TORQUE CONTROL FOR IMPACT TOOL

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This invention relates to impact wrenches and more particularly to novel control mechanism operable in impact wrenches quickly and positively to interrupt the operation of the wrench when a desired predetermined torque has been applied to the work.

Although this invention is adaptable for delivering rotating impact to many different objects, for simplicity, the same will be described only as applicable to tightening of nuts or bolts. In such an operation, an impact wrench delivers a series of rotative hammer blows to the nut, tightening it upon its threads with a torque that increases rapidly with each of the initial blows, and then increases more slowly with each blow as the total torque applied to the nut gradually approaches the maximum possible torque which the particular wrench can deliver.

As the total torque applied to the nut by successive blows increases, the rate of deceleration of the hammer member during a blow and the extent of rebound of the hammer after each blow also increase. Thus, by using a tool having a maximum possible torque substantially in excess of the desired torque to be applied to the nut, and shutting off the tool when either the rate of deceleration or the extent of rebound reach predetermined values, the nut can be tightened to the desired torque, without exceeding that torque, in a small fraction of the time that would be required if the maximum possible torque of the tool were limited to the desired torque to be applied to the nut.

One of the difficulties that has been encountered in prior efforts to control the torque delivered by an impact wrench is excessive play in the driving or control mechanism, producing variations of one or more blows in either direction from the desired cut-off point, resulting in unacceptable variations in the torque applied to a series of nuts.

According to the present invention, a latch is actuated by deceleration of the hammer exceeding a predetermined rate into direct latching engagement with the movable impact clutch member, so as to latch it out of operation and prevent additional blows when the desired torque has been attained. According to a further feature of the invention, the movable impact member is latched in engaged position when the desired torque has been attained, so that the motor is stalled, and the latch releases automatically when the power supply to the motor is interrupted.

According to another feature of this invention, an inertia member is normally held in inactive position by a preloaded spring or other predetermined biasing force so that it remains in inactive position until a predetermined rate of deceleration is reached at which time the inertia member strikes a blow on the latch member, driving it into latched position. The latch member itself is arranged so that it is not moved by deceleration or rebound and is urged to released position by a relatively light spring or other bias, so that the latch is positively held in latched position by friction so long as the torque of the stalled motor is applied to the clutch, whereas the inertia member

is actuated by relatively large forces and thus accurately senses a torque even slightly in excess of the desired maximum.

The present invention also comprises an extremely simple, durable and inexpensive construction in which the actuation of the latch is substantially independent of friction of the moving parts so that the operation is uniform in spite of variations in temperature or lubricants.

Other and further features and advantages of the invention will become apparent from a detailed description of a preferred embodiment thereof taken with the accompanying drawings in which:

Fig. 1 is a side elevation of an impact wrench to which this invention is particularly applicable;

Fig. 2 is an enlarged longitudinal sectional view of the wrench of Fig. 1 showing a portion of the automatic clutch control mechanism;

Fig. 3 is an enlarged partial section showing the clutch control mechanism taken along the line 3—3 of Fig. 2;

Fig. 4 is a side elevation of the latch mechanism; and

Fig. 5 is a cross-sectional view along 5—5 of Fig. 4.

In the illustrated embodiment the invention is applied to an impact wrench in which an impact pin is carried by the hammer and alternately projected into and retracted out of the path of a cooperating abutment surface on the anvil by means of air under pressure controlled by a valve responsive to centrifugal force of the type disclosed and claimed in the patent to Maurer, No. 2,693,867, issued November 9, 1954. It is to be understood, however, that the invention is applicable to other types of impact wrenches and, in its broader aspects, is not limited to the type of mechanism for effecting engagement and disengagement of the clutch.

Referring to Figs. 1 and 2 of the drawings, 10 represents generally an impact wrench having a motor housing 12 to which is secured an appropriate handle 14 and a barrel section 16 for housing the clutch. A motor of any suitable type, such as a pneumatic motor as shown in the aforesaid Patent No. 2,693,867, is mounted in the housing 12 and is connected to rotate a quill 18. A trigger 13 is connected to control the motor, as by opening a control valve in a compressed air supply air line. Quill 13 extends from the motor housing through a ball-bearing 24 and is splined to a cone driver 26 having a conical friction surface 28 pressed into a conical surface 30 of a massive hammer or impact member 32 by means of a retaining ring 36 and a Belleville washer 37. The friction surfaces 28 and 30 are pressed together with sufficient force to transmit without slipping the full torque of the motor, but may slip during rebound of the hammer to reduce the torque reaction on the operator.

At the forward end of the clutch housing 16, a work spindle 20 is journalled in a bushing 21 mounted in the nose of the wrench housing and is provided with an anvil 23 radially protruding from the rear end thereof for receiving torque imparting blows to be transmitted through the spindle to a work load.

During operation of the wrench, the motor delivers rotational kinetic energy to massive inertia member 32 which under the control of a clutch apparatus designated generally at 22 transmits such energy to the work load through anvil 23 and spindle 20.

Inertia member 32 is generally cylindrical in shape and hollowed at 38 to receive the clutch apparatus of the wrench and at its forward end, member 32 is supported by the rearward end of spindle 20 in an engagement allowing free relative rotation therebetween. A cylindrical recess 40 in member 32 extends axially forwardly from the hollow therein to receive a slidable clutch piston 42.

Piston 42 includes a flange 43 and is recessed at its rearward end to provide a cylinder 44 to receive the forward end of nipple 19 and is further provided with a transverse
bore 46 for receiving a cross valve 48 slidable in the bore. Air tight engagement between flange 43 of piston 42 and cylinder 40 is provided at the outer periphery of the forward end thereof.

For effective radial inward movement of cross valve 48, a bore 50 is provided axially through a portion thereof for slidably receiving a pin 51 therein and communication between the inner portion of bore 50 and a reduced outer portion 52 forming an annular space between bore 46 and the cross valve 48 is effected through a converging aperture 53 whereby air under pressure applied in recess 44 through quill 18 and nipple 19 is also applied against the end of pin 51 through an aperture 60, reduced portion 52, and aperture 53. Air pressure in bore 50 effects a force urging a radially inward movement of valve 48 relative to pin 51 since air pressure against pin 51 urges the same out of bore 50 and into contact with hollow 38 and the reactive force of the air pressure against the inner end wall of bore 50 urges the cross valve inwardly.

At the radial inward position of cross valve 48, communication is effected between recess 44 and a space 54 formed between the walls of a recess 55 in inertia member 32 and the forward end of piston 42 through aperture 60, bore 46 along reduced portion 52 and a pair of longitudinal bores 56 in piston 42 where the piston 42 is urged rearwardly by air pressure applied against its forward portion 42a whereby air may be received in space 54 at the forward extreme of the piston and the effective surface area of the surface portion of piston 42 exposed to space 54 exceeds the effective surface area at the forward end of recess 44 for effecting rearward motion of piston 42 under the simultaneous opposed forces of air under pressure in recess 44 and in space 54. At the radial outward position of cross valve 48, space 54 is vented to atmosphere through bore 56, bore 46, a bore 47 in a slidable hammer 62, and thereafter to ambient space through clearances between parts and openings 49 and 57 in housing 16. Under such latter circumstances, air pressure in recess 44 is confined whereby piston 42 is urged forwardly. Accordingly, piston 42 may be reciprocated by the reciprocation of cross valve 48.

Hammer 62 is provided with a recess 64 for receiving a transverse protrusion 65 of piston 42 and is reciprocated longitudinally along the wrench under the influence of piston 42 and in its forward position is engageable with anvil 23 of spindle 20. As impact element 33 and hammer 62 are rotated by the wrench motor, the forward end of hammer 62 and anvil 23 intermittently collide to deliver a relatively enormous impact to the wrench.

For tightening a nut or bolt, an appropriate socket is applied to the end of spindle 20 and the socket is applied to the nut or bolt head. The operator actuates a trigger valve to admit air under pressure to the wrench motor and simultaneously to admit air through quill 18, a nipple 19 and cylinder 44. Assuming that cross valve 48 is in its radial outward position as shown in Figure 2, piston 42 is forced forwardly while the wrench motor imparts rotation to the inertia member 32. It is understood that during such rotation, the nut or bolt is being "run down," that cross valve 48 is urged inwardly by air under pressure within bore 52 and that centrifugal force on cross valve 48 tends to thrust the same radially outward. Assuming that the resistance to rotation imposed by the nut or bolt is initially relatively low, the centrifugal force acting on valve 48 exceeds the force of tending to form a radial movement, whereby the valve is maintained in its outward position and piston 42 in its forward position to maintain engagement between hammer 62 and anvil 23. However, a greater resistance imposed by the nut or bolt, as may occur when the same approaches its tightened position, reduces the rotary speed of the inertia member 32 to proportionately reduce the centrifugal force acting on valve 48 whereby the force of air under pressure in bore 50 predominates over the centrifugal force and valve 48 is moved radially inwardly as hereinabove explained, to withdraw hammer 62. The clutch and inertia member in these circumstances impose only slight resistance to movement, which same accelerates the clutch to a speed where the centrifugal force acting on cross valve 48 exceeds the air pressure urging the same inwardly. The hammer 62 is accordingly extended forwardly by the forward movement of piston 42 and impact a rotary blow to anvil 23 while traveling in its orbital path. The clutch 22 and inertia member 32 are decelerated to begin a new cycle of events described. Blows are imparted in rapid succession by a repetition of the cycle of events described until the nut or bolt is tightened to a predetermined tightness.

When the nut or bolt has been tightened sufficiently, the clutch control mechanism forming a feature of the invention is operative to prevent additional blows from being delivered to anvil 23. As shown more clearly in Figures 3, 4, and 5 of the drawings, impact member 32 is provided with a transverse protrusion 69 in the side thereof for receiving a latch pin 70 slidable along aperture 68 and into cylinder 40 sufficiently to engage flange 43 of piston 42. Pin 70 is provided with head 72 at one end and is urged outwardly from aperture 68 by a leaf spring 74 surrounding the pin and engaging head 72. A flexible strip 76 is attached to the end of member 32 by a set screw 78, extends past and over latch pin 70 and is provided with a hole to receive one end of an inertia pin 80 and engage a head 81 of the pin. An aperture 82 in inertia member 32 receives a portion of pin 80 and also receives a coil spring 84 spaced between pin 80 and a set screw 86 threaded engaging the walls of aperture 82. Set screw 86 is positionable along aperture 82 to adjust the compression of spring 84 and consequently the force against pin 80 urging the same outwardly. A circular shoulder 88 in aperture 82 engages a shoulder 90 of pin 80 to limit the movement thereof in its outward direction.

It is noted that during operation of the wrench to tighten a nut or bolt with right-hand threads, impact member 32 is rotated in a counter-clockwise direction as viewed from a position forwardly thereof. Accordingly, upon differential deceleration of inertia member 32 and pin 80 as when hammer 62 strikes anvil 23, inertia pin 80 by virtue of the combined effects of its own inertia and the rebound of the impact element 33 tends to move into aperture 82 in opposition to spring 84, to pull strip 76 inwardly toward aperture 82 and consequently to drive latch pin 70 into aperture 68 under the flexure of strip 76. Latch pin 70 if sufficiently displaced by strip 76 is interposed in the rearward path of piston 42 immediately subsequent to the delivery of a blow by hammer 62. The frictional engagement between pin 70 and piston 42 is maintained by air under pressure in cylinder 40 forwardly of piston 42 and in the absence of release of said pressure, pin 70 remains in engagement with piston 42 which remains axially immobile. It is obvious that the rate of deceleration of member 32 in response to delivery of an impact blow by hammer 62 varies with the tightness of a nut or bolt to which the wrench is applied and that the force and displacement of inertia pin 80 vary with the rate of deceleration of member 32. Accordingly, the displacements of inertia pin 80 and therefore also pin 70 are proportional to the rate of deceleration of member 32. It is noted that the displacement of pin 80 is also affected by spring 84 and that the influence of spring 84 is to oppose the movement of strip 76 in response to deceleration of inertia member 32. Since set screw 86 is provided to adjust the compression of spring 84 the deceleration required to displace pins 80 and 70 sufficiently to interrupt axial movement of piston 42 may be varied whereby the tightening impact delivered by the wrench may be also varied as desired.
It is noted that components of the clutch control mechanism are relatively small and light as compared with the other components of the clutch and that the centrifugal forces are insignificant in comparison to the operating force of the mechanism. In addition, the clutch control mechanism is quickly responsive to interrupt operation of the mechanism subsequent to the delivery of a desired impact blow. Pins 80 and 70 are movable to interrupt the rearward movement of piston 43 immediately subsequent to the delivery of a blow by hammer 62 to anvil 42.

In the operation of the wrench, the operator releases the trigger throttle, as soon as the wrench is automatically interrupted by the clutch control mechanism described and removes the wrench from the nut or bolt to which applied. It is noted that subsequent to the automatic interrupting of the mechanism by the clutch control mechanism the motor torque is applied to spindle 20 through the wrench clutch as long as the wrench trigger valve is held open. However, since such torque is consequential in the condition existing at that time no adverse effects are thereafter. An operator may unwittingly retain the trigger valve open without adverse results occurring therefrom.

Upon closure of the wrench trigger valve as by release of the trigger, the wrench motor is de-energized and the friction previously existing between pin 70 and piston 40 is eliminated whereby leaf spring 74 with draw pin 70 from aperture 68 to reset the wrench for further operation.

The wrench motor of this invention is of the reversible type wherein torque may be applied to spindle 20 by impact between hammer 62 and anvil 43 in either direction. It is observed that the torque control mechanism forming the features of this invention has been set forth and described as to its applicability to control clockwise rotation of the wrench elements as viewed from the rear thereof. For threading and unthreading nuts, bolts and the like having a right hand thread, such an arrangement is preferable since for obvious reasons, it is necessary to control the degree to which such a nut or bolt is to be tightened. For loosening or unthreading such a nut or bolt, it is preferable to apply full wrench torque and torque control for unthreading rotation is neither necessary nor desired. A nut may be excessively tightened or threads may be distorted or ruptured to require a high torque for unthreading.

It is noted that a wrench may be provided with torque control features according to the invention for controlling the torque applied in clockwise rotation as seen from the front thereof. Such an arrangement would be particularly adapted for controlling the tightening of nuts, bolts and the like with left hand threads and applying full wrench torque to the same when unthreading or loosening the same. For accomplishing torque control of reverse rotation the torque control elements including latch pin 70, leaf spring 74, strip 76, inertia pin 80 and associated components may be mounted and disposed in such a manner as to be in contact with inertia member 32 so as to appear as the mirror image of Figure 5. Each of these members would be responsive to sudden deceleration of inertia member 32 while rotating in a clockwise direction as viewed in the figure.

In accordance with the foregoing, this invention contemplates the provision of torque control means for rotation of the wrench in either direction as may be desired under certain circumstances.

Having thus described this invention in such full, clear, concise and exact terms as to enable any person skilled in the art to which it pertains to understand and practice the invention it is to be understood that many changes in the details of construction and therefore substitution for or modification of the parts of the described embodiment of the invention may be made without departing from the scope of the invention as set forth in what is claimed, it being understood that equivalents or modifications of, or substitutions for, parts of the above specifically described embodiment of the invention may be made without departing from the scope of the invention as set forth in what is claimed.
said hammer; torque control means comprising a shoulder on said movable means, a latch mounted on said other member for movement into a latching position in the path of said shoulder to interrupt movement of said movable means, means biasing said latch out of latching position, inertia means carried by said driving member and means connecting said inertia means to said latch to move said latch into latching position in the path of said shoulder in response to a predetermined rate of deceleration of said driving member.

5. In an impact wrench including a rotatable driving member and a rotatable driven member, one of said members having an abutment surface spaced from the axis of rotation thereof, movable means including a hammer, said movable means being mounted on said other member for movement as a unit into advanced position to position said hammer in the rotary path of said abutment surface and into a retracted position to position said hammer out of said path, means for moving said movable means into advanced position when said driving member is rotating and into retracted position after engagement between said abutment surface and said hammer; torque control means comprising a shoulder on said movable means, a latch mounted on said other member for movement into a latching position in the path of said shoulder to interrupt movement of said movable means, means biasing said latch out of latching position, inertia means carried by said driving member, means connecting said inertia means to said latch, said inertia means being mounted on said driving member for movement in response to deceleration of said driving member in a direction to move said latch into latching position, and adjustable spring means biasing said inertia means in the opposite direction.

6. An impact wrench having a motor, a spindle and an impact clutch for transferring torque from said motor to said spindle, said impact clutch comprising an anvil on said spindle and a hammer, means drivingly connecting said hammer to said motor to be rotated thereby, means for reciprocating said hammer into and out of position to engage said anvil to impart a torque delivering blow thereto, clutch control means comprising a latch member movable to block and interrupt the reciprocating movement of said hammer, and means including inertia means responsive to sudden deceleration of said hammer to move said latch member and interrupt the movement of said hammer to discontinue the operation of said clutch.

7. A clutch control mechanism for an impact wrench including a motor, a spindle and a clutch having a rotary impact element for transferring torque from said motor to said spindle, means drivingly connecting said rotary impact element to said motor to be rotated thereby, a piston and a hammer unitarily reciprocable along said impact element to selectively effect engagement and disengagement between said motor and said spindle, means for reciprocating said piston and hammer, a latch member mounted and guided in said impact element for movement into a latching position intersecting the reciprocatory path of said piston, inertia means movable in said impact element along an axis removed from and transverse to the axis of rotation of said impact element, means interconnecting said latch member and said inertia means, said inertia means being responsive to sudden deceleration of said impact element to position said latch member in the path of said piston through said interconnecting means whereby the wrench torque is automatically controlled.

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