Feb. 18, 1969 R. J. SCHAEDLER ET AL 3,428,137

IMPACT WRENCH

Filed Oct. 12, 1967 Sheet 1 of 3

FIG. 1

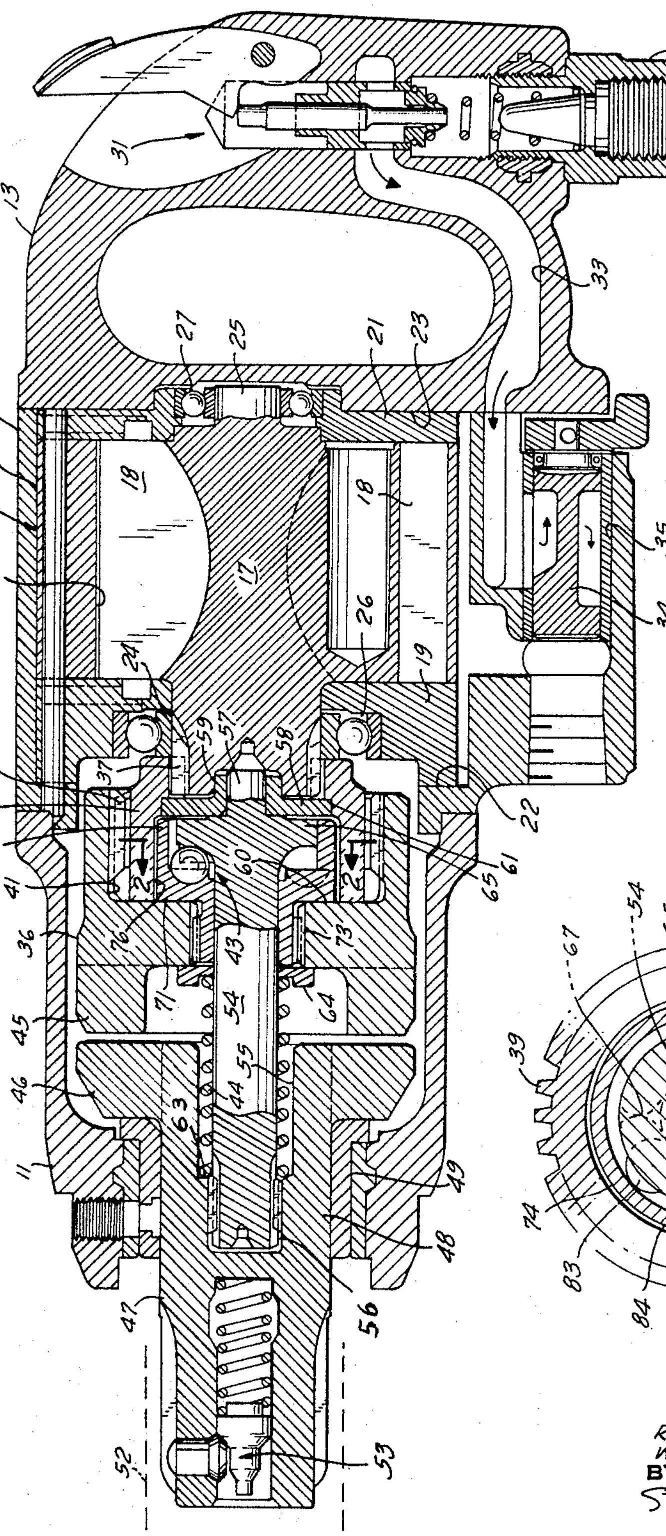

FIG. 2

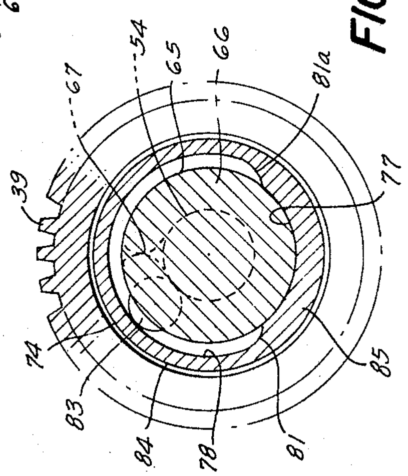

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FIG. 3

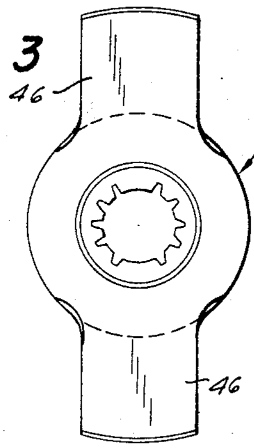


FIG. 4

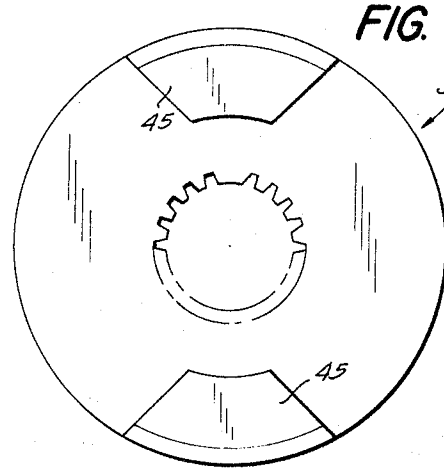


FIG. 11

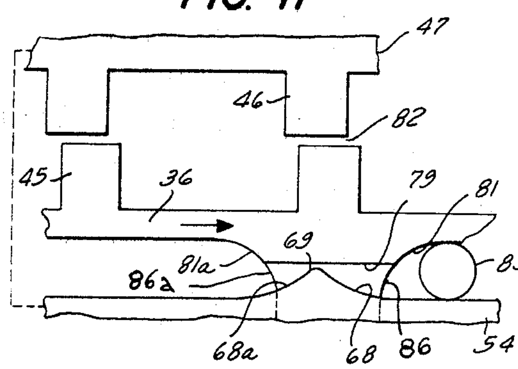
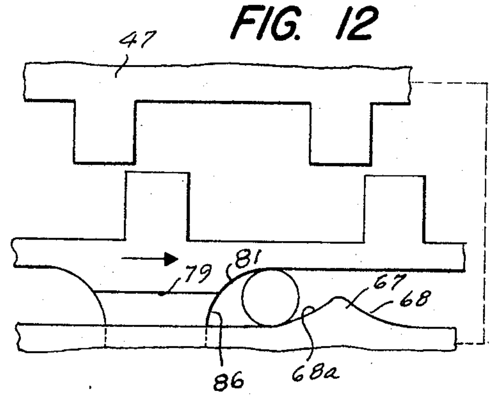


FIG. 12



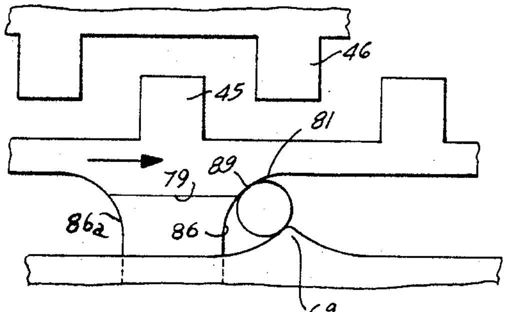


FIG. 13

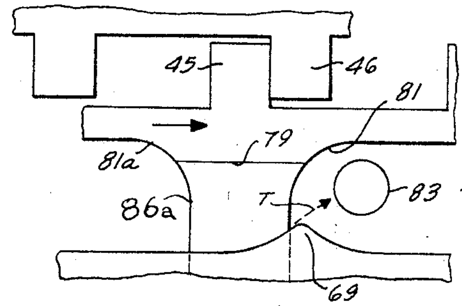


FIG. 14

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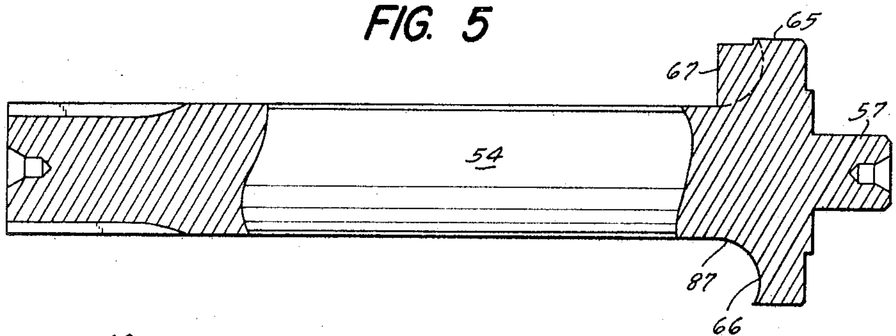
FIG. 5



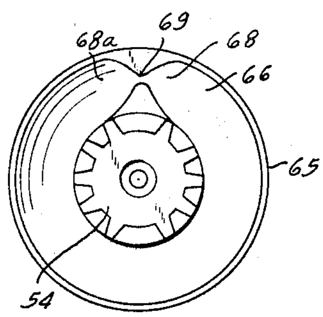


FIG. 6

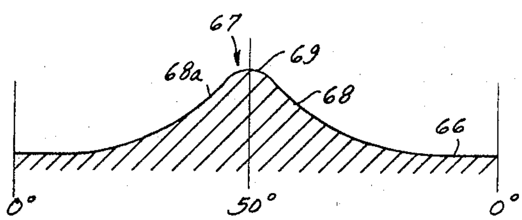


FIG. 7

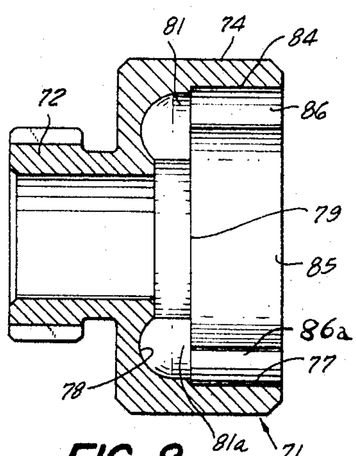


FIG. 8

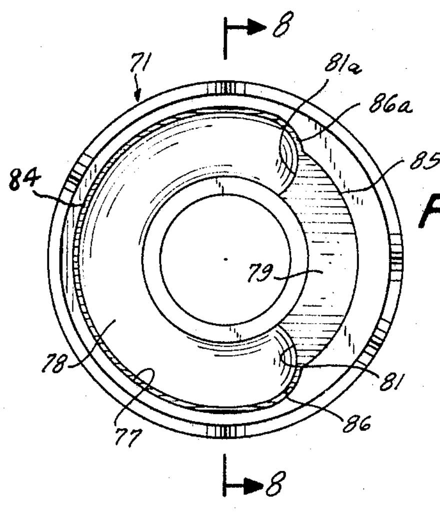
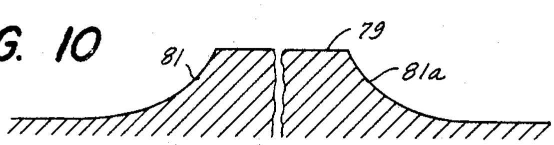


FIG. 9

FIG. 10



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3,428,137
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IMPACT WRENCH

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Filed Oct. 12, 1967, Ser. No. 674,829
U.S. Cl. 173—93.6 14 Claims
Int. Cl. B25d *15/00;* F16d *7/02*

ABSTRACT OF THE DISCLOSURE

A reversible impact wrench having a high ratio of power output relative to its size and weight. The driving shaft of the rotor of the wrench is coupled to a dog-hammer having a recess in its rear in which the coupling is compactly telescoped. The dog-hammer is movable axially relative to the coupling against a return spring by ball cam means into rotary impacting relation with an anvil carrying a wrench socket. This is unlike conventional impact wrenches in which a conventional dog is movable into such impact relation relative to a driving hammer frame of heavy mass. The dog-hammer carries a symmetrical cam as a means of driving selectively in either direction a ball follower about a track relative to a symmetrical cam tooth associated with the anvil. The arrangement is such that the dog-hammer and its cam are cooperable with the ball and cam tooth so that it is axially accelerated clear of the ball during camming action. Because of the nature of the track and cam elements, the ball cannot possibly become trapped between the cam elements upon return of the dog-hammer following impact. If it were to become trapped, the jaws of the dog-hammer and anvil would be subject to possible interlocking and malfunctioning. The wrench also includes means for diverting reactionary thrusts of tool operation from the rotor to the general housing.

Background of the invention

This invention relates to the art of rotary impact wrenches of a type in which a rotating member is periodically reciprocable into and out of rotary impacting relation with an anvil portion of a torque output shaft.

The design of the wrench of the present invention represents a decided technical advance in the art. It is such that the ratio of power output to the size and weight of the wrench is relatively higher than that of conventional wrenches. Because of the improved design, the ratio of torque available to accelerate rotating parts of the wrench compared to the inertia of such parts has been materially increased for a given motor size with consequent increased power output.

These advantages are due primarily to an improved hammer and anvil impacting arrangement from which the conventional heavy rotating hammer frame mass and its associated inertial drag upon the motor have been eliminated. Improvements have also been made in the camming means of the wrench. It includes a rolling ball and cooperating cam track arrangement which functions to

cause highly accelerated axial movement and forceful rotary impacting engagement of a rotating dog-hammer with a torque output anvil member. The elements of the cam track cooperate with one another and with the ball to insure a smooth return of the dog-hammer following an impacting action without interference with the ball. Improvement has also been made in the supporting arrangement of the driving rotor whereby operating thrusts of the impacting elements are diverted to the general housing of the tool and thus prevented from reaching and exerting an undesirable drag upon the rotor.

Summary of the invention

In accordance with the invention, there is provided an impact wrench comprising a rotor drive shaft, a driven torque output anvil means, a dog-hammer drivably connected with the shaft having relative axial movement into and out of rotary impacting engagement with the anvil means, a spring constantly urging the dog-hammer to a normally retracted position out of such engagement, camming means operable as a consequence of rotation of the dog-hammer relative to the anvil means to cause axial movement of the dog-hammer into such engagement against the resistance of the spring, an axial recess in the rear of the dog-hammer having axially extending splines, a coupling relatively lighter in weight than the dog-hammer having an internal driven spline connection at its rear with the drive shaft and having a forwardly extending portion telescoped in the recess having splines with which the splines of the dog-hammer have slidable engagement permitting relative axial movement of the dog-hammer, and means restraining the coupling against axial movement with the dog-hammer.

Brief description of drawing

FIG. 1 is a longitudinal section of an impact wrench embodying the invention;

FIG. 2 is a section on line 2—2 of FIG. 1;

FIG. 3 is a rear end view of the anvil;

FIG. 4 is a front end view of the dog-hammer;

FIG. 5 is a detail of the anvil cam shaft sectioned in part;

FIG. 6 is a left end view of FIG. 5;

FIG. 7 is a profile view of the anvil cam tooth;

FIG. 8 is a detail in longitudinal section of the dog-cam taken on line 8—8 of FIG. 9;

FIG. 9 is a right end view of FIG. 8;

FIG. 10 is a profile view of the land of the dog-cam;

FIGS. 11–14 show in schematic the events of a camming cycle in which;

FIG. 11 shows the relative positions of the camming elements at the start of a cycle;

FIG. 12 shows the position of the ball and dog-cam at the start of the movement of the ball up a slope of the anvil cam tooth;

FIG. 13 shows the position of the cam elements prior to the ball being "shot" over the anvil cam tooth; and

FIG. 14 illustrates the trajectory of the ball upon being "shot" over the anvil cam tooth, and the consequent impacting action of the jaws of the dog-hammer with the jaws of the anvil.

Description of preferred embodiment

The illustrated pneumatically powered impact wrench embodying the invention includes a general housing comprising in order a front section **11**, an intermediate motor section **12** and a live air handle section **13**, all fixed to one another in end-to-end relation.

A motor unit **14** is housed in the intermediate section. It is of a conventional pneumatic reversible type having a stationary liner **15** defining a chamber **16** in which a pneumatically powered rotor **17** is eccentrically arranged. The rotor has the usual radially slidable blades **18** which sweep the wall of the liner as the rotor turns. Opposite ends of the rotor bear upon stationary circular closure heads or end plates **19** and **21** abutting opposite ends of the liner. The front plate **19** is seated upon an annular shoulder **22** of the housing section **12**; the rear plate **21** abuts an overlying annular face **23** of the handle section **13**. The rotor is supported for rotation by means of oppositely extending shaft ends **24** and **25** respectively journaled in bearings **26** and **27**. Bearing **26** is seated in an axial recess of the front plate **19**. Thrusts imparted to this bearing during operation of the tool are transmitted through its outer race to the end plate **19**, and are absorbed by the liner **15** and general housing.

The handle section **13** is fitted with a hand operable throttle valve **31** which is connectible by means of an inlet fitting **32** with an external source of live air. The valve controls flow of operating air through passage means **33** leading to the rotor chamber **16**. The rotor is reversible. A conventional hand controlled reversing valve **34** arranged in a chamber **35** intermediately of the passage means **33** is selectively operable to direct live air to either a positive or negative area of the rotor chamber.

The rotor is drivingly coupled to a cylindrical dog-hammer **36**. In this coupling arrangement, the front shaft end **24** of the rotor has a longitudinally splined driving connection at **37** with an open-ended coupling **39**. The coupling is telescoped in an annular rear recess **41** of the dog-hammer. The coupling has longitudinal external splines with which complementary internal splines provided in the recess of the dog-hammer **36** are slidably engaged, as at **42**, whereby rotation of the rotor is transmitted through the coupling to the dog-hammer, and whereby the dog-hammer is axially slidable relative to the coupling.

Cam means **43** is incorporated in the tool. It is confined in the interior of the coupling **39** within the rear recess **41** of the dog-hammer. Its function is to force the dog-hammer axially against the resistance of a return spring **44** during each revolution of the dog-hammer so as to bring the radial sides of a pair of dogs or jaws **45** projecting axially (FIGS. 1, 4, 14) from a forward wall of the dog-hammer into rotary impacting relation with the sides of a pair of radial jaws **46** of an anvil member **47** (FIGS. 1, 3).

The anvil member **47** is supported for rotation by means of a shank portion **48** in a bushing **49** fixed in the housing section **11**. An external part of the shank is adapted for splined engagement with a wrench socket **52** (broken line). Suitable socket retaining means **53** is provided to retain the socket upon the shank. The socket is designed for engagement with a threaded fastener such as a multi-sided nut or bolt head.

An anvil cam shaft or spindle **54** (FIGS. 1, 5) is seated at one end in an axial recess **55** of the anvil member and is made unitary with the latter by means of a longitudinally splined connection **56**. An axially extending pilot portion **57** at the rear of the cam shaft is journaled in a thrust collar **58**. The latter in turn has a hub **59** journaled in an axial recess of the rotor shaft **24**.

The collar **58** extends radially beyond the rotor shaft so as to abut upon a forward face of an internal shoulder **61** of coupling **39**. The rear end of the coupling abuts the inner race of the thrust bearing **26**. The shoulder **61** spaces the collar **58** slightly clear of the end face of the rotor shaft. By means of this arrangement, the coupling is restrained against axially moving with the dog-hammer; and axial thrusts imparted to the collar during operation of the tool are transmitted to the thrust bearing **26** to be absorbed by the end plate **19**, the liner **15** and the general housing of the tool. The rotor is thus spared from such thrust forces, whereby its useful life is prolonged and the drag which might otherwise be imparted by such thrusts to the rotor is avoided.

The return spring **44** encircles the cam shaft **54**. It is seated at one end against an axially recessed shoulder **63** of the anvil member; and its opposite end presses upon a spring cup **64**. The latter is slidable along the cam shaft and overlies an adjacent forward face of the dog-hammer **36**. The spring acts through the cup **64** to bias the dog-hammer to a retracted normal position, as in FIG. 1, wherein its jaws **45** are disengaged from and are axially clear of the anvil jaws **46**. In this retracted position of the dog-hammer, its recessed back wall **60** abuts the front end of coupling **39**.

The camming means **43** (FIGS. 1, 2, 5–7) includes an annular flange **65** formed upon the cam shaft **54** forwardly of the pilot **57**. The rear face of the flange bears in part upon the thrust collar **58**. An annular groove **66** formed in a forward face of the flange is concentric with the axis of the cam shaft. This groove extends in its radial dimension to the periphery of the flange. The groove is interrupted in its continuity by means of a cam tooth **67** projecting axially substantially to the extent of the radius of the groove. Tooth **67** is defined by a pair of symmetrical slopes **68** and **68*a*** culminating in a small outside radiused crest **69**.

The camming means **43** further includes (FIGS. 1, 2, 8–10) an annular hammer cam element **71**. The latter is sleeved upon the cam shaft **54** for relative rotation and axial sliding movement. It has a cylindrical stem **72** made unitary with the dog-hammer by means of a longitudinally splined axial connection **73** internally of the dog-hammer. The dog-hammer and the hammer can have axial and rotative movement as a unit. Rearwardly of the stem **72**, the hammer cam has an annular enlarged body **74** which abuts the recessed back wall **60** of the dog-hammer and is fully received within the interior of a forward portion or skirt **76** of the coupling **39** in the retracted condition of the dog-hammer, as in FIG. 1. The body **74** is provided with a recess **77** in its rear, the side wall of which surrounds the flange **65** of the cam shaft. The bottom of recess **77** is formed with an annular groove **78** (FIGS. 2, 8, 9) which is interrupted in its continuity by means of a flat crest or land **79**, the axial projection of which corresponds to the radius of the groove **78**. The ends of the groove, which are also the ends of land **79**, are defined by means of a pair of symmetrical inside radiused shoulders **81** and **81*a*** which are longer in their incline than the slopes **68**, **68*a*** of the anvil cam tooth **67**. Groove **78** extends for about 240° and is in parallel opposed concentric relation to the groove **66** formed in the cam shaft flange **65**. The land **79** extends for about 120°.

The opposed grooves **86** and **78** define between them (FIGS. 1, 2, 8–14) a ball track in which a steel ball **83** rolls. The inner diameter of the track is defined by the periphery of the cam shaft **54**. The outer diameter of the track is defined by an arcuate wall segment **84** defining a portion of the side wall of the recess **77** of the hammer cam body. The land **79** is backed by an arcuate wall segment **85** defining a further portion of the side wall of recess **77**. The inner radius of wall segment **85** is relatively less than that of segment **84** so that wall **85** is relatively thicker and projects radially inwardly of the outer edge of groove **78**, as best appears in FIG. 9. The ends of the segment **85** are in axial extension of the end shoulders **81** and **81*a*** so as to provide stops **86** and **86*a*** for the corresponding ends of the ball track, which stops together with the shoulders **81** and **81*a*** define the limits of angular travel of the ball relative to the hammer cam. The inner wall surface **85** of the hammer cam bears upon the periphery of flange **65** for relative rotation.

In this arrangement of the cam elements, the ball **83** is caused to be pushed about the track by means of one or the other of the shoulders **81** or **81***a* of land **79**, accordingly, as the dog-hammer rotates in one direction or the other. In the fully retracted condition of the dog-hammer, the land **79** and the cam tooth **67** are axially spaced from one another by a slight clearance, as at **82** in FIG. 11, so that the one will not strike the other during relative rotation. This spacing is determined by means of the axial length of coupling **39** which lies in abutment with the recessed back wall **60** of the dog-hammer.

When the anvil cam shaft **54** is stationary, as it will be when the work offers a predetermined degree of torque resistance, the hammer cam **71** rotates under the drive of the dog-hammer relative to flange **65** and one of the shoulders **81** or **81***a* pushes the ball **83** about the track. Eventually, the ball is forced up and "shot" over the crest **69** of the cam tooth **67** into the ball track beyond the cam tooth, the trajectory of the ball being indicated by the arrow T in FIG. 14. The dog-hammer attains a high velocity as it rotates. At the time the hammer cam is forcing the ball over the cam tooth, the hammer cam together with the dog-hammer are being cammed axially as a unit relative to the flange **65** of the cam shaft against the resistance of the spring **44** to bring the sides of the dog-hammer jaws **45** into forceful rotary impacting relation with the sides of the anvil jaws **46**. In this camming action, the dog-hammer is caused to move axially at high acceleration clear of the ball because of the high velocity of rotation of the dog-hammer. The axial depth of possible engagement of the jaws of the dog-hammer with those of the anvil is such that the side wall **84** of the body **74** of the hammer cam will never move axially free of the coupling **39**. Accordingly, the ball is at all times during its rolling movement confined in the ball track. The stops **86** and **86***a* defined by the radially thickened portion **85** at the back of the land **79** prevent the ball from rolling out of the groove **78** onto the land as the cam elements separate. Accordingly, the ball is confined at all times in the extent of its rolling movement to the limits of the hammer cam groove **78**.

Immediately following impact, the spring **44** re-expands to retract or return the dog-hammer and hammer cam as a unit to normal position, and rotation of the hammer continues as before to again drive the ball about the track for a repeat camming action. Since there is a slight looseness between the ball and opposed surfaces **87** and **84** respectively of the cam shaft and the surrounding wall of the hammer cam body, the ball rolls freely about the track following its movement over the cam tooth **67**. The force with which the ball is "shot" over the cam tooh may carry it completely around the ball track. However, as mentioned earlier, it will be limited in this movement by either the stop **86** or **86***a* so that it cannot possibly roll out of the groove **78** to become trapped axially between the land **79** and the bottom of groove **66** of flange **65** when the dog-hammer is returned. If it were to become trapped, the jaws of the dog-hammer and anvil would be subject to possible interlocking and malfunctioning.

As earlier mentioned, thrusts imparted by the returning dog-hammer and hammer cam respectively to the coupling **39** and thrust collar **58** are transmitted through the inner race of the thrust bearing **26** to be absorbed by the end plate **19**, liner **15** and the general housing of the tool. Similarly, thrusts imparted by the cam shaft **54** to the thrust collar **58** are also transmitted to the thrust bearing **26** to be absorbed by the general housing. Accordingly, very little of the thrusts developing during operation of the tool are transmitted to the rotor.

The coupling **39**, being positioned between the bearing **26** and the recessed wall **60** of the dog-hammer, determines the returned position of the latter. This returned position is such that the ball **83** is not under axial compression between the bottoms **78** and **66** of the ball track so that the ball has a slight axial looseness in the track. This is of advantage in that the coupling is caused to receive the thrusts of the dog-hammer as the latter returns following an impacting action and prevents such thrusts from being transmitted to the ball.

FIGS. 11–14 schematically illustrate in greater detail the events of the camming action. The dog-hammer **36** is indicated in FIG. 11 as rotating in a positive direction. The ball **83** has obtained a position at the base of a shoulder **81** of the hammer cam and is being pushed around the ball track preparatory to a camming action.

Eventually, the ball will attain the position shown in FIG. 12 at the base of the rear slope **68***a* of the anvil cam tooth **67**. As the hammer cam continues rotating, it rolls the ball up the slope **68***a* and in doing so is itself cammed or forced axially away to carry the dog-hammer with it. The dog-hammer and hammer cam are at this time rotating at high velocity. At about the time the ball attains the position shown in FIG. 13, it will be upon the starting or initial portion of the outside radius or the crest **69** of the cam tooth and it will be engaged at a diametrically opposed area by the high end **89** of the inside radius area of the hammer cam shoulder **81**. In this position, the ball will be loaded under opposed non-parallel surfaces. Upon this condition being obtained, the ball is "shot" or forcefully slipped over the crest **69** of the cam tooth **67** by the shoulder **81** of the hammer cam in a trajectory path indicated by the arrow T in FIG. 14; and simultaneously the hammer cam and dog-hammer rotating at this time at high velocity are accelerated axially as a unit to impact the jaws **45** of the dog-hammer with those **46** of the anvil. In this action, the hammer cam moves axially clear of the ball and the ball rolls forwardly and freely beyond the cam tooth **67** into the ball track. The extent of axial movement of the dog-hammer relative to the cam tooth is such as to carry the land **79** a distance from the cam tooth **67** substantially greater than the diameter of the ball. Immediately following impact, the hammer cam and dog-hammer are axially returned by spring **44** out of impacting relation; and forward rotation of the hammer cam and dog-hammer is resumed. As rotation is resumed, the land **79** of the hammer cam is carried clear over the crest **69** of the cam tooth and eventually the forward shoulder **81** of the hammer cam re-engages the ball as in FIG. 11 to again roll it about the track preparatory to a repeat impacting action.

When the dog-hammer is operating in a negative or reverse direction, the other shoulder **81***a* of land **79** functions to push the ball about the track toward the other slope **68** of the anvil cam tooth **67**.

It is to be also noted that the dog-hammer replaces the usual heavy elongated hammer frame mass and slidable dog combination known from conventional prior art devices. Thus a tool of relatively lighter weight is provided. The elimination of the heavy hammer frame mass avoids the attendant inertial drag of the mass upon the rotor. Its elimination also enables a more compact and axially shorter overall housing to be employed, as indicated in the present invention.

What is claimed is:

1. An impact wrench comprising a rotor drive shaft, a driven torque output anvil means, a dog-hammer drivably connected with the shaft having relative axial movement into and out of rotary impacting engagement with the anvil means, a spring constantly urging the dog-hammer to a normally retracted position out of such engagement, camming means operable as a consequence of rotation of the dog-hammer relative to the anvil means to cause axial movement of the dog-hammer into such engagement against the resistance of the spring, an axial recess in the rear of the dog-hammer having axially extending splines, a coupling relatively lighter in weight than the dog-hammer having an internal driven spline connection at its rear with the drive shaft and having a forwardly extending skirt telescoped in the recess provided with splines with which the splines of the dog-hammer have slidable engagement permitting relative axial movement of the dog-hammer, and means restraining the coupling against axial movement with the dog-hammer.

2. An impact wrench as in claim 1, wherein a thrust bearing supports the drive shaft for rotation, a forward end of the coupling abuts the bottom of the recess in the retracted condition of the dog-hammer, a rear end of the coupling constantly abuts the thrust bearing, and a rotor housing supports the thrust bearing, the thrust bearing being the sole abutment blocking rearward axial movement of the coupling relative to the drive shaft so that axial thrusts imparted to the coupling by the dog-hammer under the urging of the spring are transmitted primarily to the thrust bearing and rotor housing and away from the drive shaft.

3. An impact wrench as in claim 1, wherein the anvil means includes a spindle extending axially rearward through the dog-hammer into the interior of the skirt of the coupling having an annular flange disposed in said interior, and the camming means is confined between the flange and the bottom of the recess of the dog-hammer.

4. An impact wrench as in claim 3, wherein the camming means includes a cam element carried by the dog-hammer within its recess, a ball track defined between the cam element and the flange of the anvil means, a symmetrical cam tooth on the flange projecting axially into the track, a ball rollable about the track, and an arcuate land having symmetrical inside radiused shoulders at its ends extending axially from the cam element into the ball track, one of the shoulders having driving cooperation with the ball as the dog-hammer rotates in a selected direction relative to the anvil means so as to force the ball about the track and over the cam tooth and as a consequence force the dog-hammer axially against the resistance of the spring.

5. An impact wrench as in claim 4, wherein the cam element is arranged relative to the flange so that the land lies at all times in a plane axially clear of the cam tooth.

6. An impact wrench as in claim 5, wherein the cam element has unitary axial movement with the dog-hammer sufficient to carry the land of the cam element an axial distance from the cam tooth which is greater than the diameter of the ball.

7. An impact wrench as in claim 6, wherein the ball track is defined by an annular groove in the cam element interrupted by the land and by an opposed parallel annular groove in the flange interrupted by the cam tooth in which ball track the shoulders at the ends of the land define the limits of rollable movement of the ball about the track.

8. An impact wrench as in claim 7, wherein the cam tooth has a crest defined by a small outside radius, a high end of the driving shoulder of the cam element is adapted to have engagement with the ball when the ball attains a position upon the initial portion of the outside radius of the cam tooth in which position the relative surfaces of the driving shoulder and the outside radius engaging the ball are non-parallel, so that upon continued rotation of the cam element relative to the ball and cam tooth the ball is caused to be thrown forwardly and axially over and beyond the crest of the cam tooth, and the dog-hammer is caused to be simultaneously cammed axially and centrifugally accelerated into engagement with the anvil means.

9. An impact wrench comprising anvil means having impact receiving radial jaws and an axially extending spindle provided with a cam flange, a spring upon the spindle forwardly of the cam flange, a rotary dog-hammer reciprocable axially along the spindle between the cam flange and spring against the resistance of the spring to carry radial jaws on a face thereof into rotary impact with the jaws of the anvil, and camming means operable as a consequence of rotation of the dog-hammer relative to the anvil means to force the dog-hammer axially into such impacting relation; wherein the camming means includes a ball track defined in part by an annular groove in the cam flange interrupted by a symmetrical cam tooth having an outside radiused crest projecting axially into the ball track, and in part by an annular opposed groove in the dog-hammer interrupted by a land having symmetrical inside radiused end shoulders, a ball rollable about the track by means of a selected one of the shoulders as the dog-hammer rotates in a certain direction relative to the anvil means, the ball being adapted to attain a position on a rearward portion of the crest of the cam tooth under the drive of the selected shoulder and also on the selected shoulder adjacent the land, in which position the opposing contacting surfaces of the crest of the cam tooth and the selected shoulder upon the ball are non-parallel so that the components of force acting upon the ball by the drive of the selected shoulder are directed forwardly in the direction of rotation of the selected shoulder and axially outward relative to the cam tooth, and the dog-hammer having a range of axial movement relative to the cam tooth which exceeds the diameter of the ball.

10. An impact wrench as in claim 9, wherein the land lies in a plane spaced at all times axially clear of the cam tooth, and the end shoulders of the land define the limits of the ball track.

11. In an impact wrench including a driven torque output anvil means, a rotating driving hammer having axial movement into and out of rotary impacting relation with the anvil means, and a spring urging the hammer to a normally retracted condition out of such impacting relation, camming means operable as a consequence of rotation of the hammer to cause periodic axial movement of the hammer into such impacting relation against the resistance of the spring, the camming means comprising a hammer cam element coupled with the hammer, an anvil cam element coupled with the anvil means arranged in opposed relation to the hammer cam element, a ball track defined between the hammer and anvil cam elements, an arcuate land projecting axially from the hammer cam into the track, a cam tooth projecting axially from the anvil cam into the track, a ball rollable about the track, shoulder means at opposite ends of the land limiting at all times the extent of angular movement of the ball relative to the hammer cam element, one of the shoulder means having driving cooperation with the ball as the hammer rotates in a selected direction so as to force the ball about the track and over the cam tooth and as a consequence force the unitary hammer cam element and hammer axially against the resistance of the spring, the hammer cam element having axial movement with the hammer relative to the anvil cam element which exceeds the diameter of the ball permitting free rolling movement of the ball in the ball track following its movement over the cam tooth, and wall means carried by the hammer cam element at all times circumferentially bounding the track so as to confine the ball in the track.

12. In an impact wrench as in claim 11, wherein means is provided spacing the cam elements axially from one another a predetermined distance permitting a slight axial looseness of the ball in the track relative to the cam elements and avoiding axial forces of compression of the cam elements upon the ball.

13. In an impact wrench cam clutch mechanism between rotatable drive and driven means comprising a driving cam element rotatable with the drive means, a driven cam element rotatable with the driven means arranged in opposed relation to the driving cam element, a ball track defined between the two cam elements, an arcuate land projecting axially from the driving cam element into the track, a cam tooth projecting axially from the driven cam element into the track, a ball rollable about the track, axially extending shoulder means at

opposite ends of the land limiting at all times the extent of angular movement of the ball relative to the driving cam element, the driving cam element having axial movement relative to the driven cam element, spring means yieldably resisting such movement, one of the shoulder means having driving cooperation with the ball as the driving cam element rotates in a selected direction so as to force the ball about the track and over the cam tooth and as a consequence force the driving cam element axially relative to the driven cam element against the resistance of the spring means, the driving cam element adapted when so forced to carry the land axially relative to the cam tooth for a distance substantially greater than the diameter of the ball.

14. In an impact wrench as in claim **13**, wherein the land lies in a plane spaced at all times axially clear of the cam tooth.

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64—29