

Feb. 6, 1973

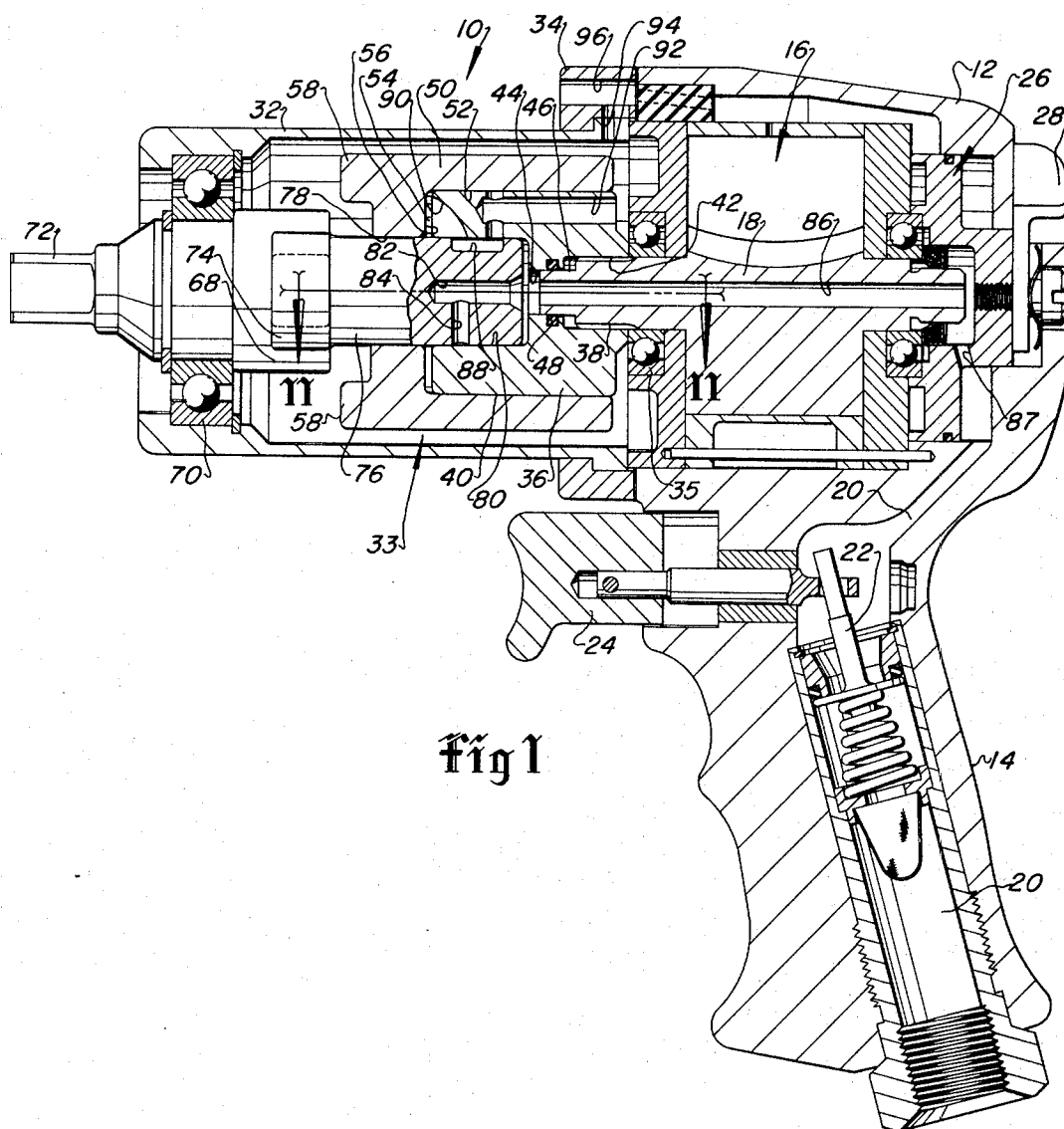
R. L. ZOERNER ET AL

3,714,994

FLUID ACTUATED IMPACT MECHANISM

Filed Nov. 29, 1971

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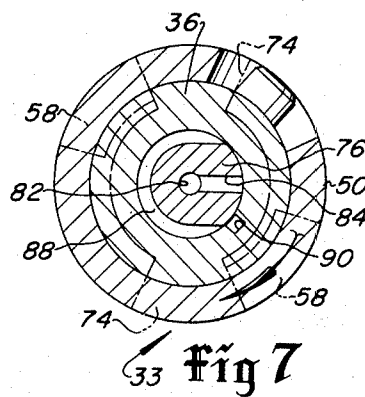
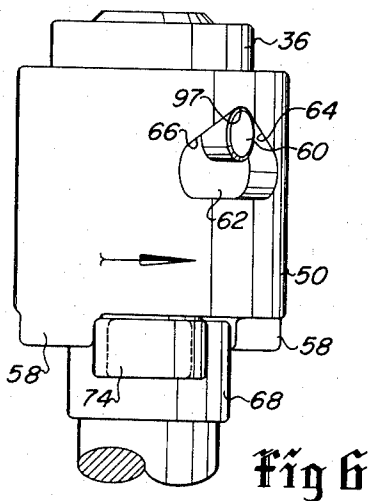
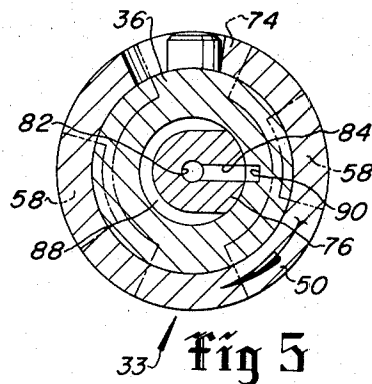
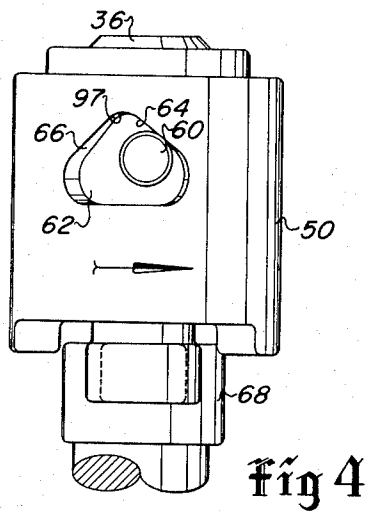
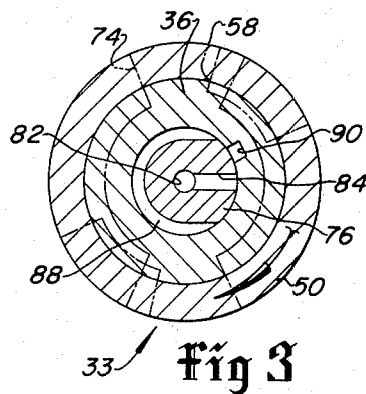
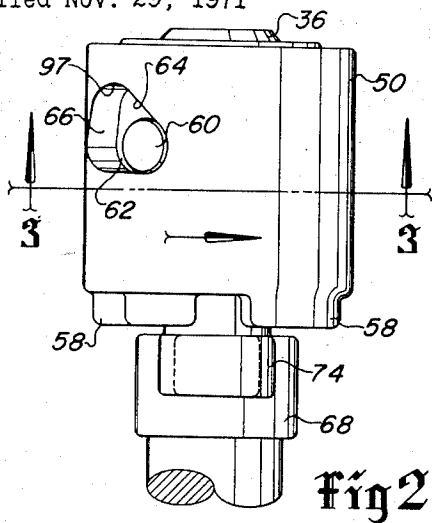
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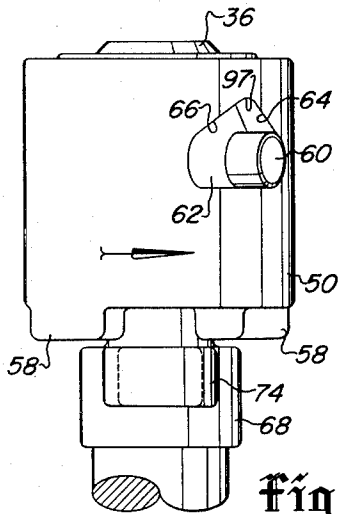


Fig 8

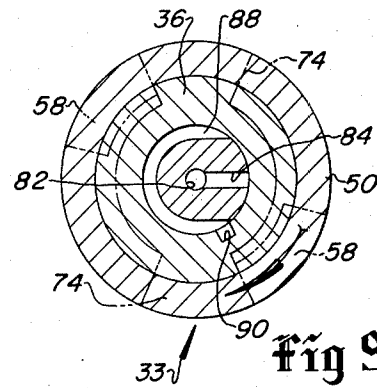


Fig 9

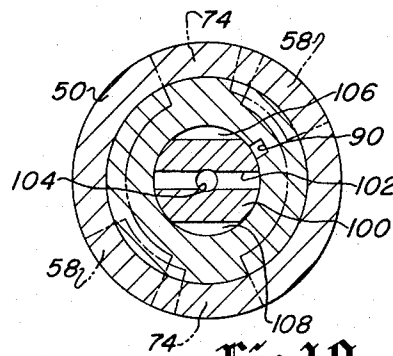


Fig 10

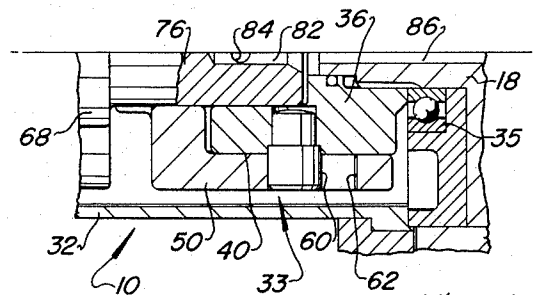


Fig 11

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**FLUID ACTUATED IMPACT MECHANISM**  
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9 Claims

## ABSTRACT OF THE DISCLOSURE

A rotary fluid actuated mechanism for an impact wrench including a rotary drive member coupled to a rotating hammer member through a pin and slot coupling which provides for rotary and axial displacement of the hammer with respect to the drive member. The hammer is mounted in sleeved arrangement over the drive member to form an expansible chamber. Pressure air is supplied to the chamber through a rotary valve formed by the drive member and a portion of a rotary anvil for forcing the hammer to move axially and accelerate rotatively to impact the anvil.

## BACKGROUND OF THE INVENTION

Impact wrench mechanisms are known in which pressure air is admitted to an expansible chamber to force a rotating hammer axially into a position wherein further rotation will result in impacting of the hammer against an anvil. U.S. Pats. 3,068,973 to S. B. Maurer and 3,104,743 to H. C. Reynolds disclose impact mechanisms of the general type above mentioned. However, known types of fluid actuated mechanisms for impact wrenches do not provide for rotary acceleration of the hammer with respect to the motor rotor to provide for impacting the anvil with greater kinetic energy than that which is provided by the rotary motor. Accordingly, the motive air expended to axially move the hammer into anvil impacting position is not put to any other useful purpose and is merely exhausted to permit the hammer to retract prior to another impacting cycle. Moreover, known types of impact wrench mechanisms which use pressure air to axially move the hammer into anvil impacting position use pressure air to retract the hammer, which is inefficient, or mechanical springs which are subject to breakage and contributes to the complexity of the impact mechanism.

## SUMMARY OF THE INVENTION

The present invention provides an impact delivery mechanism which is actuated by pressure fluid to cause impacting engagement of a rotating hammer with an anvil and which includes a drive coupling between the hammer and a rotary drive member which is operable to retract the hammer out of anvil impacting position. The improved impact delivery mechanism of the present invention provides a drive coupling between a drive member and a rotary impact hammer which is operable to rotatably accelerate the hammer to a rotary speed greater than the rotary speed of the drive member in response to pressure fluid being applied to axially move the hammer into anvil engaging position. In accordance with the present invention an impact wrench mechanism is provided which uses pressure fluid more efficiently than known pressure fluid actuated impact wrench mechanisms.

The present invention further provides an impact delivery mechanism which includes valve means for supplying a sufficient quantity of pressure fluid to axially and rotatably move a hammer element to impact an anvil and for rapidly exhausting said quantity of pressure fluid to reduce delay in hammer retraction movement. The arrangement of the rotary valve together with the drive cou-

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pling between the hammer member and the drive member also prevents the hammer from striking a secondary impact blow during the operating cycle. With the present invention any rebound action of the hammer assists the hammer retraction movement and is also dissipated through pumping residual air from an expansible chamber formed between the hammer and drive member instead of being transmitted as a reaction force acting through the tool motor to the tool operator. Significantly, the present invention also provides an impact delivery mechanism which includes relatively few working parts and is reliable and economical to manufacture.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal section view taken along the centerline of an impact wrench including the impact delivery mechanism of the present invention;

FIGS. 2, 4, 6 and 8 are detail views showing the relative positions of the hammer member, drive member, and anvil during a portion of an operating cycle of the impact mechanism of FIG. 1;

FIGS. 3, 5, 7, and 9 are section views taken substantially along the line 3—3 of FIG. 2 and showing the relative positions of the drive member, and anvil in the respective FIGS. 2, 4, 6, and 8, and also showing, with broken lines superimposed on the views, the relative positions of the dogs on the hammer and anvil;

FIG. 10 is a view taken substantially along a line in the same location as line 3—3 showing an alternate embodiment of the anvil providing for two impact blows per revolution of the drive member;

FIG. 11 is a section taken substantially along the line 11—11 of FIG. 1.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIGS. 1 and 11 a fluid operated impact wrench is illustrated and generally designated by the numeral 10. The wrench 10 is characterized by a housing 12 having a hand grip portion 14. A rotary vane fluid motor 16, disposed within the housing 12, includes a rotor 18. The motor 16 is of a type generally well known and extensively used in fluid operated power tools. Pressure fluid is supplied to the motor 16 through a passage 20 in which is interposed a fluid flow control valve 22 of conventional construction. The valve 22 is spring biased in the closed position and is operable to be opened by actuation of a trigger 24 to provide flow of fluid such as compressed air to the motor 16. The wrench 10 also includes a motor reversing valve generally designated by the numeral 26 and being of a type generally well known. The valve 26 is operated by a lever 28 to be positioned to provide for flow of fluid to spaced apart motor inlet ports, not shown, for reversible operation of the motor 16. The wrench 10 also includes a housing portion 32 removably secured on the housing 12 by a retaining ring 34 which is clamped to the housing 12 by suitable fasteners, not shown. The housing portion 32 contains, within its interior, an improved impact mechanism generally designated by the numeral 33 and described further herein.

The motor rotor 18 extends through a bearing 35 into the interior of the housing portion 32 and is drivably connected to a rotatable drive member 36 by interengaging splines 38 located on the rotor and the drive member. The drive member 36 has a cylindrical exterior surface 40 and a cylindrical recess 42 opening to one end. The drive member 36 also includes a central bore 44 in which a reduced diameter portion 46 of the rotor shaft is located and sealingly surrounded by an O-ring 48.

The drive member 36 supports a substantially cylindrical member 50 comprising the hammer of the impact

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mechanism 33. The hammer member 50 includes a cylindrical inner wall 52 which is proportioned to be in close fitting relationship to the surface 40. The hammer member 50 is, however, disposed for limited axial and rotatable movement relative to the drive member 36. The hammer member 50 also forms, together with the drive member 36, an expansible chamber 54 into which pressure fluid may be admitted to act on a pressure surface 56 for axially and rotatably moving the hammer with respect to the drive member as will be explained herein. Projecting axially from one end of the hammer member are two hammer dogs 58 integrally formed on the hammer and radially disposed 180° apart.

As shown in FIGS. 2, 4, 6, 8, and 11 the hammer member 50 and drive member 36 are interconnected by a drive coupling comprising a projection formed by a cylindrical pin 60 suitably retained on the drive member 36 and projecting radially from the surface 40. The pin 60 is disposed in a substantially triangular shaped slot 62 formed on the hammer member 50 and having two axially converging surfaces 64 and 66. The corners of the triangular shaped slot 62 are formed by radii which are dimensionally slightly larger than one-half of the diameter of the cylindrical pin 60. A suitable angle subtended by the surfaces 64 and 66 is in the range of 90° to 100°.

The impact mechanism 33 also includes an anvil 68 rotatably supported in a bearing 70 located in the housing portion 32. The anvil 68 includes a drive end portion 72 of conventional configuration for suitably mounting a wrench socket or the like thereon. A pair of radially extending dogs 74 are also formed on the anvil 68 and comprise means operable to receive impact blows from the cooperating dogs 58 on the hammer member 50 in a manner well known.

The opposite end of the anvil is formed as a circular shaft portion 76 which extends in close fitting and substantially fluid sealing relationship through an opening 78 in the hammer member 50 and into a bore 80 in the drive member 36. The shaft portion 76 has an axial passage 82 in communication with a radial passage 84 and with an axial passage 86 formed entirely through the rotor 18. The passage 86 is in communication with the passage 20 by way of a passage 87.

The anvil also includes a groove 88 formed on the periphery of the shaft portion 76 and operable, as shown in FIG. 1 and FIG. 5, to be in communication with a passage 90 and a passage 92 in the drive member 36. The passage 90 is formed as a radial slot and opens into the expansible chamber 54. The passage 92, which together with the groove 88 forms an exhaust passage, opens into the interior of the housing portion 32. An opening 94 in the housing portion 32 conducts pressure fluid to a passage 96 which forms part of an exhaust port for the motor 16. The passages 90 and 92 in the drive member 36 cooperate with the groove 88 and passage 84 in the anvil 68 to form rotary valve means for admitting pressure fluid to and exhausting pressure fluid from the expansible chamber 54. The operation of the rotary valve means may be better understood from a description of an operating cycle of the impact mechanism 33.

With pressure fluid supplied to the wrench 10, the valve 22 open, and the reversing valve 26 set to rotate the motor 16 so that the hammer member 50 is rotated in the direction indicated by the arrows in FIGS. 2 and 3, the drive pin 60 will be located in the slot 62 in the position shown in FIG. 2. In this condition the expansible chamber 54 is exhausted of pressure fluid and the hammer member 50 is axially retracted such that the dogs 58 will not be in an axial position to engage the dogs 74. As shown in FIG. 3 the passage 90 is not in communication with the groove 88 or the passage 84. It is assumed that the anvil 68 is not moving due to sufficient resistance to rotation of a fastener, not shown, which is to be tightened or removed by the wrench 10. As the drive member 36 and hammer member 50 continue to

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rotate to the position shown in FIGS. 4 and 5 the passage 84 is now in full registration with the passage 90 to communicate pressure fluid to the expansible chamber 54. Pressure fluid acting on the surface 56 already has moved the hammer member 50 axially toward the anvil 68 and at the same time the hammer is forced to accelerate rotatably with respect to the drive member 36 due to the engagement of the pin 60 with the axially sloping surface 64. As pressure fluid is admitted to the chamber 54 the hammer member 50 moves from the position of FIGS. 4 and 5 to the position shown in FIGS. 6 and 7. In moving from the FIG. 2 to the FIG. 6 position, the hammer member 50 has moved axially with respect to the anvil so that the dogs 58 will be in a proper axial position for engaging the dogs 74 on the anvil. The hammer member 50 has also accelerated rotatably with respect to the drive member 36 so that the total rotational kinetic energy of the hammer member is greater than the amount of rotational kinetic energy in the hammer member due to the rotational speed of the drive member alone. Accordingly, the impact blow delivered to the anvil 68 is increased and the pressure fluid expended to move the hammer member is used more efficiently than in prior art impact mechanisms.

A number of factors such as motor size, working air pressure, moment of inertia of the motor and hammer, and positional relationships between the cooperating hammer and anvil dogs and the rotary valve arrangement are important to providing a desired improved impact wrench in accordance with the present invention. By way of example it has been determined that an improved wrench sized for driving one-half inch thread diameter fasteners may use a conventional six-bladed rotary vane air motor of approximately 1.4 inch rotor diameter by 1.4 inch rotor length. The combined mass moment of inertia of the motor rotor 18 and drive member 36 with respect to the rotor axis has been determined to be about .00072 pounds-inches-seconds<sup>2</sup> and the mass moment of inertia of the hammer 50 about .0012 pounds-inches-seconds<sup>2</sup>. The rotational angular displacement of the hammer 50 with respect to the member 36 provided by the drive pin 60 and sloping surface 64 is about 20°. Together with the aforementioned conditions the desired angular displacement between the cooperating impact surfaces on the dogs 58 and 74 has been found to be in the range of 75° to 95° at the instant that the passage 90 commences to register with the passage 84. Assuming adequate passage area to prevent throttling of air flowing to the chamber 54, and supply pressure of 70-90 p.s.i.g., the above timing relationships have been selected to provide for the corner 97 of the slot formed by the converging surfaces 64 and 66 to be not quite engaged with the pin 60 at the instant of impact of the dogs 58 with the anvil dogs 74. This is the position of FIGS. 6 and 7 and as may be seen in FIG. 7 at the instant of impact the passage 90 is at the threshold of being in registration with the groove 88. As the passage 90 and groove 88 come into registration pressure fluid in the chamber 54 is exhausted through the passage 90, groove 88, and passage 92 to the interior of the housing portion 32, and eventually through passage 94 to the wrench exterior. After the instant of impact, the drive member 36 continues to rotate from the position of FIGS. 6 and 7 to the position of FIGS. 8 and 9 wherein the passage 90 is shown in full registration with the groove 88. With the chamber 54 relieved of fluid pressure, rotation of the drive member 36 together with the resistance to rotation of the anvil 68 and rebound action of the hammer 50 will cause the hammer to be cammed axially away from the anvil dogs 74 as the surface 64 rides along the pin 60. The hammer member 50 and drive member 36 will continue to rotate together from the position of FIG. 8 to the position of FIG. 2 where the impact cycle will commence again. With the configuration of FIG. 1 the impact mechanism 33 will deliver one impact blow per revolution of the drive member 36.

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The cycle depicted by FIGS. 2 through 9 shows the anvil 68 in a fixed position for clarity. The anvil will, of course, rotate an incremental amount with each impact blow until the resistance to rotation cannot be overcome by the impact blows of the hammer member 50. The return of the hammer member from the FIG. 6 to FIG. 8 position will be cushioned by the pumping of pressure fluid from the chamber 54. Moreover, it is believed the drive coupling formed by the pin 60 and slot 62 provides for minimum or negligible stalling of the drive member 36 and motor rotor 18 upon impact, and also smooth acceleration of the motor prior to delivery of the next impact blow.

FIG. 10 illustrates a modified embodiment of the anvil shaft portion 76 designated by the numeral 100. The modified shaft portion 100 includes a transverse passage 102 which is in communication with a passage 104, the latter corresponding to the passage 82 in the embodiment of FIG. 1. As shown in FIG. 10 the passage 102 opens to the periphery of the shaft portion 100 at two positions 180° apart. The shaft portion 100 also includes grooves 106 and 108 formed on its periphery. The grooves 106 and 108 operate to communicate the passage 90 with the passage 92 in the drive member 36 for exhausting pressure fluid from the chamber 54. The embodiment of FIG. 10 is functionally similar to the embodiment of FIG. 1 with the exception that the embodiment of FIG. 10 provides for two impact blows of the hammer against the anvil per revolution of the drive member 36 as will be readily understandable to those of ordinary skill in the art of impact mechanisms. As will also be appreciated by those skilled in the art, the impact delivery mechanism shown in FIGS. 1 through 11 is operable to deliver impact blows in both directions of rotation of the motor rotor 18. The operation of the wrench in the direction of rotation opposite to that shown in FIGS. 2 through 9 is substantially the same except that the surface 66 of the slot 62 cooperates with the pin 60 to provide the combined axial and rotational movement of the hammer member 50 with respect to the drive member 36.

What is claimed is:

1. A fluid operated impact wrench comprising: a fluid operated motor including a rotor; a rotatable anvil having means for receiving impact blows, and the improvement characterized by: a drive member operably connected to said rotor to be rotatably driven by said rotor; a hammer member operable to be rotatably driven by said drive member for delivering impact blows to said anvil; means including said hammer member defining an expansible chamber; means for admitting pressure fluid to said expansible chamber; and, a drive coupling interconnecting said hammer member and said drive member for providing rotational acceleration of said hammer member with respect to said drive member in response to the admission of pressure fluid to said expansible chamber.
2. The invention set forth in claim 1 wherein: said hammer member is axially movable with respect to said drive member from a retracted position to a position for delivering an impact blow to said anvil in response to the admission of pressure fluid to said expansible chamber.

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3. The invention set forth in claim 2 wherein: said drive coupling is operable to move said hammer member axially from said position for delivering an impact blow to said retracted position in response to the delivery of an impact blow to said anvil.
4. The invention set forth in claim 3 wherein: said expansible chamber is formed by said hammer member and said drive member and said hammer member includes a pressure surface defining a movable wall portion of said expansible chamber responsive to the admission of pressure fluid to said expansible chamber to move said hammer member axially and rotatably with respect to said drive member.
5. The invention set forth in claim 1 wherein: said means for admitting pressure fluid to said expansible chamber includes rotary valve means defined by a portion of said anvil cooperable with said drive member.
6. The invention set forth in claim 5 wherein: said rotary valve means comprises a shaft portion of said anvil disposed in a longitudinal bore in said drive member, passage means in said shaft portion opening radially to the periphery of said shaft portion, and passage means in said drive member opening into said expansible chamber and said longitudinal bore and operable to register with said passage means in said shaft portion in response to rotation of said drive member with respect to said anvil.
7. The invention set forth in claim 6 wherein: said anvil includes a groove disposed on the periphery of said shaft portion, said drive member includes exhaust passage means, and in response to rotation of said drive member with respect to said anvil said groove is operable to register with said passage means in said drive member and said exhaust passage means in said drive member to exhaust pressure fluid from said expansible chamber.
8. The invention set forth in claim 2 wherein: said drive coupling comprises a projection on one of said members and a slot defined by axially sloping surface means disposed on the other of said members, and said projection is cooperable with said axially sloping surface means to cause said hammer member to accelerate rotatably with respect to said drive member in response to admission of pressure fluid to said expansible chamber.
9. The invention set forth in claim 8 wherein: said drive coupling includes axially sloping surface means cooperable with said projection for reversible operation of said hammer member to impact said anvil.

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JAMES A. LEPPINK, Primary Examiner

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