This invention relates to impact wrenches and more particularly to control mechanisms incorporating torque controlling and automatic shut-off means for adjusting the torsional impact delivered by the wrench and for automatically interrupting operation thereof in response to delivery of desired torsion to a work load.

Although this invention is adaptable for delivering rotating impacts 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 inaccuracy in the sensing 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 an inertial cam follower element is biased, as by a relatively stiff spring, against a cam which rotates and decelerates with the wrench hammer. When the deceleration exceeds a predetermined rate, the inertial cam follower is moved a sufficient distance against its bias force by reaction against the cam to close a check valve in the compressed air line to the motor, which closes in the direction of air flow to the motor and is normally held open by a relatively light spring. The closing of the valve interrupts the supply of compressed air to the motor, and in the illustrated embodiment, in which the impact clutch is actuated by air pressure, also shuts off the air to the clutch.

According to a further feature of the invention, the spring which normally holds the check valve open has sufficient strength to hold the valve spaced from its seat while compressed air flows past it to the motor, but insufficiency strength to open the valve against the pressure of the air supply once it has been closed by the inertial cam follower. The manually operated throttle valve of the tool is interposed in the compressed air supply upstream from the check valve and is provided with an exhaust valve which is opened to atmosphere when the throttle valve is closed, so as to exhaust the compressed air trapped between the throttle valve and the check valve and permit the check valve to be opened by its spring.

According to another feature of the invention, the check valve is located in the compressed air line immediately in advance of a reversing valve and the motor inputs, so as to minimize the volume of compressed air downstream from the check valve when the latter closes.

Other and further objects and advantages will appear from a more detailed description of the invention taken with the accompanying drawings in which:

Fig. 1 is a cross-sectional, side elevation of a wrench according to the invention;

Fig. 2 is an enlarged section of a portion of the wrench shown in Fig. 1, showing the automatic valve control mechanism;

Fig. 3 is an enlarged section of a portion of the wrench shown in Fig. 1 showing the trigger operated compressed air supply valve mechanism;

Fig. 4 is a view taken along section 4—4 of Fig. 1 showing the details of the valve bias control mechanism, and

Fig. 5 is a detail view of the cam and cam follower elements of the automatic valve control mechanism.

Referring now more particularly to Fig. 1 of the drawings, wherein a preferred embodiment of the invention is shown, 10 represents generally an impact wrench including a combination handle and trigger valve block 14 adaptable to be manually gripped for manipulation therewith, of a stock section 15, a housing 16 containing an automatic valve control mechanism 17, a motor housing 18 and a clutch housing 19. Block 14 and housings 16, 18 and 19 are secured in juxtaposed relation in any suitable manner as, for example, by suitable threaded fastening means (not shown). Protruding from housing 19 is a rotary spindle 20 having a polygonal tool head 22 engageable with conventional sockets for fitting various nuts and bolt heads.

Reference will be made herein to "forward," "rear" and "rearward" positions on wrench 10 to designate relative axial locations on the wrench. It is to be understood that the tip of tool head 22 is the forward most point of the wrench and that the outer edge of block 14 is the most rearward point thereof.

A reversible, sliding vane type pneumatic motor 24 is provided within housing 18 and includes a stator lining 26 and a rotor 27 having a plurality of slidable vanes 28 connected for rotation with a hollow shaft 30. Suitable end plates 31 and 32 are provided for confining the spaces between respective vanes. Air under pressure is supplied for motor 24 through a passage 29 communicating with a manifold of motor 24 and exhaust ports 36 are provided to facilitate discharge of air utilized by motor 24.

Shaft 30 extends rearwardly from housing 18 into an opening 37 in housing 16. As shown more clearly in Fig. 2 of the drawings, a nipple 38 having opposed elongated portions 40 and 42 and a pair of spaced intermediate, enlarged portions 43 and 44 separated by a groove 45 for receiving an O ring 47, has portion 40 slidably mounted within shaft 30 to provide communication therewith for a reason to be explained. Shaft 30 is splined at the end 46 thereof for engagement with the inner surface of a round cam member 48 having a pair of cam lobes 50 protruding axially from diametrically opposed locations of a face thereof as seen more clearly in Fig. 5 of the drawings. An inertial cam follower 49 disposed axially adjacent cam 48 and having a pair of diametrically spaced recesses 52 for receiving lobes 50...
In one relative position thereof, is mounted on portion 40 of nipple 36 and has an inner annulus 38 having a face engageable with a plurality of ball bearings, a pair of which are shown at 56 and 57, and disposed between annulus 54 and a shoulder of enlarged portion 43 of nipple 38. Follower 49 is retained in axial position relative to nipple 38 by a snap ring 58 fitted in a groove of portion 40 and retaining annulus 54 and balls 56 and 57 between the snap ring and a face of portion 44 but is free to rotate on nipple portion 40 but for the influence of cam 48 thereon.

Nipple portion 42 extends from housing 16 rearwardly through a chamber 59 in housing 16 and an opening 61 in block 15 having a circular valve seat 60. A poppet valve 62 with an axial portion 64 and a radial portion 66 terminating in a lip 68 is slidably mounted on nipple portion 42. A sealing ring 70 is positioned between radial portion 66 of valve 62 and a washer 71 for engagement in one extreme position with valve seat 60.

Portion 42 of nipple 36 terminates in a spherical socket 72 for engagement with a ball bearing 74 which in turn is supported in a socket 76 of a slidable socket member 77 in a cup 78. A recess 80 in block 14 is provided for receiving cup 78 which is adjustable, axially positioned in recess 80 by a cam 82 mounted on a shaft 84 extending through block 14 and shown more clearly in Fig. 4 of the drawings. Rotation of shaft 84 moves cam 82 forwardly or rearwardly for varying the engagement with the bottom of cup 78 between the extremities of the cam surface.

A suitable coil spring 86 in abutment at its respective ends with washer 71 and socket member 77 normally urges poppet valve 62 away from seat 69 and a spring 88 is positioned within cup 78 for abutment with the bottom of the cup at one end of the spring and with an annular recess in socket member 77 at the other end of the spring. Accordingly, socket member 77 is urged against ball bearing 74 to urge nipple 36 rearwardly and follower 49 into engagement with cam 48. A suitable snap ring 90 is provided for retaining socket member 77 within cup 78.

A transverse opening 92 in nipple portion 42 is provided to facilitate communication between an air chamber in stock section 15 and the hollow of the nipple 36 and shaft 39 for operation of the wrench clutch in a manner to be explained.

As shown more clearly in Fig. 3 of the drawings, a manually operable valve mechanism is provided in trigger block 14 for controlling the working speed and for exhausting air under pressure therefrom when the motor is shut off and comprises a manually actuable valve trigger 100, a valve seat 102 on a valve seat insert 104 engageable with a rim of a head 106 of a poppet valve 108 in one position thereof. A stem 110 of valve 108 extends through insert 104 and has an opening 112 therein enlarged at portion 114 and terminating in a beveled seat 115 for receiving and engaging a valve actuator pin 114 having a complementary seating surface 117, adapted for engagement with manually operable trigger 100 to actuate valve 108. Opening 120 communicates with the hollow of block 14 through a radial opening 120 and to the atmosphere through the space between the actuator pin 116 and the enlarged portion 114 of opening 112 in the released position of pin 116. Seats 115 and 117 are effective when engaged to render the opening 112 closed to the atmosphere and when disengaged are effective to vent the interior of insert 104 and part communica
tive therewith to atmosphere to release the pressure therein.

A suitable spring 122 is provided for abutment with valve head 106 and a cage 124 at respective ends thereof to normally urge valve head 106 into engagement with seat 126 and a suitable opening 128 is provided for receiving air under pressure from a source (not shown) to operate the wrench.

A suitable channel 132 extending through stock 157 from block 14 is provided for directing air into chamber 59 to be controlled by valve 62 for operation of motor 24 and the wrench clutch mechanism.

Located at 138 is a hammer and clutch apparatus 130 responsive to desirable conditions of operation to deliver an impacting blow to spindle 20 for every revolution of the motor 24 in a manner to be described. A relatively heavy inertia member 132, hallowed to provide a cylinder at 134 is provided for rotation within housing 19 and a hammer 136 is axially slidably mount
ed in member 132. Hammer 136 terminates in a head 137, engageable in one axial extreme position, with an anvil 138 radially protruding from one end of spindle 20. Inertia member 132 is in driving engagement with shaft 30 through a quill 140 splined to the end of the shaft and splined to member 132 at a radially enlarged portion 141 of the quill 140. A piston 142 is slidably axial
ly within cylinder 134 and is provided with a transverse bore 143, communicating with a bi-partite discharge port 145 in hammer 136 which is vented to atmosphere and with a radial extension 144 in engagement with a recess in hammer 136 for sliding movement thereof in a man ner to be set forth. Piston 142 is hollowed at one end 146, to receive an end of a nipple 148 which is hollowed to provide communication between cylinder 146 and the inner space of shaft 30. A cross valve 150 annularly recessed at 151 and having a head 152 is transversely slide
able in opening 143 under the influence of air pressure or centrifugal force as hereinafter described, and a pair of holes 153 and 154 are provided in piston 142 for facilitating communication between cylinder 134 and discharge port 145 and between bore 143 and the cylinder 146, respectively.

Cross valve 150 is provided with a longitudinal bore 155 for receiving a pin 157. Communication between the interior of nipple 148 and the upper portion of bore 155 is provided through transverse bores 159 in valve 150. Cross valve 150, in the absence of any other inluence, is responsive to air pressure admitted through opening 152 to move into opening 143 since air in bore 155 exerts a force against the inner end of the bore to urge the valve inwardly and since a reactive force on pin 157 merely tends to rotate the same from bore 155 without exerting a force on valve 150. Consequently, the application of air under pressure to cylinder 146 through opening 92, shaft 39 and nipple 148 at low angular velocity of the motor provides a force tending to move cross valve into opening 143 to effect communication between cylinders and air to cylinder 146 and opening 154. Under the influence of centrifugal force present and acting on head 153 when motor 24 is operating to rotate the clutch assembly, cross valve 150 is urged out of opening 143 against the influence of air pressure in a manner already described. Accordingly, by virtue of the respective influences applied to cross valve 150, it is reciprocable to selectively provides communication between cylinder 146 and cylinder 134, and between cylinder 134 and exhaust, through openings 154 and 145. In the outer position of valve 150 pressure applied in cylinder 143 forces piston 142 forwardly while bore 154 allows exhaust flow from cylinder 134 and the inner position of valve 150 pressure applied in cylinder 134 against the forward end of piston 142 provides a force to move piston 142 rearwardly whereby selective forces are applied to reciprocate piston 142. Since the effective surface area of piston 142 applied to air in cylinder 134 exceeds the effective surface area of piston 142 ex
pended to cylinder 146, simultaneous application of air under pressure to cylinders 134 and 146, as may be the case when cross valve 150 is fully in opening 143, causes a rearward movement of piston 142 and hammer 136 and application of air to cylinder 146 when cross valve is in its outer position causes a forward movement of piston 142 and hammer 136.

In accordance with inventive features set forth in ap
plication Serial No. 619,510 of James Sturrock, filed Oc
October 31, 1956, a latch 170 is provided for retaining hammer 136 retracted for more than one revolution of the hammer after which a cam lobe 172 releases the latch to allow the hammer to advance for impact.

The wrench has a lever under pressure applied thereto is admitted through opening 92 to the inner spaces of shaft 30, nipple 148 and cylinder 146. Such air pressure is effective when cross valve 150 is in its extreme outer position to force piston 142 forwardly as already explained. It is to be understood that under the application of air pressure to the wrench, motor 24 rotates and in the cylinder 134 a decrease in cylinder 134 or more rotate whereby an engagement between head 137 and annul 138 may be effected by sufficient rotation of member 132 after head 137 is axially advanced as explained. In the event that cross valve 150 is in its extreme inner position when air pressure is applied to the wrench, air pressure is effective to move piston 142 rearwardly.

Motor 24, however, in rotating piston 142 through heavy member 132 and hammer 136 imparts a centrifugal force to valve 150 and under full angular velocity, forces valve 150 outwardly against the influence of air pressure. Accordingly, communication between cylinder 146 and cylinder 134 through openings 152, 154 and recess 151 is cut off and present in cylinder 134 is retained by valve 150 and the hammer 136 forwardly since cylinder 134 is vented to atmosphere through openings 154 and 145. As a consequence, head 137 engages annul 138 delivering a blow thereto and rotation of member 132, hammer 136 and piston 142 is retarded whereby air pressure again acting against reduced centrifugal force, causes valve 150 to move into opening 143.

The described cycle of events recurs rapidly to cause a delivery of many blows to annul 138 to effect a rotation of spindle 20 against the resistance of a load applied thereto until operation of the wrench is discontinued manually or automatically as hereinafter described.

As a feature of this invention, the automatic valve control 17 is adaptable to cause the wrench to discontinue operation in response to excessive torque resistance to spindle 20. For a clearer understanding of the operation of this invention it is assumed that air under pressure is supplied through opening 126 in block 34 by some suitable hose connection, for example, and that an operator has adapted and applied spindle 20 to a suitable socket or other means for tightening a nut, bolt or other torque load. Trigger 109 is actuable by the operator to depress actuator pin 116 and therefore valve 108, to remove valve head 106 from its seat 105 allowing air under pressure to flow past the valve opening into chamber 128 into chamber 59. Poppet valve 62 and ring 70 having been biased to “open” position by spring 86 are remote from seat 60 to permit the flow of air into chamber 94 and into a motor manifold to operate motor 24 in a manner well known. Additionally, air is supplied to the clutch and hammer apparatus 130 through opening 92 and the hollows of nipple 38 and shaft 30 to operate clutch 130 to cause impacting blows to be delivered to spindle 29. Under the condition wherein torsional resistance to spindle 20 is low, as when a nut is being run down threads, the wrench continues to operate wherein motor 24 rotates continuously since valve 150 remains in its outer position against the force of air pressure in bore 155. After the nut is tightened to a certain degree, the wrench impacts blows to the annul 138 to rotate spindle 20 sufficiently to tighten the nut. Shaft 30 rotates cam member 48 which in turn, by virtue of engagement of cams 50 with recesses 52 in follower 49, rotates cam follower 49. Nipple 38 is in its extreme forward position and virtue of the influence of spring 88 against valve 62 which engages a shoulder of portion 44 of nipple 38.

Assuming next that spindle 20 encounters a high torsional resistance as occurs, for example, upon the full tightening of a nut or bolt, spindle 20 and all components including cam 48 of wrench 10 rotateably move therewith are quickly angularly decelerated. Follower member 49, however, being free to rotate but for the restraining influence of cams 50 tends to continue to rotate by virtue of the inertia thereof. Assuming that the inertia of follower 49 is sufficiently great and that it continues to rotate a sufficient angular distance, the surfaces of recesses 52 bear against cams 50, imparting an axial rearward thrust to follower 49, nipple 38 and valve 62 causing engagement of ring 70 with seat 60. In this position, air under pressure in chamber 93 forces and retains poppet valve 62 in closed position even in the absence of any axial thrust of follower 49 so as to effect an interruption of operation of the wrench in response to full torsional load resistance. It is to be understood that the rate of deceleration hereinafter described varies directly according to the tightness of the load and that with each successive blow follower 49 moves further axially until interruption of air flow past seat 60 occurs.

As a further feature of the invention provision is made to prevent any further impact blows from being delivered to annul 138 after a blow encountering a high torsional resistance has been delivered. As follower 49 forces nipple 38 and valve 62 rearwardly in response to a sudden deceleration of motor 24 and cam 48 as herein described, the supply of air under pressure to the impact clutch through nipple 40, shaft 30 and nipple 148 is cut off. Since piston 142 is in its extreme forward position when impact between head 137 and annul 138 is made, air pressure remaining within the air channels beyond valve 62 including shaft 30, nipples 40 and 148 and the impact clutch is sufficient and effective to return piston 142 to its rearward position. The respective elements of the clutch are sized and proportioned that such remaining air is disipated by the return of piston 142. Consequently, no further impact blows can be delivered to annul 138 after the closing of port 92. Accordingly, an automatic “shut off” is provided for the wrench whereby it automatically discontinues operation when the load member has been sufficiently tightened or a sufficient torsional force has been applied thereto.

To initiate further operation of the wrench, it is necessary to release trigger 100 after which valve 108 closes under the influence of spring 82 and the air pressure in channels 138 and chamber 94 are vented to atmosphere through opening 126, bores 112 and 114 to remove the closing pressure against poppet valve 62. Accordingly, valve 62 opens under the influence of spring 86. The wrench is again in its initial condition and is ready for application to another torsional load.

As a further feature of the invention, it is noted that the wrench is adjustable to automatically deliver a desired torsional output by a mere adjustment of the compression of spring 88. An adjustment of this spring is effected by an axial positioning of cup 78 by cam 82 operable by a rotation of shaft 84 to bear against the cup as shown most clearly in Fig. 4 of the drawings. It is to be understood that increased compression in spring 88 accomplished by a forward positioning of cup 78 by rotation of shaft 84 increases the force urging follower 49 forwardly and consequently a greater force is required to move the same rearwardly against the spring. As a further consequence, a greater angular deceleration is required by cam ring 45 to cause follower 49 acting in cooperation therewith in a manner explained hereinafore, to deliver a greater axial thrust against spring 86 to initially close valve 62. Accordingly, since valve 62 interrupts the operation of motor 24 only when moved sufficiently far by follower 49 the resistance to axial movement applied to follower 49 by spring 88 is effective to also determine the value of torque at which valve 62 is closed.

A suitable handle 150 fitted for rotation of shaft 84 is provided and an edge thereof is preferably shown at 182 marked with spaced graduations designating units
of torque deliverable by the wrench when set in alignment with a suitable fixed mark. It is to be observed that this invention is adaptable for use with uniform torque output as when tightening or loosening bolts and the like, even by an unskilled operator by a mere adjustment of cam 32 through knob 130 and that when the predetermined torquous output has been delivered by the wrench the same is simply and automatically shut off by the action of cam follower 49 in said engagement.

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 make and use the same, and having set forth the best mode contemplated of carrying out this invention, I state that the subject matter which I regard as being my invention is particularly pointed out and distinctly claimed 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.

What is claimed is:

1. A pneumatic impact wrench comprising a driving motor, a driven spindle and an impact clutch for transmitting the driving torque from said motor to said spindle, a channel in said motor for providing communication between said channel and ambient space and means for opening said manually operable valve and for interrupting communication between said bore and ambient space, said last mentioned means being releasable to close said valve and being responsive to sudden deceleration of said motor due to resistance to rotation of said hammer, to continue rotation and operate against said cam to interrupt the supply of air to said motor and to said clutch, whereby the residual air pressure in said channel aids said hammer with said spindle and further rotation of said motor dissipates the residual air pressure in said clutch.

2. A pneumatic impact wrench having a rotary spindle comprising a driving motor and a pneumatic clutch having a rotatable hammer axially slideable for selective engagement with said spindle, means for an apertured nipple and an air channel for providing communication between said clutch and an air source, a valve slideable along said nipple for selectively covering said apertures and for closing said channel, spring means in said channel for restraining movement of said valve toward said aperature, a cam having lobes in said engagement with said spindle and a follower in said engagement with said cam, said follower being responsive to sudden deceleration of said spindle to bear against said cam and axially thrust said valve against said spring and close said channel, said valve in closed position being exposed responsive to air under pressure in said channel to remain closed against the bias of said spring, a manually operable poppet valve in said channel and including a stem having a bore providing communication between said channel and ambient space, a pin in said pinion aperture and a manually operable trigger adaptable to selectively engage said pin and close said aperture and to open said valve, said pin being releasable to release the pressure in said channel.

3. A pneumatic impact wrench comprising a driving motor, a spindle and an impact clutch for transmitting the driving torque from said motor to said spindle, a channel having a peripheral shoulder providing communication between a source of air and said motor, means including a hollow shaft and an apertured nipple for providing communication between said channel and ambient space, a cam having lobes in said engagement with said cam, said follower being responsive to sudden deceleration of said motor to bear against said cam and axially thrust said poppet valve against said cam whereupon communication between said air source and said motor and clutch and adaptable in another position to engage a shoulder of said nipple, a spring having one end in abutment with said nipple and another end in abutment with said hammer to urge the same away from said shoulder, a cam rotatable with said motor, a follower in abutment with said nipple and engaging with said cam, said follower being responsive to sudden deceleration of said spindle to bear against said cam and axially thrust said poppet valve against said cam whereupon communication between said air source and said motor and clutch is interrupted.

4. An impact wrench having a rotary spindle comprising a pneumatic driving motor and a pneumatic clutch for selectively transmitting rotary motion from said motor to said spindle, an air channel with a peripheral shoulder for supplying air to said motor, a nipple extending through said channel having a valve slidably mounted thereon being apertured to provide communication between said clutch and said channel, a first spring urging said valve into abutment with a portion of said nibble and a second spring urging said portion of said nibble away from said shoulder, means responsive to sudden deceleration of said motor to thrust said nipple portion against said valve and valve against said shoulder whereby the air pressure in said channel is effective to retain said valve against said shoulder and said second spring is effective to resist axial movement of said valve, and cam means for adjusting the compression of said second spring.

5. An impact wrench comprising a rotatable driven spindle, a rotatable hammer assembly, a motor for rotating the hammer assembly, an impact clutch for coupling said hammer assembly intermittently with said...


spindle to deliver a series of rotational impacts thereto, pneumatic means for operating said impact clutch, a valve for controlling the supply of air to said pneumatic means, said valve being balanced with respect to air pressure and arranged to close in the direction of flow of air to said pneumatic means, a spring biasing said valve to open position, a cam rotatable with said motor, an inertia cam follower engageable with said cam and responsive to deceleration of said motor to continue rotation and exert a thrust against said valve in the direction to close the same, said valve being held closed by differential pressure when air flows to said pneumatic means while said valve is thrust to closed position by said follower, thereby interrupting operation of said impact clutch.

8. A pneumatic impact wrench comprising a driving motor, a driven spindle and an impact clutch for transmitting the driving torque from said motor to said spindle, a channel connected at the inlet end to a source of air under pressure and at the outlet end to said motor, a poppet valve interposed in said channel for controlling the supply of air to said motor, said valve being positioned to close in the direction of air flow, a biasing spring maintaining said valve open against the flow of air during operation of said motor, a cam rotatable with said motor, an inertia cam follower engageable with said cam, said cam follower being responsive to sudden deceleration of said motor and said cam to continue rotation and to react against said cam to impart a closing thrust to said valve against the bias of said spring whereby said valve is retained in closed position against the bias of said spring by the differential pressure across said valve.

9. A pneumatic impact wrench comprising a driving motor, a driven spindle and an impact clutch for transmitting the driving torque from said motor to said spindle, a channel connected at the inlet end to a source of air pressure and at the outlet end to said motor, a poppet valve interposed in said channel for controlling the supply of air to said motor, said valve being positioned to close in the direction of air flow, a biasing spring maintaining said valve open against the flow of air during operation of said motor, a cam rotatable with said motor, an inertia cam follower engageable with said cam, said cam follower being responsive to sudden deceleration of said motor and said cam to continue rotation and to react against said cam to impart a closing thrust to said valve against the bias of said spring whereby said valve is retained in closed position against the bias of said spring by the differential pressure across said valve.

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