May 12, 1964 R. BASSINGER ETAL 3,132,704

FLUID ACTUATED IMPACT TOOL

Filed Dec. 5, 1960

4 Sheets-Sheet 1

Fig. 1

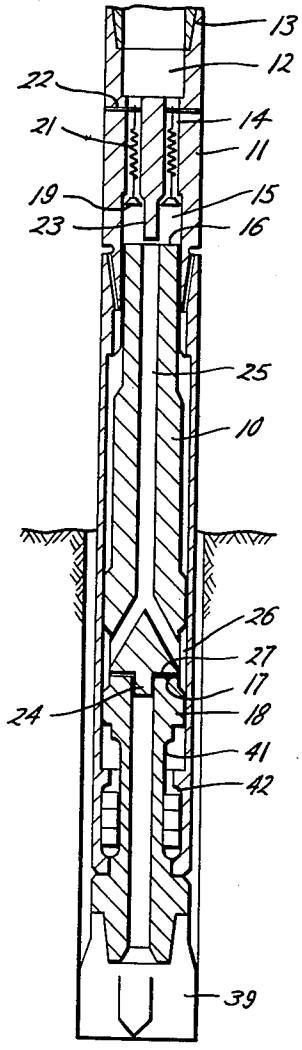


Fig. 2

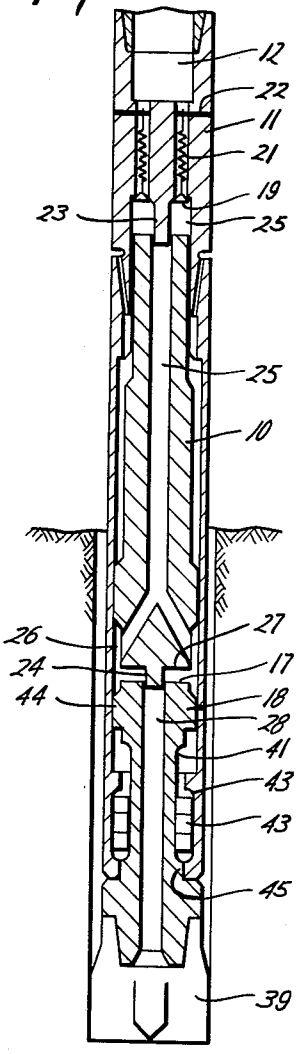
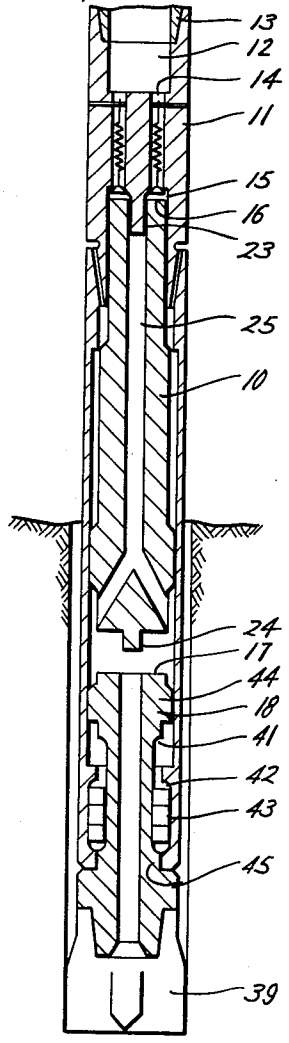


Fig. 3



Ross Bassinger
James D. Gardner
INVENTORS

BY Browning Simms
Hyer & Eisenbrandt
ATTORNEYS

May 12, 1964 R. BASSINGER ETAL 3,132,704

FLUID ACTUATED IMPACT TOOL

Filed Dec. 5, 1960

4 Sheets-Sheet 2

Fig. 4

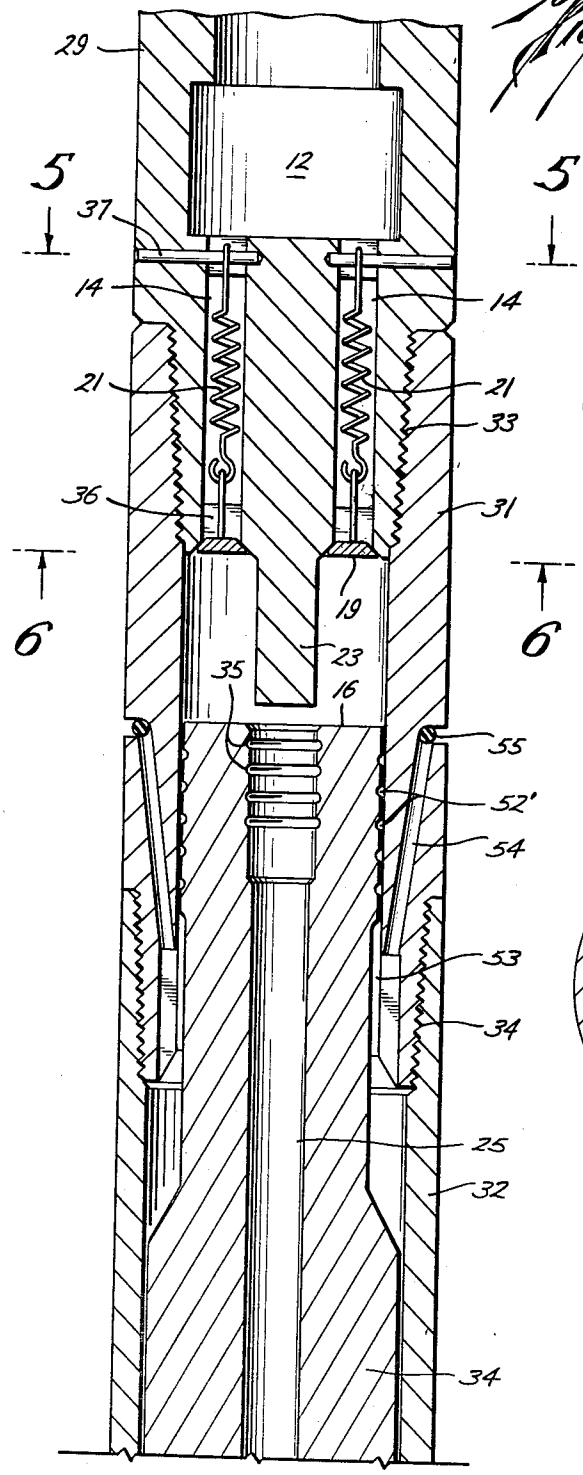


Fig. 5

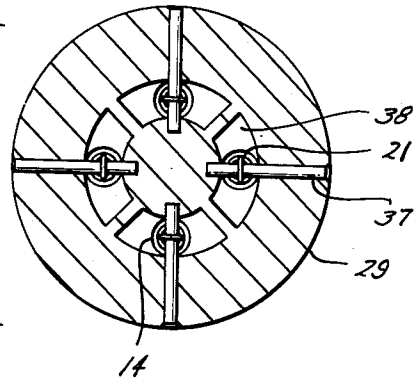
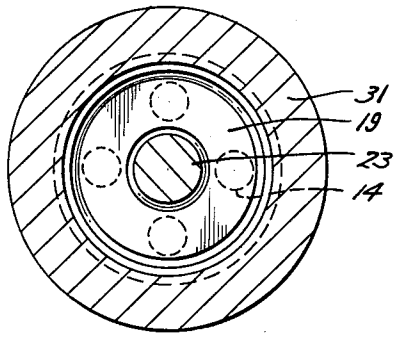


Fig. 6



Ross Bassinger
James D. Gardner
INVENTORS

BY Browning Simmons Hyer & Eisenbrandt

ATTORNEYS

May 12, 1964 R. BASSINGER ETAL 3,132,704

FLUID ACTUATED IMPACT TOOL

Filed Dec. 5, 1960

4 Sheets-Sheet 3

Fig. 7

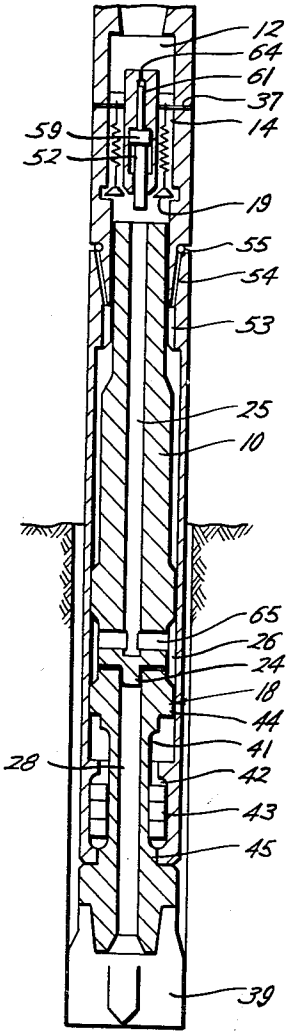


Fig. 8

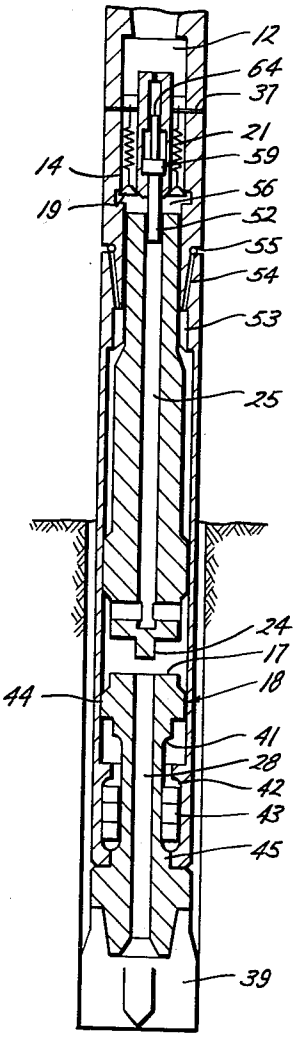
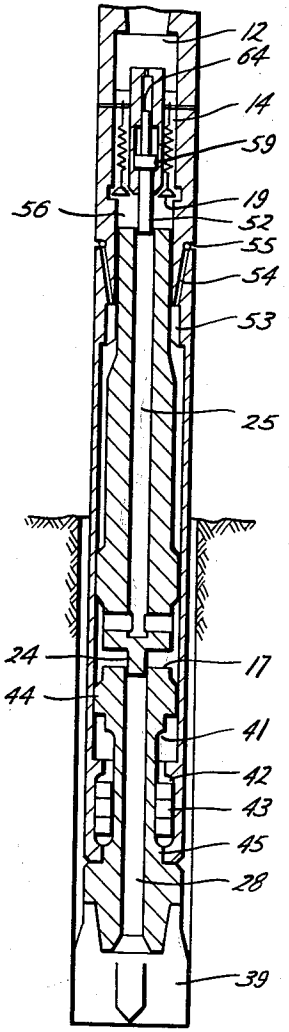


Fig. 9



Ross Bassinger
James D. Gardner
INVENTORS

BY Browning, Simms, Hyer & Cincinnati

ATTORNEYS

May 12, 1964 R. BASSINGER ETAL 3,132,704

FLUID ACTUATED IMPACT TOOL

Filed Dec. 5, 1960

4 Sheets-Sheet 4

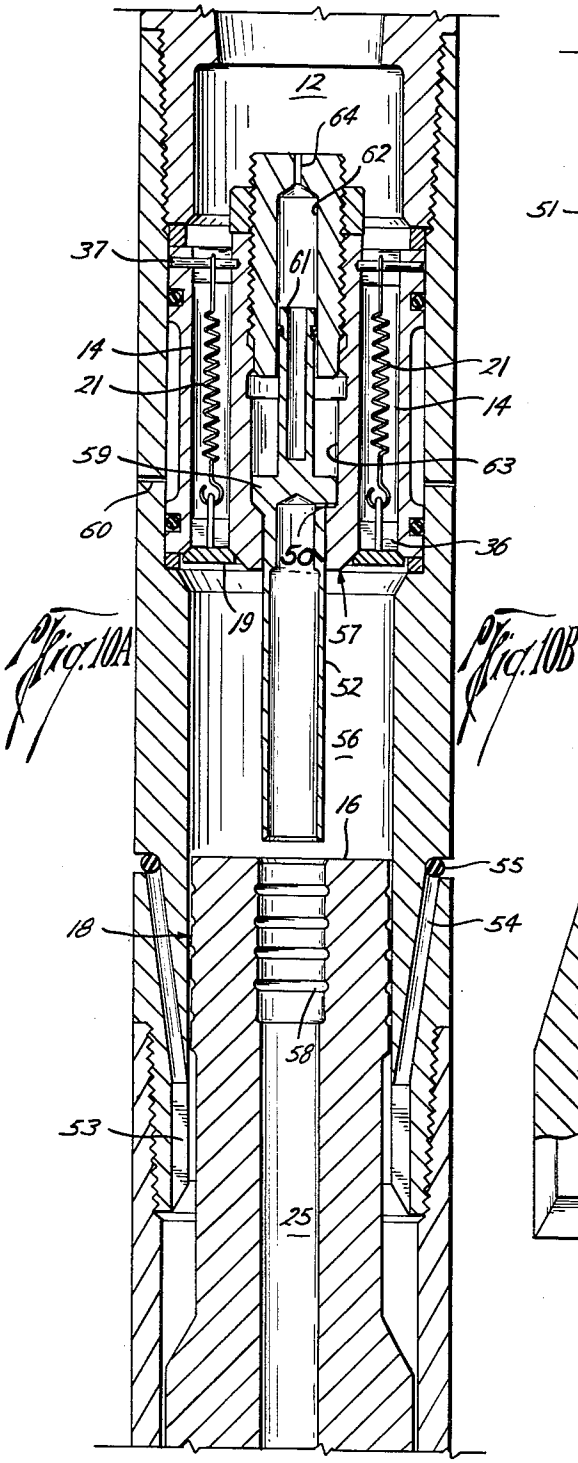


Fig. 10A

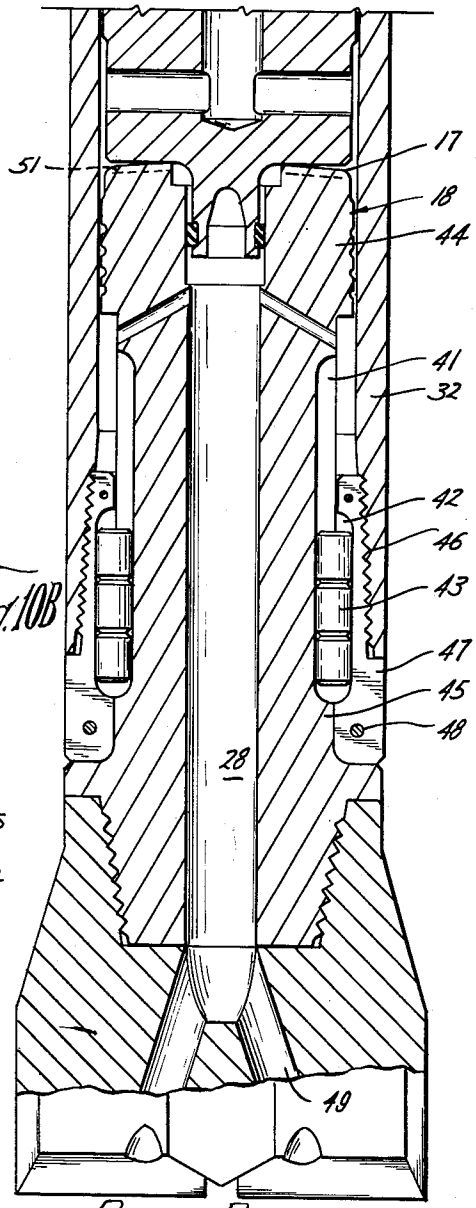


Fig. 10B

Ross Bassinger
James D. Gardner
INVENTORS

BY Browning Simms Hyer & Eisenwerth

ATTORNEYS

United States Patent Office 3,132,704 Patented May 12, 1964

3,132,704

FLUID ACTUATED IMPACT TOOL

Ross Bassinger and James D. Gardner, San Antonio, Tex., assignors to Bassinger Tool Company, San Antonio, Tex.

Filed Dec. 5, 1960, Ser. No. 73,611
15 Claims. (Cl. 173—71)

This invention relates to improvements in fluid actuated impact tools of the type especially adapted to be operated by a pneumatic medium such as compressed air or steam. It is particularly directed to improvements in fluid actuated impact tools such as those described in U.S. Patent No. 2,859,733 and in U.S. Patent No. 2,943,603. In one aspect it relates to a tool of this class having an improved valving arrangement for reciprocating the hammer, and in another aspect it relates to valving arrangements particularly effective in increasing the frequency of reciprocation of a hammer in such tools.

In impact tools, the type of which this invention relates, power fluid is applied to endwise surfaces of a reciprocable hammer to drive the hammer in both power and return strokes. The application of actuating fluid to the hammer is controlled by a valve means arranged so that pressure from the power fluid on a surface of the hammer is effective to drive the hammer in a power stroke but is ineffective to prevent the hammer moving in its return stroke.

For example, it has been suggested that a hammer in a tool of this type be provided with a passageway for power fluid through the hammer and that flow of power fluid through the passageway be controlled by a fingerlike valve element which telescopes into and out of the passageway, thus closing and opening the passageway to flow of fluid. Such fingerlike valve closure members may be stationary and fixed to a stationary part of the impact tool, or they may be of "diving" or reciprocating type. In either case, alternate closing and opening of a passageway through the hammer increases and decreases the pressure of the power fluid applied to the hammer thus moving the hammer in a power stroke at increased pressure and permitting it to move in a return stroke against slightly decreased pressure.

In the diving finger type tool, the hammer moves toward the finger until the finger begins to enter the passageway through the hammer. The finger then plunges, or "dives," into the hammer passageway for a predetermined distance. As a result the portion of the stroke through which full pressure of power fluid is applied to drive the hammer through its power stroke is lengthened by maintaining closure of the passageway through the hammer.

The total length of the power stroke will be the sum of the overtravel of the hammer plus the distance the finger moved, the term "overtravel" being applied to the distance the hammer moves after the passageway is blocked by insertion of the finger and before power fluid reverses the direction of movement. In the fixed finger type tool, there is no diving movement of the finger into the passageway through the hammer, and the length of the power stroke depends upon overtravel unassisted by movement of the finger.

The present invention is directed to improvements in fluid actuated impact tools of either the fixed finger or diving finger type. It will be obvious that the total effect of a tool of this type is a function of the number of strokes delivered per minute and the force applied in each stroke.

It is an object of this invention to provide a valving means for fluid actuated impact tools of stationary or diving finger types in which the frequency of strokes is greatly increased.

Another object is to provide an improved valving arrangement which shortens the time required for actuating fluid to begin moving the hammer in its power stroke.

Another object is to provide a means for utilizing movement of the hammer in its return stroke for increasing pressure applied upon a face of the hammer to start the hammer in a power stroke.

Another object is to provide a unique valving arrangement which traps and further compresses power fluid in the inlet portion of the tool adjacent to the power face of the hammer during return stroke of the hammer and provides maximum pressure at the instant required to overcome inertia of the hammer.

Another object is to provide such valve means which is simple and cheap in construction, strong, rugged and dependable in operation and is not subject to excessive metallic fatigue.

In the present invention a check valve is provided in a branched passageway for actuating fluid between the inlet to the tool and the power face of the hammer which closes instantly during the return stroke upon the finger entering the passageway through the hammer. As the return stroke continues, power fluid trapped in the body of the tool between the advancing face of the hammer and the check valve is further compressed by the momentum of the hammer which is moving at high velocity. When the lower finger valve opens and releases driving pressure for the return stroke, the highly compressed fluid ahead of the moving hammer quickly stops the motion of the hammer. At this instant when the power fluid is under highest compression and the hammer is at rest, maximum force is exerted on this hammer. This condition occurs at the instant of greatest need for power required to overcome the inertia of the hammer and to start the hammer on its power stroke. As the power stroke progresses, the power fluid in contact with the hammer face expands until its pressure approaches that of the fluid at the inlet to the tool. The check valve opens and admits power fluid to complete the power stroke and that portion of the return stroke prior to opening of the lower finger valve. This new valving arrangement has increased the stroke frequency of a tool of this type by about 40 percent.

The check valve preferably is actuated by a weak spring disposed to close the valve at any time when pressure upon the power surface of the hammer exceeds a value lower than inlet pressure by a small amount determined by the strength of the spring. Preferably this valve is annular and is disposed in the tool around the finger to close all branches of a branched power fluid inlet simultaneously.

While it is quite possible to utilize a plurality of check valves, one disposed to close each branch of the passageway for power fluid around the finger, such arrangement is not preferred because the valves must be made quite small and their small size makes them sufficiently fragile that they cannot withstand long periods of heavy use at speeds of several thousand strokes a minute without developing metallic fatigue or becoming badly worn. Also a single valve might be disposed in the main inlet passageway for power fluid, but the size of a check valve in this location makes it a less preferred arrangement. A valve of the size necessary to close the unbranched passage near the inlet becomes large enough and heavy enough that its momentum characteristics interfere with the high speeds that are developed by the lighter valve arrangement closing the branched passageway.

In the attached drawings:

FIGS. 1, 2 and 3 illustrate schematically a fixed finger tool of the present invention and show the cooperation of valves in succeeding parts of the power and return strokes.

FIG. 4 is an enlarged detailed view of the inlet end of a fixed finger impact tool showing in detail a pre-

ferred modification of the check valve of the present invention.

FIG. 5 is a cross section through the tool of FIG. 4 on the line 5—5 of FIG. 4; and

FIG. 6 is a cross section through the tool of FIG. 4 on the line 6—6.

FIGS. 7, 8 and 9 are schematic representations of a tool of reciprocating or "diving" finger type, improved according to the present invention, in succeeding parts of the power and return strokes.

FIG. 10*a* is a detail of the inlet end of a diving finger tool constructed according to the present invention showing a preferred type of check valve arranged to cooperate with the diving finger valve of this tool.

FIG. 10*b* illustrates an end of the tool opposite to the end shown in FIG. 10*a* and is a continuation of FIG. 10*a* downward.

Generally, the apparatus illustrated in FIGS. 1, 2 and 3 includes a hammer **10** mounted for reciprocation within and relative to a hollow body **11**. The hollow interior of body **11** serves as a conduit means for applying actuating fluid and comprises an inlet constructed as a single large bore **12** adapted to be connected at **13** to a conduit for power fluid. A plurality of branch openings **14** communicate with the bore **12** and a space **15** between the branch openings **14** and an upper face **16** of hammer **10**.

Pneumatic fluid under pressure entering the inlet bore **12** flows through openings **14** in the branched portion of the power fluid conduit into space **15** and exerts pressure on face **16** of the hammer to drive the hammer downward until it strikes a face **17** of an anvil **18**.

A check valve **19**, which is preferably an annular member, is disposed transversely to the direction of fluid flow to open and close all of openings **14** in the branched portion of the fluid conduit simultaneously. The valve closure member **19** is suspended from and urged upward by a plurality of weak springs **21** singly disposed in each of openings **14** and suspended therein from pins **22**. Since springs **21** are quite weak, the valve closure member **19** presents little resistance to flow of actuating fluid from inlet bore **12** to the fluid conduit section **15** between the check valve and the hammer face **16**.

In the fixed finger form illustrated in FIGS. 1 to 6, the tool includes upper and lower valve closure members, or fingers, **23** and **24** arranged so that when the upper valve closure member, or finger, **23** enters and closes a passageway **25** through the hammer, the hammer may be moved through a power stroke by power fluid entering from bore **12** ultimately to deliver a blow to the anvil **18**. Then, upon opening of the upper valve means by withdrawal of finger **23** from opening **25**, pressure of power fluid acts to move the hammer in a return stroke to complete the cycle. In order to conserve power fluid, the arrangement is such, as will be explained in detail below, at least one of the valve closure members, or fingers, restricts flow through the tool at substantially all times so that free flow of fluid without exerting a desired actuating force on the hammer is prevented.

At an instant before the end of the power stroke, as illustrated in FIG. 1, power fluid is flowing from bore **12** through openings **14**, space **15**, conduit **25**, and an annular space **26** around the lower end of the hammer and is applying pressure upon a lower face **27** of the hammer tending to force the hammer upward. Since the lower end of the hammer has a larger effective piston surface than the upper face **16**, the hammer moves upward against pressure of actuating fluid in space **15**. Before the lower finger **24** is withdrawn from an opening **28** through the anvil and the upper finger **23** closes passageway **25** through the hammer, a considerable volume of actuating fluid under pressure is accumulated in passageway **25**, annular space **26** and a space between the faces **27** of the hammer and **17** of the anvil. Momentum of the hammer and pressure from this volume of fluid continues to move the hammer upward until pressure of fluid in space **25** approaches the

pressure at which actuating fluid is delivered to the tool. At this time, valve closure member **19** snaps shut as is shown in FIG. 2, thus trapping fluid in the space **15** between the hammer and valve closure member **19**. Momentum of the hammer, which is traveling at high speed, carries the hammer upward, further compressing the air or other actuating fluid in space **15**. As the hammer reaches its upper limit of travel, the pressure of actuating fluid in this space **15** is at its maximum at the exact instant at which maximum power is required to overcome inertia of the hammer and start the power stroke.

Turning now to a detailed description of the tool as shown in FIGS. 4 to 6, the hollow interior of the tool functioning as a fluid supply conduit comprises an inlet section **29** having a large central bore **12** and is provided at its upper end with a suitable connection to a conduit for actuating fluid (not shown). This connection may be a standard tool box or pin for connection with a drill string so that power fluid can be connected to the tool through the drill string; and as the tool sinks lower and lower into a bore hole, the tool can be rotated and its position otherwise regulated by suitable manipulation of the drill string. For ease in assembly the hollow body preferably comprises an upper section **29** containing the bore **12**, a valve enclosure section **31** and a lower section **32**. Sections **29**, **31** and **32** preferably are fixedly connected together by suitable threads **33** and **34**.

The hammer **10** preferably is of one piece construction and is disposed to reciprocate within sections **31** and **32**. It is provided with an upper piston face **16** of smaller diameter than the cross section of the lower part **34** of the hammer.

The upper valve closure member, or finger, **23** is fixed to the upper inlet section **29** and is preferably integral therewith. The upper part of the passageway **25** through hammer **10** fits snugly upon finger **23** and preferably is surrounded by labyrinth grooves **35** to decrease leakage of actuating fluid around the finger.

The annular valve member **19** is disposed around finger **23** to close all openings **14** forming the branched section of the actuating fluid supply conduit. Closure member **19** is equipped with fins **36** extending into openings **14** and maintaining the closure member **19** centered upon the lower end of the openings. The closure member is biased upward by weak springs **21** disposed in each of openings **14** and thus maintaining balance of member **19**. Pins **37** extending from the outside of the tool through an annular groove **38** communicating with the inlet section **12** and with openings **14** are arranged to support springs **21**.

The anvil **18** of FIGS. 1 to 3 is disposed in a hollow interior of housing **11** for limited reciprocal motion and serves as a holder for a suitable tool, illustrated as a drill bit **39**. While many arrangements of anvil and tool elements carried thereby may be used in the device of this invention, one preferred arrangement illustrated will be described for the purposes of completeness. In the device illustrated in the drawings, means are provided for slidably connecting anvil **18** to the housing so that the housing and anvil can have limited longitudinal movement relative to each other and yet relative rotation between them is substantially prevented. The purpose of a connection of this type is twofold in that it provides a torque transmitting connection for rotating the anvil and a working tool such as bit **39** attached thereto, by rotation of a drill string attached to the upper end of housing **11**. Rotation of the drill string enables the bit to be rotationally indexed to take a new bite of the working face of the bore hole without applying such torque to the hammer in a manner to interfere with its reciprocation. A sliding connection also permits the bit to drop away or drill away from the housing when the latter is being moved too slowly to keep up with the bit so as to reduce the impact energy of the hammer and

thereby avoid damaging the connection of the fluid supply conduit means.

It also provides a means for supporting the anvil and bit as the tool is being lowered into a bore hole until the bit encounters a working face of the hole and it permits changing the beating frequency of the hammer without withdrawing the tool from the bore hole as will be explained in more detail later.

In a preferred form the connective means comprises a plurality of longitudinally extending splineways in the anvil and in a lower part of the housing. These splineways are arranged in matched pairs. A splineway **41** of each pair being located in the anvil and a second splineway **42** in a lower part of the housing. The opposing splineways **41** and **42** are radially aligned and suitable bridging elements illustrated as roller bearings **43** are disposed in the splineway to transmit torque between the lower part of the housing and the anvil while permitting relative longitudinal movement between the housing and anvil.

In order to hold the anvil in proper axial alignment with the housing without imposing any substantial aligning stresses on the bridging elements or splineways, the anvil preferably is provided with an upper piston part **44** and another piston portion **45**, each having a close sliding bit in the lower part of the housing. Since the two piston parts **44** and **45** are spaced apart longitudinally, they provide axially aligned bearing points maintaining the anvil in axial alignment during reciprocation of the anvil. The anvil is thus freely slidable through a distance limited by the travel of splineway **41**.

The lower end of the tool just described is substantially identical with that shown in FIGS. 7 to 9, inclusive, and it is to be understood that in all these figures tools of other kinds may be substituted for the drill bit **39** if desired.

FIG. 10*b* is an enlarged detail of the tool connection shown schematically in FIGS. 1 to 3 and 7 to 9 and particularly illustrates a method for assembling the tool. The lower portion of the body **32** is preferably threaded at **46** with tapered threads designed to take a split nut **47**. The nut **47** preferably is vertically divided into two semi-annular halves, and the division occurs upon splineway **42** in the nut. In assembling the tool, the bridging members **43** are placed in the splineways **42** and **41** while the vertical halves of the nut are separated. The halves of the split nut are placed in contact surrounding the bridging members and are held together by a pin **48** and are then screwed rigidly into position by means of threads **46**. The interior of a lower part of nut **47** forms a cylinder in which a piston portion **45** of the hammer **25** is longitudinally slidable. A passageway for actuating fluid through the hammer **28** communicates with branched passageways **49** in the bit shown so that the exhaust of actuating fluid occurs at the face of the work and assists the drill bit by removal of chips cut from the bottom of the hole.

The upper face **17** of the anvil preferably is shaped to avoid full contact of all its area with the opposing face of the hammer so that at the moment of impact there is sufficient space for compressed pneumatic fluid to flow between the hammer and anvil faces to exert pressure for the return stroke. If desired, grooves **51** also may be cut in the hammer or anvil face to assist in the distribution of such pneumatic fluid.

The upper end of the hammer preferably is equipped with labyrinth grooves **52'** for reducing leakage around the hammer, but a small amount of leakage can be permitted and is desirable. A slight leak of pneumatic fluid around the hammer past labyrinth grooves **52'** into an annular space **53** around the hammer results in an outward flow of fluid through passageway **54** into the atmosphere, or well cavity, around the body of the tool. Passageway **54** is normally closed by an O-ring seal **55** which prevents the entrance of dust, grit and undesirable substances which might increase friction of the hammer with the interior of the body. A slight outflow of fluid through passageway **54** at all times prevents such entrance of foreign material.

The valving arrangement of the tool shown in FIGS. 7 to 10*a* differs from that described above in that a reciprocating or "diving" finger valve closure member is used. The supply conduit for actuating fluid comprises a central bore **12** in an inlet portion of the housing which communicates with a space **56** between an upper face of the hammer and the valve arrangement **57** to apply actuating pressure to the upper surface **16** of hammer **18**.

As a part of the valve or flow control means, the reciprocable hammer **10** is provided with a passageway **25** which acts as a valve element cooperating with a reciprocable finger member **52** to open and close passageway **25** to flow of actuating fluid. Finger member **52** preferably has a sufficiently close fit in the upper part of passageway **25** as to substantially block flow therethrough and labyrinth grooves **58** may be provided in the upper part of passageway **25** to aid in stoppage of flow.

In accordance with this invention, the arrangement is such that the finger member **52** reciprocates between retracted and extended positions, the retracted position being more remote from the hammer than the extended position. The arrangement is such that the finger will be in retracted position until the hammer, after it has struck a blow upon the anvil, moves in its return stroke far enough that the tip of finger **52** begins to enter the upper part of bore **25**. Thereafter, on pressure in passageway **25** dropping as a result of restriction of actuating fluid flowing thereinto, finger will move or "dive" into the hammer bore **25** until it reaches its extended position. It remains in extended position until movement of the hammer in its return stroke is reversed, and the hammer is moved through at least a portion of its power stroke sufficient to disengage the tip of finger member **52** from the upper end of passageway **25**. During the final movement of the hammer in its power stroke, passageway **25** moves out of telescopic relation with the finger whereupon the finger moves into retracted position.

To provide this action for the finger element, it is made with larger and smaller piston portions **59** and **61**, respectively. The means for reciprocating the finger includes a smaller cylinder **62** containing the smaller piston portion **61** and a larger cylinder **63** in which the larger piston portion of the finger **59** reciprocates. A small passageway **64** is disposed to admit actuating fluid from inlet bore **12** at all times.

The conduit for actuating fluid has a branched portion composed of a plurality of openings **14** communicating with the inlet bore **12** and space **56**. An annular valve closure member **19** having upright guide fins **36** disposed in each of passageways **14** is disposed to open and close all of said passageways simultaneously. Valve closure member **19** is suspended on a plurality of weak springs **21** singly disposed in each of passageways **14** and carried by pins **37**. The valve closure member **19** is thus urged upward at all times by the tension of springs **21** and functions as a check valve to prevent back flow of pneumatic fluid from the space **56** into the inlet bore **12**.

The cooperation of this check valve **19** with the diving finger **52** is best understood by reference to FIGS. 7, 8 and 9. In FIG. 7 the hammer **10** is approaching the end of its power stroke at the instant before impact with the upper face of anvil **18**. Actuating fluid is flowing from inlet bore **12** through openings **14** around springs **21** and is maintaining the check valve **19** in unseated position allowing free flow of fluid. The actuating fluid pressure is applied to the upper surface of the hammer, driving it downward and fluid is flowing through passageway **25** and branched passageways **65** into the annular space **26** around the lower end of the hammer and communicating with space between the hammer and the anvil.

In this position the full pressure of actuating fluid is

applied through the small openings 64 on the smaller upper piston end 61 of the finger; but the full force of the actuating fluid also is applied upon the larger piston portion 59 of the finger, and the finger is thus forced upward to the full limit of its travel.

After impact, actuating pressure exerted on the larger lower end of hammer 10 starts the hammer in its return stroke. After the hammer has traveled through a portion of its return stroke, the parts will have the relative position shown in FIG. 8. In this position the lower finger member 24 has been withdrawn from passageway 28 through the anvil by upward movement of the hammer thus releasing pressure in passageways 25 and 28. In the position shown, the upper or "diving" finger has engaged the upper part of passageway 25, thus lowering pressure on the underside of piston 59 by at least partially exhausting fluid from cylinder 63 through a vent 50 (shown only in FIG. 10*a*) and the hollow interior of finger 52.

The relative proportions of pistons 59 and 64 are so chosen that the full pressure of actuating fluid from inlet bore 12 entering through opening 64 is sufficient to overcome pressure on the lower side of piston 59 and move the finger 52 downward for the full length of its travel, thus effectively closing off passageway 25.

The upward momentum of the hammer, which is traveling at high speed, compresses the pneumatic fluid in space 56. In the position shown in FIG. 8 the pressure in space 56 has substantially equaled that in the inlet bore 12 with the result that the springs 21 have drawn the annular valve closure member 19 into position to close off all openings 14. It will be obvious that additional upward travel of hammer 10 will further compress gas in this space until the hammer reaches its upper limit of travel. At this point where maximum power is required to overcome inertia of the hammer and start the hammer upon its power stroke, pneumatic fluid in space 56, under pressure far exceeding that in inlet bore 12, is available to perform this function and the frequency of reciprocation of the hammer is greatly increased.

In the position of parts shown in FIG. 9, the power stroke has continued through a distance such that the pneumatic fluid compressed in space 56 has dropped in pressure sufficiently to permit check valve 19 to be opened by inlet pressure. Actuating fluid is flowing from bore 12 through openings 14 into space 56 where it exerts its full force upon the upper face of hammer 10. In the position shown, the lower finger 24 is beginning to engage bore 28 through the anvil and the finger 52 is about to be withdrawn from bore 25 in the hammer by movement of the hammer. It will readily be seen that the application of the full pressure from bore 12 to the upper face of the hammer in the reciprocating finger tool will be continued for an increased time depending upon the distance through which finger 52 reciprocates. At the instant finger 52 emerges from bore 25 of the hammer, the full force of the actuating fluid is applied through vent passageway 50 on the lower face of piston 59 and is sufficient to overcome the force on piston 64 and to drive the finger into its retracted position.

Thus, it will be seen that the improved valving arrangement of this invention results in a tool in which the frequency of reciprocation is greatly increased whether the finger type valve performing the main valving function and applying pressure to opposite ends of the hammer be of the fixed finger or reciprocating finger type. There is always a point at the upper limit of the stroke of the hammer where pressure on a unit area of the hammer's upper face is much greater than the inlet pressure in bore 12. This occurs at the exact instant when the greatest power is needed, and the lag between return stroke and power stroke is shortened.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. An impact tool powered by a compressible fluid which comprises in combination a housing; an inlet for actuating fluid into the housing; an anvil mounted in the housing for limited reciprocating movement; a hammer mounted between the inlet and anvil and reciprocable in the housing to beat upon the anvil, said hammer having endwise surfaces of different areas against which pressure from fluid in the housing can act to urge the hammer in power and return strokes; a first fluid passageway through the hammer extending between said surfaces; a second fluid passageway through the anvil extending from a surface of the anvil opposed to the hammer to the exterior of the tool; a first valve closure member, carried by the housing, disposed to open and close said first passageway after finite movement of the hammer in power and return strokes, respectively; a second valve closure member, carried by the hammer, disposed to close and open said second passageway after finite movement of the hammer in power and return strokes, respectively, said valve closure elements being cooperable to apply pressure from fluid in the housing alternately to said endwise surfaces of the hammer and too reduce pressure on the endwise surface opposite to the one upon which pressure is applied; and a check valve biased against inlet pressure disposed in an inlet portion of the housing to prevent reverse flow of actuating fluid into the inlet, said check valve, housing, hammer and first valve closure member being cooperable to provide a closed small volume chamber in the housing when said first passageway is closed by said first valve closure member.

2. An impact tool powered by a compressible fluid which comprises in combination a housing; an inlet for actuating fluid into the housing including a section having a plurality of openings therethrough; an anvil mounted in the housing for limited reciprocating movement; a hammer mounted between the inlet and anvil and reciprocable in the housing to beat upon the anvil, said hammer having endwise surfaces of different areas against which pressure from fluid in the housing can act to urge the hammer in power and return strokes; a first fluid passageway through the hammer extending between said surfaces; a second fluid passageway through the anvil extending from a surface of the anvil opposed to the hammer to the exterior of the tool; a first valve closure member, carried by the housing, disposed to open and close said first passageway after finite movement of the hammer in power and return strokes, respectively; a second valve closure member, carried by the hammer, disposed to close and open said second passageway after finite movement of the hammer in power and return strokes, respectively, said valve closure elements being cooperable to apply pressure from fluid in the housing alternately to said endwise surfaces of the hammer and to reduce pressure on the endwise surface opposite to the one upon which pressure is applied; and a check valve in said inlet section biased against inlet pressure disposed to close all openings in said section simultaneously to prevent reverse flow of actuating fluid into the inlet, said check valve, housing, hammer and first valve closure member being cooperable to provide a closed small volume chamber in the housing when said first passageway is closed by said first valve closure member.

3. An impact tool powered by a compressible fluid

which comprises in combination a housing; an inlet for actuating fluid into the housing including a section having a plurality of openings therethrough symmetrically arranged on the circumference of a circle; an anvil mounted in the housing for limited reciprocating movement; a hammer mounted between the inlet and anvil and reciprocable in the housing to beat upon the anvil, said hammer having endwise surfaces of different areas against which pressure from fluid in the housing can act to urge the hammer in power and return strokes; a first fluid passageway through the hammer extending between said surfaces; a second passageway through the anvil extending from a surface of the anvil opposed to the hammer to the exterior of the tool; a first valve closure member carried by the housing disposed to open and close said first passageway after finite movement of the hammer in power and return strokes, respectively; a second valve closure member carried by the hammer disposed to close and open said second passageway after finite movement of the hammer in power and return strokes, respectively, said valve closure elements being cooperable to apply pressure from fluid in the housing alternately to said endwise surfaces of the hammer and to reduce pressure on the endwise surface opposite to the one upon which pressure is applied; and an annular check valve closure member biased against inlet pressure disposed to close all openings in said inlet section simultaneously to prevent reverse flow of actuating fluid into the inlet, said check valve, housing, hammer and first valve closure member being cooperable to provide a closed small volume chamber in the housing when said first passageway is closed by said first valve closure member.

4. The impact tool of claim 3 wherein the check valve closure member has guide fins slidably disposed in each of said openings maintaining the valve closure member centered on each of the openings.

5. The impact tool of claim 4 wherein the valve closure member is biased against inlet pressure by a plurality of springs singly disposed in each of said openings and maintaining a balanced tension on said closure member.

6. An impact tool powered by a compressible fluid which comprises in combination a housing; an inlet for actuating fluid into the housing; an anvil mounted in the housing for limited reciprocating movement; a hammer mounted between the inlet and anvil and reciprocable in the housing to beat upon the anvil, said hammer having endwise surfaces of different areas against which pressure from fluid in the housing can act to urge the hammer in power and return strokes; a first fluid passageway through the hammer extending between said surfaces; a second fluid passageway through the anvil extending from a surface of the anvil opposed to the hammer to the exterior of the tool; a first valve closure member carried by the housing in fixed position, disposed to open and close said first passageway after finite movement of the hammer in power and return strokes, respectively; a second valve closure member carried by the hammer in fixed relationship thereto, disposed to close and open said second passageway after finite movement of the hammer in power and return strokes, respectively, said valve closure elements being cooperable to apply pressure from the fluid in the housing alternately to said endwise surfaces of the hammer and to reduce pressure on the endwise surface opposite the one upon which pressure is applied; and a check valve in an inlet section of the housing biased against inlet pressure arranged to prevent reverse flow of actuating fluid into the inlet, said check valve, housing, hammer and first valve closure member being cooperable to provide a closed small volume chamber in the housing when said first passageway is closed by said first valve closure member.

7. An impact tool powered by a compressible fluid which comprises in combination a housing; an inlet for actuating fluid into the housing, including a section having a plurality of openings therethrough; an anvil mounted in the housing for limited reciprocating movement; a hammer mounted between the inlet and anvil and reciprocable in the housing to beat upon the anvil, said hammer having endwise surfaces of different areas against which pressure from fluid in the housing can act to urge the hammer in power and return strokes; a first fluid passageway through the hammer extending between said surfaces; a second fluid passageway through the anvil extending from a surface of the anvil opposed to the hammer to the exterior of the tool; a first valve closure member carried by the housing in fixed position, disposed to open and close said first passageway after finite movement of the hammer in power and return strokes, respectively; a second valve closure member carried by the hammer in fixed relationship thereto disposed to close and open said second passageway after finite movement of the hammer in power and return strokes, respectively, said valve closure elements being cooperable to apply pressure from fluid in the housing alternately to said endwise surfaces of the hammer and to reduce pressure on the endwise surface opposite to the one upon which pressure is applied; and a check valve at said inlet section of the housing biased against inlet pressure disposed to close all openings in said section simultaneously and prevent reverse flow of actuating fluid into the inlet, said check valve, housing, hammer and first valve closure member being cooperable to provide a closed small volume chamber in the housing when said first passageway is closed by said first valve closure member.

8. An impact tool powered by a compressible fluid which comprises in combination a housing; an inlet for actuating fluid into the housing, including a section having a plurality of openings therethrough symmetrically arranged on the circumference of a circle; an anvil mounted in the housing for limited reciprocating movement; a hammer mounted between the inlet and anvil and reciprocable in the housing to beat upon the anvil, said hammer having endwise surfaces of different areas against which pressure from fluid in the housing can act to urge the hammer in power and return strokes; a first fluid passageway through the hammer extending between said surfaces; a second fluid passageway through the anvil extending from a surface of the anvil opposed to the hammer to the exterior of the tool; a first valve closure member carried by the housing in fixed position disposed to open and close said first passageway after finite movement of the hammer in power and return strokes, respectively; a second valve closure member carried by the hammer in fixed relationship thereto disposed to close and open said second passageway after finite movement of the hammer in power and return strokes, respectively, said valve closure elements being cooperable to apply pressure from fluid in the housing alternately to said endwise surfaces of the hammer and to reduce pressure on the endwise surface opposite to the one upon which pressure is applied; and an annular check valve closure member biased against inlet pressure disposed to close all openings in said inlet section simultaneously and prevent reverse flow of actuating fluid into the inlet, said check valve, housing, hammer and first valve closure member being cooperable to provide a closed small volume chamber in the housing when said first passageway is closed by said first valve closure member.

9. The impact tool of claim 8 wherein the check valve closure member has guide fins slidably disposed in each of said openings maintaining the valve closure member centered on each of the openings.

10. The impact tool of claim 9 wherein the valve closure member is biased against inlet pressure by a plurality of springs singly disposed in each of said openings and maintaining balanced tension on the said closure member.

11. An impact tool powered by a compressible fluid which comprises in combination a housing; an inlet for actuating fluid into the housing; an anvil mounted in

the housing for limited reciprocating movement; a hammer mounted between the inlet and anvil and reciprocable in the housing to beat upon the anvil, said hammer having endwise surfaces of different areas against which pressure from fluid in the housing can act to urge the hammer in power and return strokes; a first fluid passageway through the hammer extending between said surfaces; a second fluid passageway through the anvil extending from a surface of the anvil opposed to the hammer to the exterior of the tool; a first valve closure means carried by the housing, including a reciprocable finger disposed to enter and close said first passageway, and means for reciprocating the finger between advanced and retracted positions, disposed to advance the finger after the hammer has moved through an initial part of a return stroke and to retract the finger after the hammer has moved through an initial part of a power stroke; a second valve closure means carried by the hammer disposed to close and open said second passageway after finite movement of the hammer in power and return strokes, respectively, said valve closure means being cooperable to apply pressure from the fluid in the housing alternately to said endwise surfaces of the hammer and to reduce pressure on the endwise surface opposite to the one upon which pressure is applied; and a check valve in an inlet section of the housing biased against inlet pressure arranged to prevent reverse flow of actuating fluid into the inlet, said check valve, housing, hammer and first valve closure member being cooperable to provide a closed small volume chamber in the housing when said first passageway is closed by said first valve closure member.

12. The impact tool of claim 11 wherein the check valve closure member has guide fins slidably disposed in each of said openings maintaining the valve closure member centered on each of the openings.

13. The impact tool of claim 11 wherein the valve closure member is biased against inlet pressure by a plurality of springs singly disposed in each of said openings and maintaining balanced tension on said closure member.

14. An impact tool powered by a compressible fluid which comprises in combination a housing; an inlet for actuating fluid into the housing including a section having a plurality of openings therethrough; an anvil mounted in the housing for limited reciprocating movement; a hammer mounted between the inlet and anvil and reciprocable in the housing to beat upon the anvil, said hammer having endwise surfaces of different areas against which pressure from fluid in the housing can act to urge the hammer in power and return strokes; a first fluid passageway through the hammer extending between said surfaces; a second fluid passageway through the anvil extending from a surface of the anvil opposed to the hammer to the exterior of the tool; a first valve closure means carried by the housing including a reciprocable finger disposed to enter and close said first passageway, and means for reciprocating the finger between advanced and retracted positions, advancing the finger after the hammer has moved through an initial part of a return stroke and retracting the finger after the hammer has moved through an initial part of a power stroke; a second valve closure means carried by the hammer, disposed to close and open said second passageway after finite movement of the hammer in power and return strokes, respectively, said valve closure means being cooperable to apply pressure from fluid in the housing alternately to said endwise surfaces of the hammer and to reduce pressure on the endwise surface opposite to the one upon which pressure is applied; and a check valve biased against inlet pressure disposed in said inlet section of the housing arranged to prevent reverse flow of actuating fluid into the inlet, said check valve, housing, hammer and first valve closure member being cooperable to provide a closed small volume chamber in the housing when said first passageway is closed by said first valve closure member.

15. An impact tool powered by a compressible fluid which comprises in combination a housing; an inlet for actuating fluid into the housing including a section having a plurality of openings therethrough symmetrically arranged on the circumference of a circle; an anvil mounted in the housing for limited reciprocating movement; a hammer mounted between the inlet and anvil and reciprocable in the housing to beat upon the anvil, said hammer having endwise surfaces of different areas against which pressure from the fluid in the housing can act to urge the hammer in power and return strokes; a first fluid passageway through the hammer extending between said surfaces; a second fluid passageway through the anvil extending from the surface of the anvil opposed to the hammer to the exterior of the tool; a first valve closure means carried by the housing, including a reciprocable finger disposed to enter and close said first passageway, and means for reciprocating the finger between advanced and retracted position advancing the finger after the hammer has moved through an initial part of a return stroke and retracting the finger after the hammer has moved through an initial part of a power stroke; a second valve closure means carried by the hammer in fixed relationship thereto disposed to close and open said second passageway after finite movement of the hammer in power and return strokes, respectively, said valve closure means being cooperable to apply pressure from fluid in the housing alternately to said endwise surfaces of the hammer and to reduce pressure on the endwise surface opposite the one upon which pressure is applied; and an annular check valve closure member disposed to close all openings in said inlet section simultaneously when pressure on the hammer face nearest the inlet is lower than inlet pressure by a predetermined amount, said check valve, housing, hammer and first valve closure member being cooperable to provide a closed small volume chamber in the housing when said first passageway is closed by said first valve closure member.

References Cited in the file of this patent

UNITED STATES PATENTS

837,347	Smith	Dec. 4, 1906
2,262,432	Rodder et al.	Nov. 11, 1941
2,422,031	Merten	June 10, 1947
2,620,162	Pennington	Dec. 2, 1952
2,719,510	Elder	Oct. 4, 1955
2,746,721	Moore	May 22, 1956
2,859,733	Bassinger et al.	Nov. 11, 1958
2,943,603	Bassinger	July 5, 1960
2,947,519	Feucht	Aug. 2, 1960
2,979,033	Bassinger	Apr. 11, 1961
3,040,710	Wilder	July 26, 1962