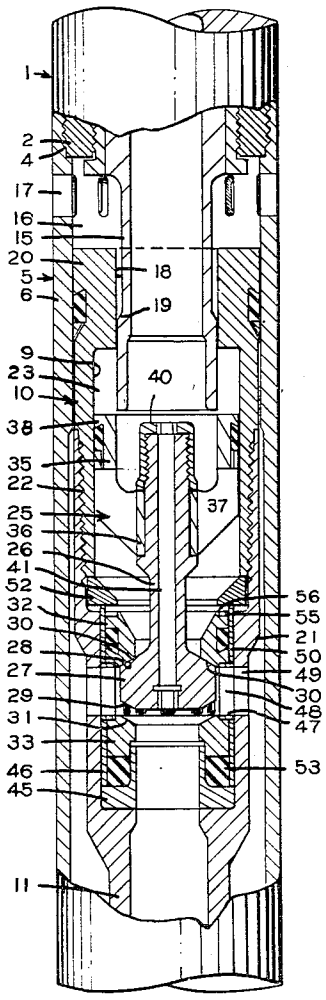


Fig. 2

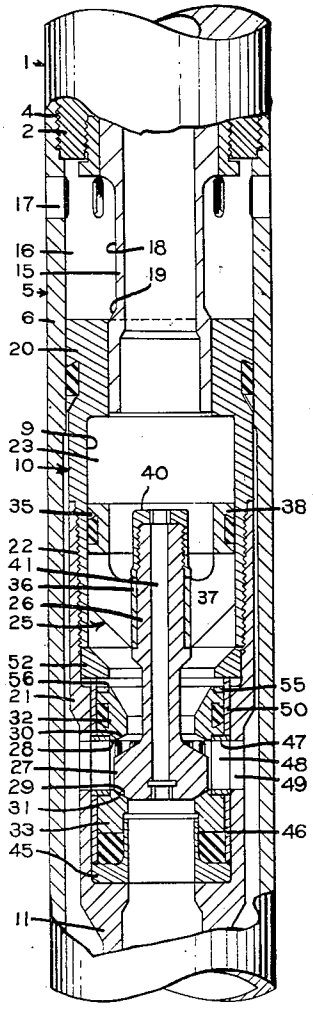


Fig. 3

WILLIAM H. CLINE, Jr.
INVENTOR.

BY Ray L. Smith
Attorney

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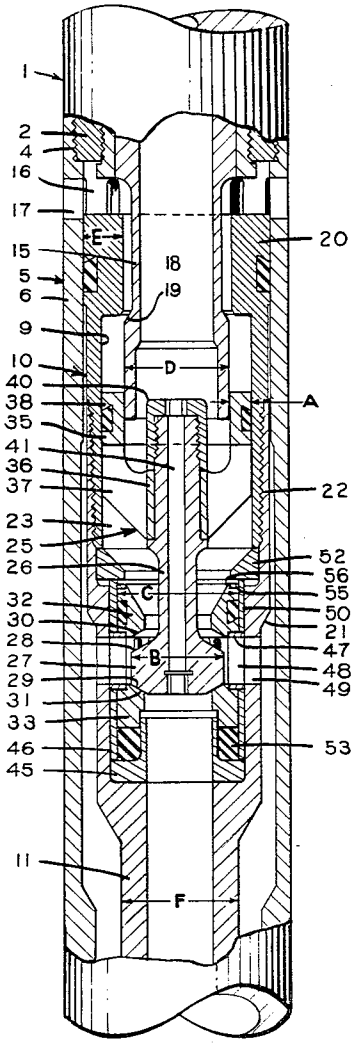


Fig. 4

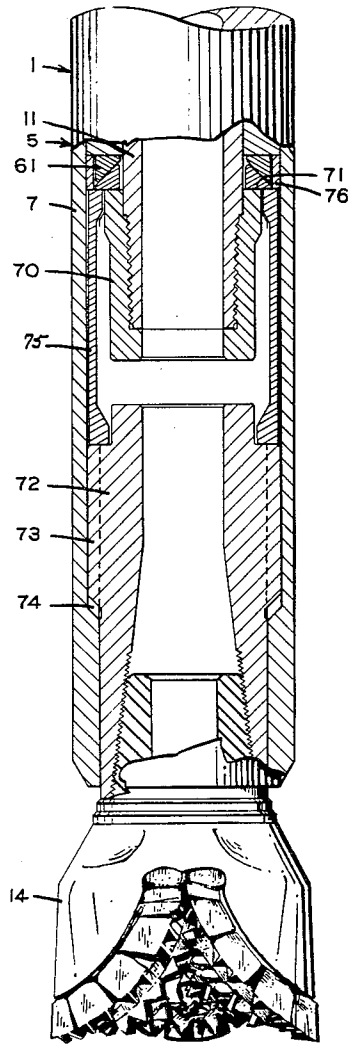


Fig. 5

WILLIAM H. CLINE, Jr.
INVENTOR.

BY Ray L. Smith
Attorney.

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RECIPROCATING PRIME MOVER

William H. Cline, Jr., Houston, Tex., assignor to Hughes Tool Company, Houston, Tex., a corporation of Delaware

Application May 1, 1953, Serial No. 352,544

14 Claims. (Cl. 121—28)

This invention relates to prime movers of the reciprocatory type and more particularly to a device of this type having particular utility as a drill or tool of the impact type to provide cutting action upon the bottom of an earth bore by a combination of conventional rotation of an earth boring bit on bottom and the simultaneous application of impacts to such bit.

It is an object of the invention to provide a fluid actuated reciprocatory prime mover having improved features of construction and operating characteristics.

Another object is to provide a prime mover of the class described of compact design and limited in axial extent whereby the device is capable of being readily moved axially of a bore hole formed when the device is used as a well drilling tool.

Still another object is to provide a prime mover which, though of limited physical dimensions, is capable of withstanding rigorous use such as is encountered when using the device as an impact or percussor tool when drilling well bores.

It is also an object to provide a prime mover adapted for use as a well drill of the impact type that is capable of maintaining an efficient rate of drilling while using light weight on the drill where conditions prohibit or limit the use of heavy weight.

A further object is to provide a device of the class described which, when used as a well drilling device, will maintain an efficient rate of drilling with relatively light weight on the drill in areas where heavy weight is normally required.

Still another object is to provide a reciprocatory type of prime mover which is fully fluid actuated whereby the use of actuating springs, with attendant difficulties, is avoided.

Another object is to provide a prime mover which, when used as a well drilling tool, will not produce high pressure fluctuations in the fluid proximate the wall of the well bore, such fluctuations being conducive to caving of the wall.

The invention also comprehends an impact type of well drill capable of imparting impacts to a drill bit on bottom or of oscillating the drill bit to apply impacts at the surface being disintegrated to form hole.

Still another object is to provide a device of the class described, provided with a valving mechanism which travels with and is movable relative to the piston, parts being so constructed and arranged that at a predetermined position of the piston and valve assembly the power stroke is terminated and valving action preliminary to the succeeding stroke takes place as the piston travels to terminal position.

A further and more specific object of the invention is to provide a fluid actuated device of the class described including a housing having a reciprocable piston therein, said piston comprising an annular upper portion and a peripherally reduced lower portion, there being spaced seals between said respective portions of the piston and the housing, and means for alternately directing pressure

fluid to the exterior of the piston between the seals and confining the fluid within the piston to produce reciprocatory movement of the piston.

The foregoing objects together with other objects will be more fully apparent from the following descriptions, considered in connection with the accompanying drawings in which:

Fig. 1 is a vertical sectional view through a well drill embodying the invention and showing the parts in their relative position at the beginning of the power stroke;

Fig. 2 is an enlarged vertical sectional view through the upper portion of the device showing the relative positions of parts at the end of the power stroke;

Fig. 3 is a sectional view similar to that of Fig. 2 but showing the relative positions of parts when the piston has reached its lowermost position of travel;

Fig. 4 is a sectional view similar to that of Figs. 2 and 3 but showing the relative positions of parts near the end of the return stroke and when fluid power is applied to move the valve from its seat preliminary to initiation of the succeeding down stroke;

Fig. 5 is a sectional view of the lower portion of the device used as a well drill and showing a modification whereby the drill is of the hammer and anvil type.

In the drawings, showing an embodiment of the invention used as a well drill, the device is shown at 1 and comprises an adapter 2 threaded at 3 for attachment to the lower end of a drill string. The adapter 2 is threaded externally at 4 at its lower end for attachment to the housing or casing 5 made up of an upper section 6 and a lower section 7 threadedly interconnected at 8, such feature of construction facilitating assembly and disassembly of the housing which encases a piston assembly 10 reduced at its lower end to form downwardly extending piston rod 11 threadedly connected at 12 to a guide bushing 13 to which the bit 14 is secured.

A sleeve or tail pipe 15 is secured in and depends from the adapter 2 thus forming with the surrounding housing 5 a chamber 16 there being a series of openings or ports 17 in the housing at the upper end of the chamber. The sleeve 15 is reduced peripherally at 18 intermediate its ends and forms a shoulder 19 proximate the free end of the sleeve to serve a purpose that will be further explained.

The piston assembly 10 fits slidably within the housing and includes an annular piston head 20 undercut internally at 9 so that the end portion of the piston may move beyond the shoulder 19 on the sleeve 15. The lower end of the piston head is secured to the body 21 by threads 22 and such body is reduced in cross section at its lower end to form the piston rod 11. The piston thus comprises an annular upper portion and a peripherally reduced lower portion thereby providing an annular chamber 23' between the piston and the surrounding housing there being spaced seals between the piston and housing to prevent leakage of fluid from within this chamber.

The structure of the piston, as just described, also provides an internal chamber 23 for valve 25 within the piston whereby the valve travels with the piston and is reciprocable therein in such a manner that fluid pumped downwardly through the adapter 2 and into the housing 5, as indicated by the arrow 24, will reciprocate the piston to impart impact energy to the drill bit 14. In this manner the usual disintegrating action produced by rotation of the drill bit is supplemented by impacts of the drill bit on bottom.

The valve 25 includes valve stem 26 which terminates at its lower end in the valve head 27 having upper and lower seating surfaces 28 and 29 for engagement, respectively, with upper and lower seats 30 and 31 on upper and lower seat rings 32 and 33.

Mounted upon the upper end of the valve stem **26** is the valve piston **35** having a central boss **36** which slidably fits upon the valve stem and has ribs or fins **37** which provide a supporting spider for the ring **38**. This ring has such dimensions that it may move telescopically within that portion of the chamber **23** that exists between the sleeve **15** and the inner wall of the piston **10**.

The valve piston **35** fits slidably upon the upper end of the valve stem **26** and is rigidly secured thereto by means of cap nut **40**. Attention is directed to the fact that the cap nut **40**, the valve stem **26** and the valve head **27** have an axial passage **41** whereby a passage is provided at all times between the upper and lower sides of the valve.

The seat rings **32** and **33** are part of a seat ring assembly mounted in the lower end of the chamber **23**. This assembly comprises a retainer ring **45** surmounted by spacer ring **46** and port ring **47** having ports **48**, there being complemental ports **49** in the piston thereby providing passageways between the interior and exterior of the piston from between the seat rings and to the chamber **23'**.

Another spacer ring **50** rests upon the port ring **47** and seat ring **32** fits slidably therein. The entire seat ring assembly is secured in place by means of clamp ring **52** which is engaged by the lower end of the piston head **20** when the component parts of the piston are interconnected by the threads **22**.

To minimize shock when the valve moves into engagement with the seat ring **33** this seat ring is mounted for limited axial movement upon an annular body **53** of deformable material encased within the chamber formed by the retainer ring **45**, spacer ring **46** and the seat ring.

Seat ring **32** is likewise mounted for limited axial movement and has its upper end grooved at **55** the central upstanding flange **56** being of a dimension to slidably move within the clamp ring **52**. This feature of construction provides a dashpot action which together with fluid forces acting upon the seat ring prevent excessive stresses in parts of the structure as a result of the engagement of the seat **30** by the valve head **27**.

The piston rod **11** passes downwardly through a guide and seal ring **60** which forms the lower seal between the piston and the housing and this ring also serves as an abutment for the ring spring **61** engageable by the upper end of the guide bushing **13**. This structure serves to resiliently terminate upward movement of the piston and associated elements and to absorb energy therefrom and redeliver such energy to the assembly at the beginning of the succeeding downward stroke.

The guide bushing **13** has peripheral splines **65** which fit within complementary grooves **66** in the housing **5**. It seems apparent therefore that the drill bit **14** may be rotatably driven in a conventional manner but may also be moved axially of the housing **5** as the piston **10** is caused to reciprocate. By virtue of such mode of operation the conventional action of the bit **14** upon bottom is supplemented by impacts from operation of the well drill from energy supplied to the tool by the flushing fluid pumped through the drill stem and thence to and through the tool and the drill bit **14**.

As already indicated the invention comprehends a structure in which the use of springs to effect movement of either the piston or valve is avoided and one which will not stall. To further describe the disclosed embodiment and explain its operation, attention is directed to the fact that, as shown in Fig. 4, the annular area E of the piston head **20** is greater than the overall area F of the piston rod **11**. Also, the overall area C of the seat ring **32** is greater than the annular area A of the valve ring **48** and such area A is, in turn, greater than the effective area B of the valve head **27**.

It will now be assumed that the parts are in the relative positions shown in Fig. 1 when actuating fluid is introduced to the device as indicated by the arrow **24**, although it is to be understood that operation will be initiated regardless of the position of the piston and valve when the actuating fluid is introduced. The force exerted upon and producing downward movement of the piston **10** is that produced by the fluid acting upon the area D, the effective area for downward force exerted by the fluid.

During the succeeding downward power stroke, the valve head **27** is held upon the seat ring **32** by an excess of upward force acting on the area A over the downward force acting upon the smaller area B. This condition continues to exist and the power stroke continues until the valve piston **35** withdraws from its telescopic relation with the sleeve **15**. This marks the end of the power stroke and the piston **10** continues to travel downward under the momentum previously imparted thereto.

At this instant the force exerted upon the lower side of the valve ring **38** is neutralized by a like force now exerted upon the upper side of this ring. Hence, the downward fluid force exerted upon the valve head **27** causes the valve to move downwardly and to leave the seat **30** whereby opening of a passage through the piston is initiated.

The piston assembly **10** continues to travel downwardly until the bit **14** has effected impact upon the bottom of the hole being drilled. Thus the downward movement of the piston assembly is terminated but the momentum of the valve **25** plus the fluid pressure exerted upon the area B thereof causes rapid closure of the valve upon the seat ring **33**. As already explained, the cushion ring **53** functions to resist shock of closure of the valve upon the seat ring.

Pumped fluid is now diverted through ports **48**, **49** to the chamber **23'** where it exerts an upward force upon the piston assembly, such force being the difference between the fluid forces acting upon the areas E and F, and at the same time the valve is held upon the lower valve seat by fluid pressure acting upon the area B. Hence, the piston assembly moves upwardly on the return stroke. The motivating force continues until the annular upper end of the piston head **20** clears the shoulder **19** at the lower end of the reduced area **18** on the sleeve **15**. In the meantime the ring **38** of the valve **25** has entered the annulus between the interior of the piston **10** and the lower end of the sleeve **15**. It is apparent therefore that at no time is there a through passage from the interior of the piston to and through ports **17** to the exterior of the housing **5**.

As soon as the upper end of the piston clears the shoulder **19** differential pressure is created between the upper and lower surfaces of the valve ring **38**. At this instant the valve **25** tends to move from engagement with the valve seat **31** because of the differential fluid force acting upon the areas A and B. The kinetic energy of the valve is absorbed, following closure upon the valve seat **30**, by the differential of forces acting upon the areas C and A.

Inasmuch as the seat ring **32** is mounted for limited axial movement, efficient absorption of the kinetic energy of the valve is had, such energy being absorbed by the actuating fluid whereby excessive impact stresses in the valving mechanism are prevented. The dashpot formed by ring **52** and the cooperating groove **55** in the seat ring **32** functions to absorb excessive kinetic energy which the valve may possess, at times, from abnormal operating conditions.

When the valve engages upper seat **30** the succeeding power stroke is begun. Initial application of power together with the energy absorbed by the ring spring **61** decelerate the piston assembly until its velocity is zero and then the piston is accelerated downwardly on the power stroke in the manner above explained.

The distance that the piston moves upwardly after it clears the shoulder **19** on the sleeve or tail pipe **15** is the lead of the piston. It is during this lead period that a

differential pressure upon the upper and lower surfaces of the valve ring 38 overcomes the fluid pressure upon the area B of the valve and tends to move the valve from the lower seat 31 to the upper seat 30, From flexibility in design the lead may be made very small in which case the valve has insufficient time to actually move from the lower seat 31 before the piston travel is terminated by engagement with the ring spring 61. In such case the differential pressure tending to move the valve is supplemented by the kinetic energy of the valve to effect closure of the valve upon seat 30.

It seems apparent that this feature in the construction and operation of the device enables great flexibility in operating characteristics of the device inasmuch as operating characteristics may be readily changed by modifying or replacing the sleeve 15 for a selected lead. In this manner compensation may be had for the use of various fluids, both gaseous and liquid, and various rates of supply of actuating fluid to the device.

It is to be noted that the valve assembly 25 serves as a barrier within the piston 10 and is operable, with associated valving elements, to alternately confine the actuating pressure fluid within the piston and direct the fluid to the exterior of the piston to advance and retract the piston within the housing 5. Also, the upper annular portion of the piston 10 and the valve 25 co-act with the sleeve or tail pipe 15 in a manner that, at the instant the piston head 20 clears the shoulder 19 on the tail pipe 15, the annular upper and lower surfaces of the valve ring 38 are subjected to the fluid pressure existing exteriorly of the tool. Then, as already explained, the valve assembly begins to move upwardly by virtue of an excess of upward force acting on the valve assembly and, at the same time the piston continues to travel under its momentum to complete its stroke, and effect the desired impact, if the device is utilized as an impact tool.

It is to be noted also that the ports 17 serve as breather openings to permit displacement of fluids to and from the chamber 16 as the piston reciprocates. Such displacement is subtantially equal and opposite the displacement of the piston rod 11 as it reciprocates and it is thus apparent that the device does not produce high fluctuations in fluid pressure upon the walls of a well bore formed by the tool. This minimizes conditions which tend to produce caving of the walls.

Fig. 5 of the drawings shows the piston rod 11 terminating in a hammer collar 70 which presents an upwardly facing shoulder 71 adapted to engage ring springs 61 so that these springs will absorb energy during terminal upward movement of the piston assembly which, in this form serves as a hammer.

The bit 14 is attached to an anvil bushing 72 having splines 73 slidable in complementary grooves 74 in the lower section 7 of the housing 5. A sleeve 75 fits slidably within the housing between the bushing 73 and the spacer ring 76 and this feature of construction permits the entire well drill to be lowered to apply a constant downward force upon the bit 14 to induce cutting action thereby. This cutting action is supplemented by impacts from the hammer collar 70 upon the anvil 72 from operation of the well drill mechanism as already described.

Attention is directed to the fact that the device herein described is capable of operation whether fluid is supplied as indicated by the arrow 24 or in the reverse direction. For this reason, when the device is used as a well tool and is being lowered into a well bore filled with liquid, operation of the mechanism takes place thus rapidly filling the drill string with liquid and at the same time preventing the lodging of debris upon moving parts. Conversely, when withdrawing the device from a well bore filled with liquid automatic actuation facilitates drainage of fluid from within the drill string thus eliminating the disadvantages of pulling a fluid filled drill string.

While the disclosed embodiment of the invention is described in connection with its utilitarian application as a well drill of the impact or percussive type it is to be understood that the invention is not confined to such but may be used in any environment where it is desired to convert the energy of a fluid stream to reciprocatory mechanical movement.

Broadly the invention comprehends a fluid actuated reciprocatory prime mover capable of converting the energy of a fluid stream to mechanical energy such as impact energy or other energy of reciprocatory movement.

I claim:

1. In a reciprocatory prime mover the combination comprising, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, an annular piston slidably mounted within the housing and having an end thereof peripherally reduced, a depending sleeve at the inlet to the housing forming with the housing an annular chamber, an end portion of the piston slidably fitting within said chamber, there being a passage between said chamber and the exterior of the housing, spaced seals between the piston and housing, and means for alternately confining pressure fluid within the piston and diverting the pressure fluid to the exterior of the piston between said seals to advance and retract the piston within the housing.

2. In a reciprocatory prime mover the combination comprising, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, an annular piston slidably mounted within the housing and having an axial passage therein and an end thereof peripherally reduced, a depending sleeve at the inlet to the housing forming with the housing an annular chamber, an end portion of the piston slidably fitting within said chamber, there being a passage between said chamber and the exterior of the housing, spaced seals between the piston and housing, there being a port through the piston wall between said seals, means for closing the axial passage through the piston above and below said port whereby pressure fluid from the inlet is alternately confined within the piston and directed to the chamber exteriorly of the piston and between said seals.

3. In a reciprocatory prime mover the combination comprising, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, a piston slidably mounted within the housing and having an axial passage therein and an end thereof peripherally reduced, a depending sleeve at the inlet to the housing forming with the housing an annular chamber, an end portion of the piston slidably fitting within said chamber, there being a passage between said chamber and the exterior of the housing, spaced seals between the piston and housing, a port in the piston wall between said seals, and a valve slidably movable relative to the piston to form a barrier transversely of the piston alternately above and below said port whereby pressure fluid from the inlet is alternately confined within the piston and directed to the chamber exteriorly of the piston and between said seals.

4. In a reciprocatory prime mover the combination comprising, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, an annular piston slidably mounted within the housing and having an end thereof peripherally reduced, a depending sleeve at the inlet to the housing forming with the housing an annular chamber, an end portion of the piston slidably fitting within said chamber, there being a passage between said chamber and the exterior of the housing, spaced seals between the piston and housing, a port in the piston wall between said seals, and a valve carried by and slidably movable relative to said piston to form a transverse barrier in the piston alternately above and below said port, said valve including means cooperating with the end portion of the piston slidably fitting within said first mentioned chamber to hold the valve in position above said port during the downward stroke of the piston.

5. In a reciprocatory prime mover the combination comprising, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, an annular piston slidably mounted within the housing, said piston being undercut interally proximate its end, a depending sleeve at the inlet to the housing forming with the housing an annular chamber adapted to slidably receive the end of the piston, there being a passage between said chamber and the exterior of the housing, said sleeve being reduced peripherally intermediate its ends to form a shoulder so that the piston head clears said shoulder as the piston moves to its outermost position, a valve seat in said piston, a valve carried by and movable relative to said piston and adapted to engage said seat and form a barrier in the piston, and means carried by said valve and slidable within the annulus between the sleeve and piston and responsive to pressure fluid within the piston to hold the valve on its seat when the piston is in spaced relation with said shoulder.

6. In a reciprocatory prime mover the combination comprising, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, an annular piston slidably mounted within the housing, said piston being undercut internally proximate its end, a depending sleeve at the inlet to the housing forming with the housing an annular chamber to slidably receive the end of the piston, there being a passage between said chamber and the exterior of the housing, said sleeve being reduced pripherally intermediate its ends to form a shoulder so that the end of the piston clears said shoulder during the outermost portion of travel of the piston, a valve seat in said piston, a valve carried by and movable relative to said piston to engage said seat and form a barrier in the piston, means carried by said valve and responsive to fluid pressure within the piston for holding the valve on its seat during the power stroke.

7. In a reciprocatory prime mover the combination comprising, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, an annular piston slidably mounted within the housing, said piston being undercut internally proximate its end, a depending sleeve at the inlet to the housing forming with the housing an annular chamber to slidably receive the end of the piston, there being a passage between said chamber and the exterior of the housing, said sleeve being reduced peripherally intermediate its ends to form a shoulder so that the end of the piston clears said shoulder during the outermost portion of travel of the piston, a valve seat in said piston, a valve carried by and movable upwardly relative to said piston to engage said seat and form a barrier in the piston, a valve piston carried by the valve and slidable within the annulus between the sleeve and piston, the area of said valve piston being greater than the cross sectional area of the valve, whereby the valve is held upon its seat as the piston advances.

8. In a reciprocatory prime mover the combination comprising, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, an annular piston slidably mounted within the housing, said piston being undercut internally proximate its upper end and reduced peripherally at its lower end, spaced seals between the piston and housing, there being a port through the piston wall between said seals, a depending sleeve at the inlet to the housing forming with the housing an annular chamber to slidably receive the end of the piston, there being a passage between said chamber and the exterior of the housing, said sleeve being reduced peripherally intermediate its ends to form a shoulder so that the end of the piston clears said shoulder during the uppermost portion of travel of the piston, a valve carried by and movable relative to said piston to form a barrier transversely of the piston alternately above and below said port, and means carried by said valve and slidable within the annulus between the sleeve and piston to hold the valve in its uppermost position during the power stroke of the piston.

9. In a reciprocatory prime mover the combination comprising, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, an annular piston slidably mounted within the housing, said piston being undercut internally proximate its upper end and reduced peripherally at its lower end, spaced seals between the piston and housing, there being a port through the piston wall between said seals, a depending sleeve at the inlet to the housing forming with the housing an annular chamber to slidably receive the end of the piston, there being a passage between said chamber and the exterior of the housing, said sleeve being reduced peripherally intermediate its ends to form a shoulder so that the end of the piston clears said shoulder during the uppermost portion of travel of the piston, spaced seats in the piston above and below the port therein, a valve movable relative to the piston to engage the uppermost of said seats and form a barrier transversely of the piston during the downward stroke of the piston, said port being open so that pressure fluid is exhausted through the port and axially of the piston below the valve during the downward stroke of the piston, and means responsive to fluid pressure within the piston for holding the valve on the uppermost of said seats during the downward power stroke of the piston.

10. In a reciprocatory prime mover the combination comprising, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, an annular piston slidably mounted within the housing, a depending sleeve at the inlet to the housing forming therewith an annular chamber, there being a passage between said chamber and the exterior of the housing, said sleeve and piston being constructed and arranged to provide an annulus therebetween during a portion of the advancing stroke of the piston, spaced seals between the piston and housing, there being a port in the piston between said seals, a valve seat in the piston above said port, a valve carried by and movable relative to the piston to engage said seat and form a barrier in the piston, means responsive to pressure fluid within the piston to move the valve from its seat after the piston had advanced a predetermined distance.

11. In a reciprocatory prime mover, a housing having an inlet at one end thereof for the admission of pressure fluid to the interior of the housing, an annular piston slidably mounted within the housing and having an end thereof peripherally reduced, spaced seals between the piston and housing forming an annular chamber about the piston and within said housing, there being a port in the piston between said chamber and the interior of the piston, a valve mounted on and movable relative to said piston to alternately form a barrier transversely of the piston above and below said port, and means responsive to pressure fluid in the piston for holding the valve in position above the port as the piston moves downwardly a predetermined distance, said means being thereafter responsive to move the valve to a position below the port, to direct pressure fluid to said annular chamber and move the piston on the return stroke.

12. In a device of the class described in combination, an annular piston, there being a port communicating between the interior and exterior of the piston, a valve carried by and movable axially of said piston, a valve seat ring slidably mounted within the piston proximate said port and engageable by said valve to form a barrier to the flow of pressure fluid to said port, said seat ring having a surface exposed to the pressure fluid within the piston to absorb kinetic energy of and reduce shock upon the valve at the time of closure of the valve upon the seat ring.

13. In a device of the class described, in combination, an annular piston having a passage to conduct pressure fluid axially thereof, there being a port communicating

between the interior and exterior of the piston, a valve mounted on and movable axially of the piston, a valve seat ring slidably mounted within said passage proximate and in advance of said port, and means for holding said valve on the seat ring during the advancing power stroke of the piston, whereby seat ring is subjected to the force of the pressure fluid actuating the piston to absorb kinetic energy of and reduce shock upon the valve at the time of closure of the valve upon the seat ring.

14. In a device of the class described in combination, an annular piston adapted to conduct pressure fluid axially thereof, there being a port communicating between the interior and exterior of the piston, a valve mounted on and movable axially of said piston, a valve seat ring

slidably mounted within the piston proximate said port and engageable by said valve to form a barrier to divert flow of pressure fluid to and through said port, and means resiliently engaging said seat ring and operable to absorb kinetic energy of the valve at the time of closure of the valve upon the seat ring.

References Cited in the file of this patent

UNITED STATES PATENTS

1,265,133	Sturtevant	May 7, 1918
1,605,865	Stevens	Nov. 2, 1926
1,705,800	Akeyson	Mar. 19, 1929
1,964,687	May	June 26, 1934