Feb. 7, 1967 J. A. ROLL 3,302,732

IMPACT TOOL

Filed Oct. 28, 1963 4 Sheets-Sheet 1

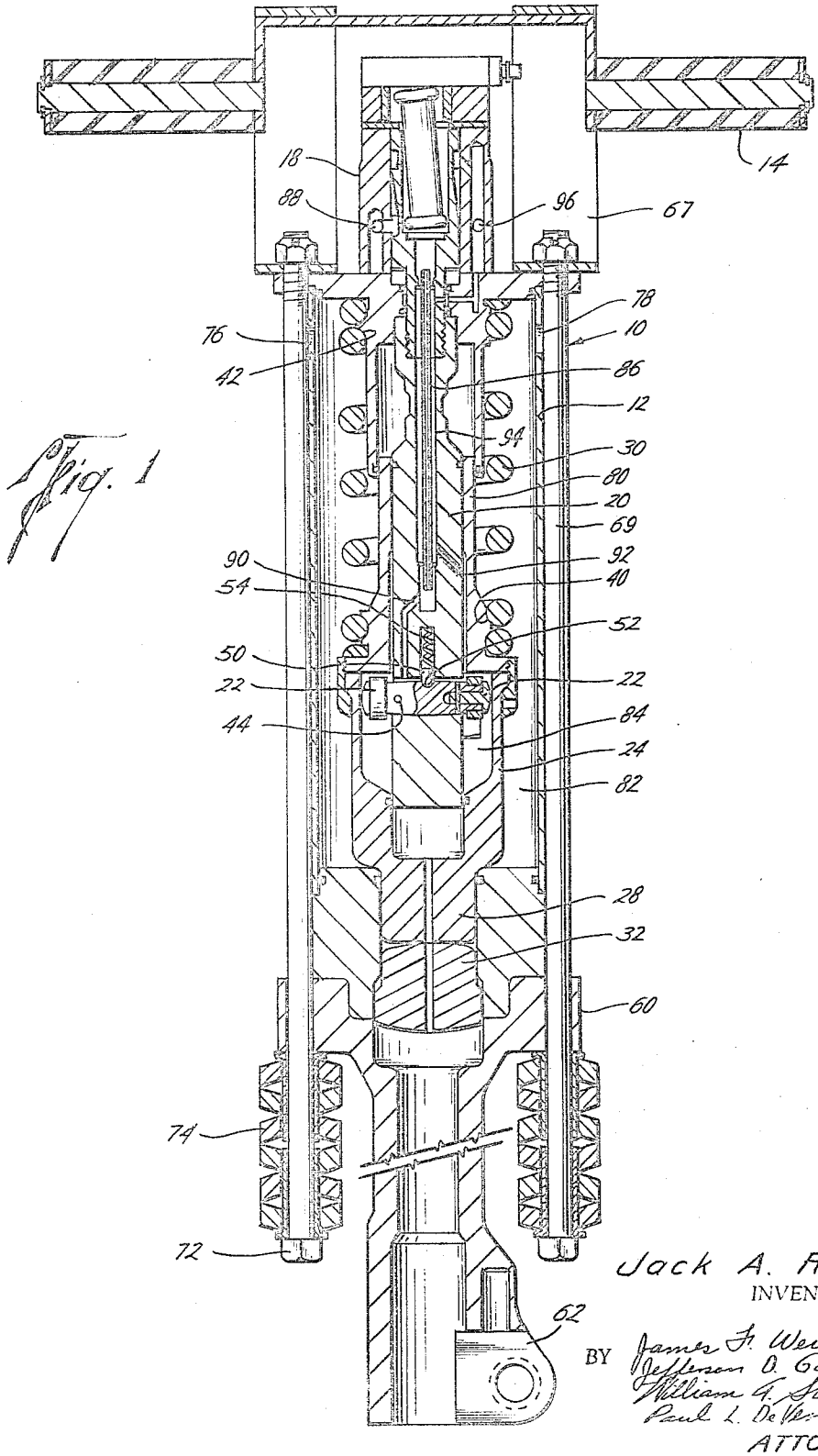


Fig. 1

Jack A. Roll
INVENTOR.

BY James F. Weiler
Jefferson O. Gilbert
William A. Stout
Paul L. DeVerter II
ATTORNEYS

Feb. 7, 1967 J. A. ROLL 3,302,732

IMPACT TOOL

Filed Oct. 28, 1963 4 Sheets-Sheet 2

Fig. 2

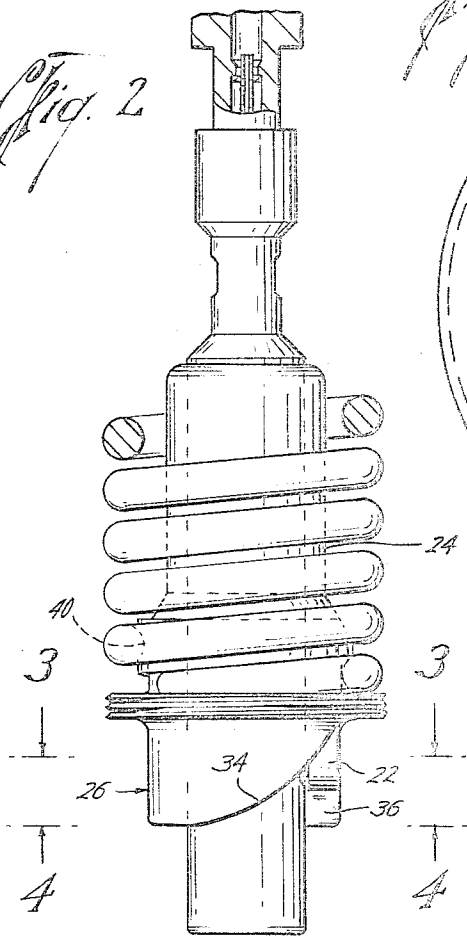


Fig. 4

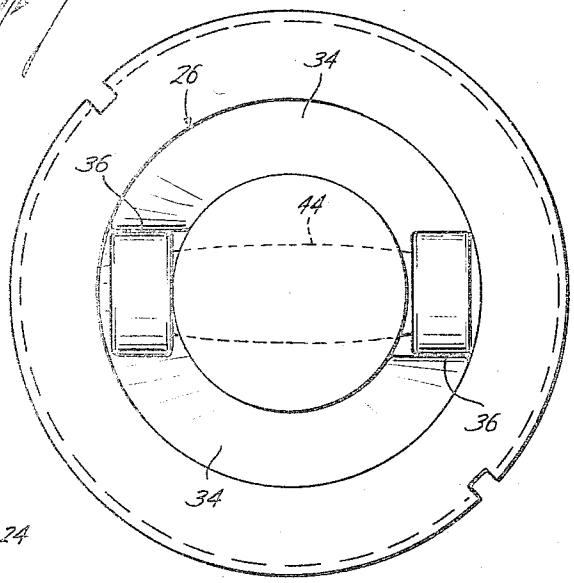


Fig. 3

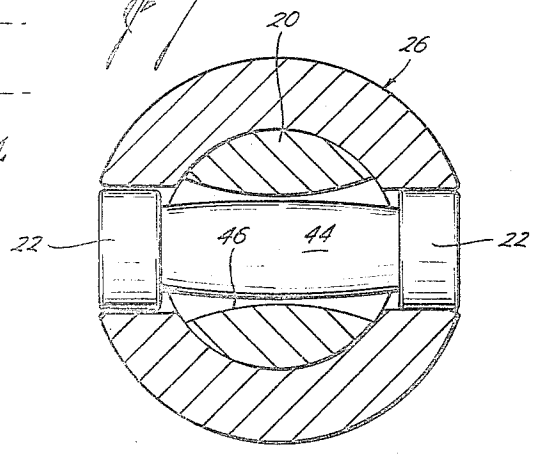
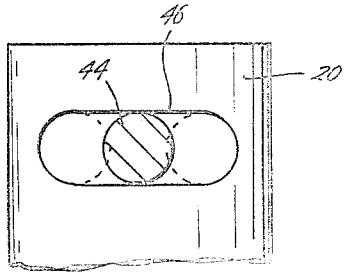


Fig. 5



Jack A. Roll
INVENTOR.

BY James F. Weiler
Jefferson D. Gilley
William G. Stout
Paul L. DeVorte II
ATTORNEYS

Feb. 7, 1967 J. A. ROLL 3,302,732

IMPACT TOOL

Filed Oct. 28, 1963 4 Sheets-Sheet 3

Fig. 6

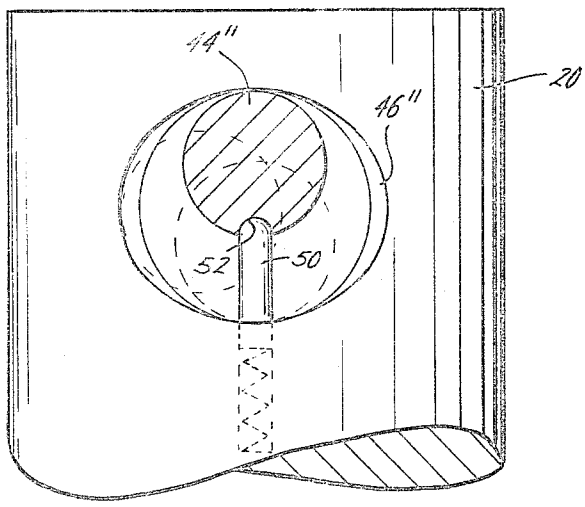
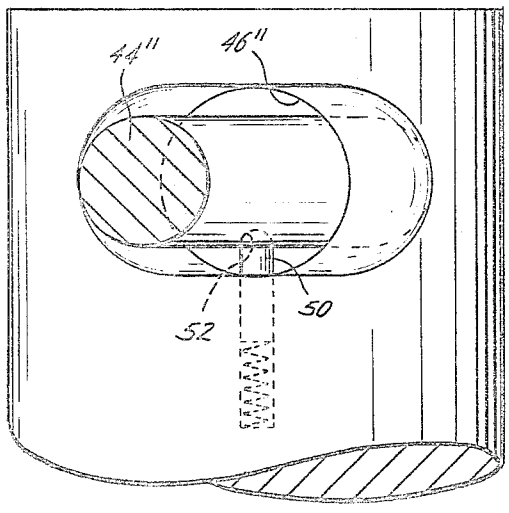


Fig. 7



Jack A. Roll
INVENTOR.

BY James F. Wiles,
Jefferson D. Gilles,
William A. Stout
Paul L. De Vester II
ATTORNEYS

Feb. 7, 1967 J. A. ROLL 3,302,732

IMPACT TOOL

Filed Oct. 28, 1963 4 Sheets-Sheet 4

Fig. 8

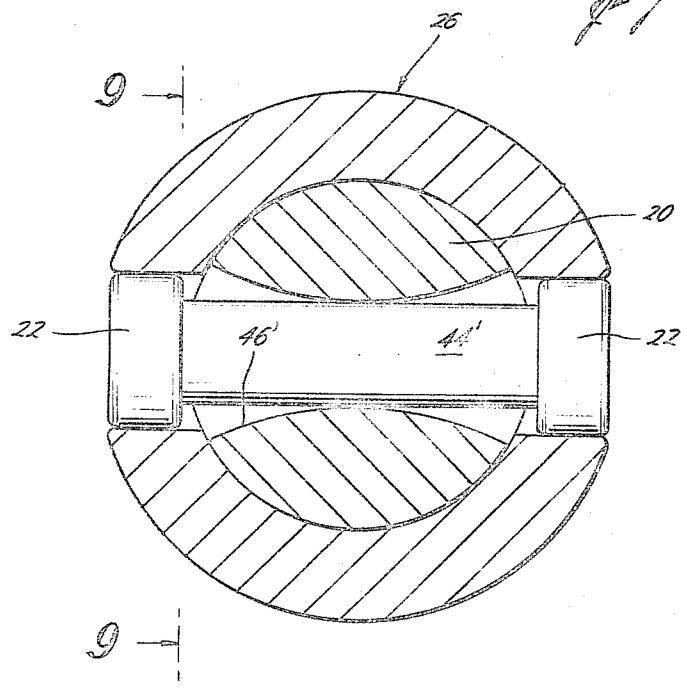
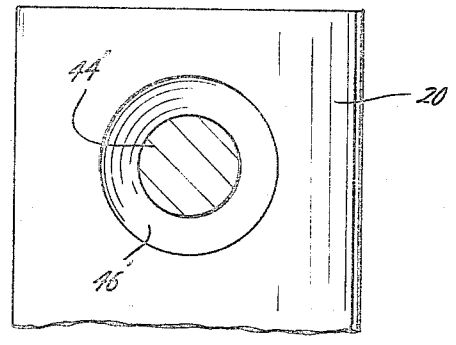


Fig. 9



Jack A. Roll
INVENTOR

BY James D. Wheeler
Jefferson D. Gilliam
William A. Smith
Paul L. DeVoster II
ATTORNEYS

United States Patent Office 3,302,732 Patented Feb. 7, 1967

3,302,732

IMPACT TOOL

Jack A. Roll, Bryan, Tex., assignor, by mesne assignments, to Hughes Tool Company, Houston, Tex., a corporation of Delaware

Filed Oct. 28, 1963, Ser. No. 319,331
10 Claims. (Cl. 173—123)

The present invention relates to improvements in an impact tool, and more particularly relates to improvements in a power rotary actuated hammer using a spring and cam mechanism to convert rotary motion into longitudinal impact motion. The present invention is an improvement to my copending patent application entitled Impact Tool, Ser. No. 142,393, now Patent No. 3,186,498.

The principle of using a spring and cam mechanism to convert rotary motion to that of a longitudinal impact has been used in the past, such as in electric motor hand drill impact hammer attachments and the like. However, this type of impact hammer has been restricted to application requiring relatively small energy transfer. It is a general object of the present invention to provide an impact tool which is operated by a rotary motor and which uses a spring and cam mechanism to provide a longitudinal impact blow and is sufficiently powerful and efficient to provide impacts of sufficient magnitude and rate for heavy duty use, for example, for breaking up very hard formations such as rock, concrete, paving and the like.

However, in the use of a powerful hammer it becomes necessary to provide an efficient mechanism which will provide maximum transmission of the energy stored in the spring each cycle to the impacting mass in order to obtain maximum effectiveness from the tool.

One object of the present invention is a provide a power impact tool in which the power spring is connected to the hammer and cam assembly to resist rotation of the cam and which occur in structures where the hammer is positively restrained from rotation by means such as splines, balls and grooves or by keys and keyways. The structure of supporting the cam and hammer element from a coil power spring assists in obtaining maximum output from the spring in that the cam has the usual inclined surface and axial shoulder portions and as the bearings approach the axial shoulder portion of the cam, just at maximum spring compression, the spring is relieved of the torsional force which is exerted on it as the bearings ride up the cam incline. The spring thereby returns the cam to and beyond its neutral rotational position thereby rotating the axial shoulders out of the way of the bearings allowing the spring to exert maximum acceleration and velocity on the hammer assembly without interference between the bearings and the cam. In addition, the use of the power spring to support and resist the rotation of the cam and hammer assembly reduces the shock to the bearings which ride on the cam surface in that the bearing contact is elastic (both rotationally and laterally) rather than imparting a rigid shock load as the bearings contact the cam surface.

Yet a further object of the present invention is the provision of an improvement to a spring and cam impact tool in the connection of the bearing to the driving shaft. That is the bearings are supported from a support axle which in turn is positioned in a transverse hole in the driving shaft and in which the supporting axle is slightly larger in diameter adjacent its center than on the ends which support the bearings. This structure equalizes the load on each bearing allowing for inaccuracies in the machining of the cam surfaces and the connection of the bearings to the driving shaft.

Still a further object of the present invention is the provision of an improved impact spring and cam type impact tool wherein the bearings are connected to a support axle which in turn is positioned in a transverse hole in the driving shaft, said transverse hole being larger at each end than the ends of the axle. The enlargement of the hole as compared with the ends of the axle allow movement of the support axle in a transverse plane to provide backlash in the movement of the rollers relative to the cam. This backlash permits the bearings to snap forward immediately after the power spring has been compressed to maximum compression to allow the bearings to quickly clear the axial shoulder of the cam surface. Thus the backlash quickly removes any interference between the cam and the bearings to permit the hammer assembly to obtain maximum energy thereby obtaining maximum output from the compressed spring. In addition, the enlargement of the axle hole at each end in a plane passing through the longitudinal axis of the driving axis allows the axle to move to equalize the load on each bearing with a conventional cylindrical axle.

Another object is the provision of a yieldable means connected to the driving shaft and urging the support axle away from the cam surface and which may be used in combination with an enlarged transverse hole to assist in reducing the shock load on the bearings.

Still a further object of the present invention is the provision of an improved impact tool wherein a hydraulic lubricating chamber is provided about the cam surface and cam followers so that these important parts may be provided with a flow of hydraulic fluid for cooling and/or lubrication.

Yet a still further object of the present invention is the provision of an improved impact tool wherein a hydraulic balance within the housing is provided so that a flow of hydraulic fluid under pressure may be passed through the housing without any pressure effect on the hammer thereby providing cooling and/or lubricating the working parts of the hammer mechanism.

Other and further objects, features, and advantages will be apparent from the following description of a presently preferred embodiment of the invention, taken in conjunction with the accompanying drawings, and in which like character references dseignate like parts throughout the several views, and where,

FIGURE 1 is an elevation view, in cross section, illustrating a power impact tool according to the present invention,

FIGURE 2 is an enlarged fragmentary view showing the coaction of the hammer assembly and driving mechanism and the spring support,

FIGURE 3 is an enlarged cross sectional view taken along the line 3—3 of FIGURE 2,

FIGURE 4 is an enlarged cross sectional view taken along the line 4—4 of FIGURE 2,

FIGURE 5 is a diagrammatic elevational view illustrating the transverse movement of the bearing axle to provide backlash,

FIGURE 6 is an enlarged cross sectional view illustrating the normal position of the bearing axle when utilizing an enlarged axle hole,

FIGURE 7 is an enlarged cross sectional view illustrating the position of the bearing axle of FIGURE 6 as the bearings move up the cam incline,

FIGURE 8 is an enlarged cross-sectional of another modification of the bearing axle and support hole similar to FIGURE 3, and

FIGURE 9 is a cross-sectional view taken along the line 9—9 of FIGURE 8.

Referring now to the drawings, and particularly to FIGURE 1, the power impact tool of the present invention is generally designated by the reference numeral 10

and includes a housing **12**. The tool **10** may be powered by any convenient rotary motor, but preferably a hydraulic motor is used as will be presently described. In this event, the handles **14** may include a conventional valve control (not shown) for controlling the rate of flow of hydraulic fluid to the hydraulic motor **18** from any suitable source.

The housing **12** generally encloses the various working components of the power tool. Generally, the impact tool includes the rotary motor **18** which rotates a driving shaft **20** and includes a pair of bearing cam followers **22**. A spring **30** acts against the hammer assembly **24** to urge assembly **24** downwardly into impact such as with a tappet member **32**. Thus, as the driving shaft **20** is rotated the followers **22** roll along a cam surface which includes as best seen in FIGURES 1, 2 and 4, an inclined surface **34** and an axially aligned shoulder **36** for each follower **22**, and alternately moves the hammer assembly **24** against and compressing spring **30** and subsequently releasing assembly **24** allowing the spring **30** to provide a longitudinal impact.

The above described impact tool is generally described in my copending Patent No. 3,186,498. In order to utilize the present impact tool for heavy duty and to provide a powerful impact blow it is necessary that the tool obtain as much as possible of the energy stored in the spring **30** on the compression stroke out of the spring on the impact stroke to provide an efficient apparatus. In addition, it is necessary that the parts not be subjected to shock and/or impact stresses of such magnitude so as to cause failure or fatigue of the structure.

One feature of the present invention is the use of the power spring **30** as the means to support and to resist rotation of the hammer assembly **24**. Generally, the hammer assembly **24** is positioned in the housing **12** for limited axial movement relative to the shaft **20**. And as the cam followers **22** ride upon the inclined cam surfaces **34** of the cam element **26** the hammer assembly **24** is moved upwardly compressing or cocking the spring **30** until the followers **22** move off of the axial cam shoulders **36** thereby allowing the power spring **30** to move the hammer assembly **24** downwardly and provide an impact blow. Of course, as the cam followers **22** ride up the inclined cam surfaces **34** they tend to cause the cam **26** and the hammer assembly **24** to rotate in one direction and as they move off of the cam shoulders **36** tend to cause the hammer assembly **24** to rotate in the opposite direction. Generally, this rotation of the hammer assembly **24** has been restricted by devices such as splines, keys and keyways, or balls and grooves between the hammer assembly **24** in the housing **12** to prevent this rotation. However, this has resulted in a loss of power caused by the friction of these guides as the hammer assembly **24** is longitudinally moved and by the interference between the followers **22** and the axial cam shoulders. However, by supporting the hammer assembly **24** from the spring **30** the frictional and interference losses caused by rotation preventing guide means between the hammer element **24** and the housing **12** are avoided. Thus, as best seen in FIGURES 1 and 2, the spring is secured at a first end to the housing **12** and is secured at a second end to the hammer assembly **24**. While any desired means of connection may be used, it has been satisfactorily found that the ends of the spring **30** may be screwed into a threaded connection **40** and **42** on the hammer assembly **24** and on the housing **12**, respectively. It has been found that the thereaded connection to the spring **30** will securely hold the hammer assembly **24** to the spring. That is, the spring **30** tends to unwind as it is screwed on thereby readily allowing such a connection. But any attempt to unscrew the spring tends to tighten the coil on the threaded connection. In addition, the support of the hammer assembly **24** by the spring **30** reduces the shock to the bearing followers **22** as their impact against the cam surfaces is elastic

rather than rigid. Furthermore, the use of the spring support **30** for the hammer assembly assists in obtaining an increased impact in that it allows the cam **26** to rotate out of the way of the bearings **22** after maximum spring compression. That is, when the cam followers **22** reach the top of the cam incline the spring **30** is relieved of torsional force in one direction caused by the followers **22** moves against the inclined surfaces **34** and thus tends to quickly release the hammer assembly **24** for maximum acceleration ad velocity of the impacting mass.

Another feature of the present invention is the provision of a movable support axle **44** for connecting the bearings **22** to the driving shaft **20**. Since the bearing followers **22** must compress the spring **30** as they rotate over the cam **26** they are subjected to heavy loads and impact because of the power and speeds involved. Referring specifically to FIGURES 1, 3, and 4 the movable axle **44** is positioned in a transverse support hole **46** in the driving shaft **20**. Preferably, the axle **44** is barrel shaped, that is slightly larger in diameter in its center than at its ends which support the bearing followers **22**. This allows the axle **44** to move in the supporting hole **46** and equalize the load on the bearings **22** thus allowing for slight inaccuracies in either the machining of the cam surfaces or in the connection of the cam followers **22** to the driving shaft **20**. Another feature and advantage of making the axle **44** barrel shaped is that it will provide artificial backlash so as to more quickly release the cam **26** and thus the hammer assembly **24** as the bearing followers **22** rotate over the axially aligned shoulders **36**. That is, it is to be noted that because of the barrel shape of the axial **44** that the axle **44** and thus the bearing followers **22** are able to rotate about the longitudinal axis of the driving shaft **20**. Thus, as the cam rollers are rotated up the inclined surfaces **34** of the cam they and the axle **44** tend to rotationally move and lag behind the direction of the rotation of the driving shaft **20**. However, as soon as they reach the axially aligned shoulders **36** and thus are no longer traveling up the inclined surface of the cam there is no force component tending to cause them to lag behind the driving shaft. On the contrary as they contact the axially aligned shoulders **36** they are caused to rotate forwardly relative to the direction of movement of the drive shaft **20**. This artificial backlash allows the bearings **22** to move more quickly over the axially aligned shoulders **36** thereby quickly releasing the hammer assembly and allowing the power spring **30** to exert its maximum acceleration and velocity and to obtain a maximum output from the spring **30**. This artificial backlash prevents the bearings **22** from merely rolling down the shoulders **36** thereby allowing the spring **30** to uncoil a distance of one-half the bearing diameter with a consequent loss of power.

In order to increase the artificial backlash in one modification the support hole **46** in the driving shaft **20** which encloses the bearing axle **44** may be flared outwardly from the center toward each end in a transverse plane as best seen in FIGURES 3 and 5 to provide a "wobble" hole. Thus, the flared or "wobble" hole **46** in combination with the axle **44** permits the bearings **22** to snap forwardly prior to reaching the axially aligned shoulders **36** on the cam surface, at the point of maximum power spring compression, thereby removing the interference between the cam and the bearings **22** permitting the hammer assembly **24** to obtain maximum velocity and energy and to obtain maximum power output from the spring **30**. Referring to FIGURE 5, the solid outline of axle **44** shows its normal position and the dotted outlines show the outer extreme positions which axle **44** may take to provide this backlash or snap action. Without the backlash feature, the bearings **22** would roll over the drop-off shoulders **36** of the cam as they are rotated by the driving shaft **20** and restrain the forward axial movement of the

hammer assembly 22 to a certain extent thereby resulting in a loss of power.

Of course, the amount of backlash needed will depend to some extent on the flexibility of the spring if it supports the hammer assembly as shown in FIGURES 1 and 2. That is, if the spring 30 is flexible enough to rotate the hammer assembly 24 and cam 26 a distance of one-half the diameter of the followers 22 as the followers reach the position of maximum spring compression no additional backlash is needed as there would be no interference between the bearings and the cam.

In addition, in another modification as best seen in FIGURES 8 and 9, the opening 46' may be dimensioned slightly larger at its ends than the diameter of the axle 44' at its ends in a plane passing through the longitudinal axis of the driving shaft. This may be used to allow the axle 44' to move to equalize the load on each bearing 22 instead of using a barrel shaped axle.

Referring now to FIGURE 6, and still a further modification, the normal position of the bearing axle 44" with reference to an exaggerated enlarged diameter hole 46" having flared ends is best seen. This is the position of the axle 44" prior to the time that the bearings 22 make contact and start up the inclined surface 34 of the cam 26. However, as previously mentioned as soon as the cam followers 22 contact the inclined surfaces 34 the cam bearings 22 and the axle 44" will lag behind the driving shaft 20 in the direction of rotation of the driving shaft 20, because of the outwardly flared ends of hole 46". Assuming that the hole 46" is larger in diameter than the bearing axle 44", the normal position of axle 44" with reference to the enlarged hole 46" is best seen in FIGURE 6. At that time the axle 44" will move in the opening 46" to a position away from the cam because of the difference in size of the hole 46" and the axle 44". However, as soon as the bearings 22 contact the inclined surfaces 34 of the cam the axle 44" and the bearings 22 will move to a "lag" position behind the direction of rotation of the driving shaft 20. Then the axle 44" will move to the position shown in FIGURE 7 relative to the enlarged hole 46". Since the bearings 22 and the axle 44" are not rigidly attached to the driving shaft 20 they are allowed to move from the position in FIGURE 6 to the position shown in FIGURE 7 when the bearing contacts the cam surface 34 and thereby obtain a slight time delay or cushioning effect to prevent impact and shock loads on the bearings 22 as they start up the inclined surfaces 34 of the cam. A pin 50 is used in combination with the enlarged hole 46" positioned in the driving shaft 20 along the longitudinal axis as best seen in FIGURES 1, 6 and 7. Pin 50 acts against pin notch 52 in the bearing axle 44". The pin 50 serves to radially align the axle 44" in the enlarged hole 46" and also yieldably urges the axle 44" by reason of a shock spring 54 acting to normally position the axle 44" as shown in FIGURE 6. Thus it is also noted that the shock spring 54 aids in reducing the shock to the bearings 22 as they move from the position shown in FIGURE 6 to that in FIGURE 7 when they first contact and start up the inclines 34 of the cam 26.

The hammer assembly which includes an impact element 28 is positioned to strike a tappet 32 as it is accelerated downwardly by the action of the compression spring 30 when the hammer assembly 24 is released to provide the longitudinal output impact. A nose cone 60 forms part of the housing 12 and encloses the lower end of the assembly thereby locking the tappet member 32 in place. Bit holding means 62 may be provided to releasably hold any suitable bit (not shown) within the nose cone 60 of the impact hammer and is positioned whereby the tappet 32 is directed against the head of the bit. Of course, the tappet 32 may be omitted and the bit may be directly actuated by the hammer element 28. While the housing 12, its closure members, its nose cone 60 and motor enclosure 67 may be connected in any suitable manner it has been convenient to provide bolts 69, nuts 72, and shock springs 74 to perform this function.

Referring again to FIGURE 1, the structure herein shown permits the flow of hydraulic fluid to be passed through a portion of the housing 12 when the impact tool is operating under conditions where it might be desirable to use the hydraulic fluid from the hydraulic motor 18 to circulate through the housing structure for cooling and/or lubricating purposes. Thus, an inlet port 76 and outlet port 78 are provided in the housing 12 whereby suitable hydraulic connections such as from the hydraulic motor 18 may be provided to permit the flow of hydraulic fluid under pressure through a cooling chamber 82. However, in order to provide a hydraulic balance in the tool and to prevent any adverse pressure effect on the hammer by the hydraulic fluid, a hammer assembly extension 80 is provided which extends around the shaft 20 and telescopically extends out of the chamber 82. The outer diameter of extension 80 is sized the same as the outer diameter of the hammer striking element 28 thereby eliminating volume changes and permitting a hydraulic balance in the cooling chamber 82 as the hammer assembly 24 is reciprocated in the chamber 82. Both the extension 80 and the hammer element 28 are sealed as they pass out of the chamber 82 by the conventional use of the "O" rings.

Referring still to FIGURE 1, the hammer assembly 24 may include a lubricating chamber 84 which may be filled with a suitable lubricant to enclose the cam surface and the cam followers 22. In addition hydraulic fluid from the hydraulic motor 18 may be circluated through the chamber 84 for both cooling and/or lubricating purposes. Thus an inlet tube 86 is in fluid communication with the inlet port 88 of the hydraulic motor 18 whereby fluid may be pumped down through the shaft 20 through a passageway 90. Return flow of fluid from the chamber 84 flows through a passageway 92 and through passageway 94, which is coaxially spaced with reference to tube 86, whereby the fluid may flow to hydraulic motor outlet 96. Thus a continuing flow of hydraulic fluid may pass through the lubricating chamber 84 to lubricate and/or cool the cam surfaces and the cam followers 22.

In operation, a suitable hydraulic source (not shown) is connected to the hydraulic motor 18 which when rotated rotates the driving shaft 20 as is conventional. The rotation of the shaft 20 consequently rotates the bearing followers 22 which coact with the cam 26 thereby moving the hammer assembly 24 longitudinally and compressing the spring 30. As the bearing followers 22 rotate over the axially aligned cam shoulders 36 (FIGURES 2, 3 and 4), the entire hammer assembly 24 is released and the energy built up in the spring 30 accelerates the hammer assembly 24 downwardly to provide an impacting blow. Thus, the hammer element 28 is driven against the tappet 32 which in turn contacts and impacts a suitable bit (not shown).

It is noted that the hammer assembly 24 is supported from the power spring 30. Thus, the power spring yieldably resists rotation of the cam 26 and the hammer assembly 24 but yet does not restrict longitudinal acceleration of the hammer assembly 24 such as positive guide means as keys and keyways. The support by the power spring 30 of the hammer assembly 24 assists in obtaining a maximum output from the power spring 30 in that it allows the cam 26 to snap to some extent out of the way of the bearings 22 before they pass the axially inclined shoulder cam surfaces 36 to provide a snap effect and quickly relieve the spring 30 and the hammer assembly 24 of any restraint. In addition, the spring support also reduces the shock to the bearings 22 in that as the bearings 22 ride up the inclined surfaces 34 of the cam 26 the contact or impact of the bearings 22 on the cam surface is elastic rather than rigid. This is important in the present device where the bearings 22 are not always in contact with the cam.

It is also noted that the use of a movable connection of the bearing axle **44** to the driving shaft **20** allows the axle **44** to move and equalize the load on each bearing **22** which allows for inaccuracies in the machining of the coacting components. This may be accomplished by the use of a barrel shaped axle **44** or by enlarging the outer ends of the opening **46**.

In addition, the use of the barrel shaped axle **44** permits artificial backlash between the bearings **22** and the cam **26**. And as previously mentioned additional artificial backlash may be provided by enlarging or flaring out the outer ends of the opening **46** which encloses the axle **44**. This artificial backlash, as best seen in FIGURE 5, permits the bearings **22** and the axle **44** to snap forward from their lagging position in which they are placed during the portion of the cycle in which they are placed during the portion of the cycle in which they are traveling up the inclines **34** of the cam surface. However, at the point of maximum spring compression which is usually prior to the abrupt shoulder surfaces **36** of the cam they snap forward to quickly clear the abrupt shoulders **36** permitting the spring **30** to move the hammer assembly **24** forwardly with maximum acceleration and velocity and to obtain the maximum energy output from the spring **30**. Thus, the artificial backlash reduces any period of restraint at the abrupt shoulder which would restrain any forward motion of the spring **30** and hammer assembly **24**.

In addition, the support hole **46''** may be enlarged with regard to the bearing axle **44''** to obtain a cushioning effect as the bearings **22** start up the inclines **34** of the cam. That is, the support hole **46''** is made larger than the diameter of the axle **44''** so that its normal position is as shown in FIGURE 6. However, when bearings **22** contact the inclined surfaces **34** of the cam the bearings **22** and the axle **44''** rotate relative to the driving shaft **20** to lag behind the direction of rotation of the driving shaft and the time delay and movement from the position shown in FIGURE 6 to that shown in FIGURE 7 provides a cushioning effect which reduces the shock of the impact of the bearings **22** as they start the compression cycle. A pin **50** is utilized in combination with the enlarged support hole **46''** to aid in cushioning the bearings **22** as they pick up contact with the cam on the inclined portion **34**. Thus, the pin **50** and shock spring **34** (FIGURE 1) tend to align the axle **44''** about the longitudinal axis of the drive shaft **20** and also tend to position the axle in the opening as shown in FIGURE 6. Thus, on pick up of load and contact of the bearings **22** with the cam surface **34** the shock spring **54** yieldably acts against the axle **44''** to provide a cushion and break the force of the impact on the bearings **22**. In addition, in the modification shown in FIGURES 8 and 9, the opening **46'** may be flared outwardly and the axle **44** will move to equalize the load on the bearings **22** and to provide backlash.

Referring again to FIGURE 1, the provision of a hammer extension **80** substantially equal in cross sectional area to the cross sectional area of the hammer element **28** provides a hydraulic balance within the housing cooling chamber **82** for cooling purposes. This structure thereby permits, even when the hammer assembly **24** is reciprocating within the housing that hydraulic fluid may be passed under pressure through the cooling chamber **82** without any pressure effect on the hammer assembly **24**.

In addition, a lubricating chamber **84** may be provided inside of the hammer assembly **24** through which hydraulic fluid is passed to cool and/or lubricate the cam surfaces and the cam followers.

While a presently preferred embodiment of the invention has been given for the purpose of disclosure, numerous changes in the details of construction and the arrangement of parts may be made which are within the spirit

of the invention and the scope of the appended claims.

What is claimed is:

1. In an impact tool having a housing, a driving shaft mounted in the housing for rotation relative to said housing, a hammer assembly in the housing and positioned about the shaft for axial movement relative to said shaft, a cam connected to the hammer assembly, at least one bearing follower connected to said shaft and positioned to mate with said cam to retract said hammer assembly as the driving shaft is rotated, said cam having an inclined surface and an axially aligned shoulder surface permitting sudden axial travel of the hammer assembly in one direction, a spring in said housing and around the shaft urging said hammer assembly in said one direction to provide an impact, the improvement comprising,

said spring being a coil spring having first and second ends, the first end being connected to the housing, the second end of the spring being adjacent to and acting against the hammer assembly, a threaded connection for threadably receiving at least the first end of the spring, and a shoulder adjacent the threaded connection for limiting the distance the spring can be threaded on said connection.

2. In an impact tool having a housing, a driving shaft mounted in the housing for rotation relative to said housing, at least one bearing follower connected to said shaft, a hammer assembly in the housing and positioned about the shaft for axial movement relative to said shaft, said assembly including a cam member for mating with the bearing and an impact member connected to said cam member, said cam surface including an inclined surface and an axially aligned shoulder surface for coaction with each bearing, a compression spring in the housing and positioned to urge the hammer assembly in one direction, the improvement comprising,

a chamber in said housing surrounding the shaft, a hammer extension member connected to the hammer assembly, said hammer assembly and said extension member extending out of opposite ends of said chamber, said hammer assembly and said extension member at the point of extension from said chamber having substantially equal cross-sectional areas, seal means sealing between the chamber and the hammer assembly and extension member at the point of extension, and

said chamber including an inlet and outlet for providing liquid cooling.

3. In an impact tool having a housing, a driving shaft mounted in the housing for rotation relative to said housing, a hammer assembly in the housing and positioned about the shaft for axial movement relative to said shaft, a cam connected to the hammer assembly, two bearings connected to said shaft and positioned to mate with said cam, said cam including an inclined surface and an axially aligned shoulder surface for coaction with each bearing, a spring in said housing and around the shaft urging said hammer assembly in one direction to provide an impact, the improvement in the connection of the bearings to said shaft comprising,

said shaft having a transverse hole adjacent said cam,

a support axle movably positioned in said hole for supporting said bearings at either end of said support axle,

said support axle being larger in the middle than at its ends by being barrel shaped thereby equalizing the load on each bearing and providing backlash.

4. The invention of claim **3** wherein the transverse hole is enlarged outwardly at each end from the longitudinal axis of the axle in a plane transverse to the longitudinal axis of the shaft thereby allowing additional movement of the support axle in a transverse plane.

5. The invention of claim **3** wherein the transverse hole is sufficiently larger than said support axle to allow movement between the hole and axle and including,

yieldably means connected to said shaft urging said support axle in said one direction.

6. In an impact tool having a housing, a driving shaft mounted in the housing for rotation relative to said housing, a hammer assembly in the housing and positioned about the shaft for axial movement relative to said shaft, a cam connected to the hammer assembly, two roller bearings connected to said shaft and positioned to mate with said cam, said cam including an inclined surface and an axially aligned shoulder surface for coaction with each bearing, a spring in said housing and around the shaft urging said hammer assembly in one direction to provide an impact, the improvement in the connection of the bearings to said shaft comprising,

said shaft having a transverse hole adjacent said cam,

a bearing support axle movably positioned in said hole for supporting said bearings at either end of said support axle,

said transverse hole being substantially larger than the diameter of said support axle to allow the axle to equalize the load on the bearings and to provide backlash.

7. The invention of claim 6 wherein the hole is flared outwardly at each end from the longitudinal axis of the shaft in a plane transverse to the longitudinal axis of the shaft thereby allowing additional movement of the support shaft in a transverse plane.

8. In an impact tool having a housing, a driving shaft mounted in the housing for rotation relative to said housing, a hammer assembly in the housing and positioned about the shaft for axial movement relative to said shaft, a cam connected to the hammer assembly, two roller bearings connected to said shaft and positioned to mate with said cam, said cam including an inclined surface and an axially aligned shoulder surface for coaction with each bearing, a spring in said housing and around the shaft urging said hammer assembly in one direction to provide an impact, the improvement in the connection of the bearings to said shaft comprising,

said shaft having a transverse hole adjacent said cam, a bearing support axle movably positioned in said hole for supporting said bearings at either end of said support shaft,

said transverse hole being substantially larger than the diameter of said support axle to allow the axle to equalize the load on the bearings,

said hole being flared outwardly at each end from the longitudinal axis of the shaft in a plane transverse to

the longitudinal axis of the shaft thereby providing artificial backlash, and

yieldable means connected to said shaft urging said support axle in said one direction.

9. In an impact tool having a housing, a driving shaft mounted in the housing for rotation relative to said housing, a hammer assembly in the housing and positioned about the shaft for axial movement relative to said shaft, a cam connected to the hammer assembly, two bearings connected to said shaft in position to mate with said cam, said cam including an inclined surface and an axially aligned shoulder surface for coaction with each bearing, a spring in said housing and around the shaft urging said hammer assembly in one direction to provide an impact, the improvement in the connection of the bearings to said shaft comprising

said shaft having a transverse hole adjacent said cam,

a support axle positioned in said hole for supporting said bearings at either end of said support axle,

said transverse hole being flared outwardly and enlarged at each end from the longitudinal axis of the axle in a plane transverse to the longitudinal axis of the shaft thereby allowing movement of the support axle in a transverse plane to the driving shaft to provide backlash.

10. The invention of claim 9 wherein the transverse hole is flared outwardly at each end from the longitudinal axis of the support axle in a plane passing through the longitudinal axle of the driving shaft.

References Cited by the Examiner

UNITED STATES PATENTS

652,208	6/1900	Hadfield et al.	74—86
1,505,493	8/1924	Roberts	173—123
2,328,542	9/1943	Bates	74—56
2,442,140	5/1948	Mohr	173—13
2,556,163	6/1951	Buson et al.	173—123
2,741,924	4/1956	Tartwater	173—123
2,819,041	1/1958	Beckham	173—57
3,051,976	9/1962	Dubois et al.	267—1
3,112,964	12/1963	Matthey	308—72
3,169,757	2/1965	Roder et al.	276—1

FRED C. MATTERN, JR., *Primary Examiner.*

BROUGHTON G. DURHAM, *Examiner.*

L. P. KESSLER, *Assistant Examiner.*