Dec. 20, 1955 W. G. MITCHELL ET AL 2,727,598

IMPACT WRENCH TORQUE CONTROL

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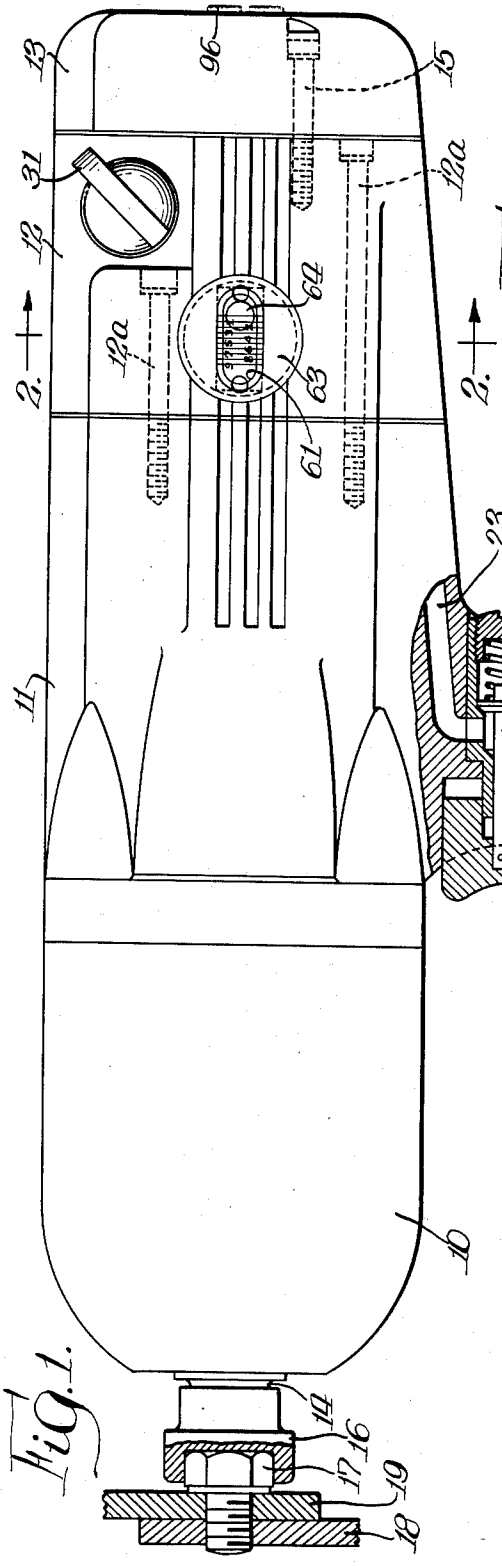


Fig. 1.

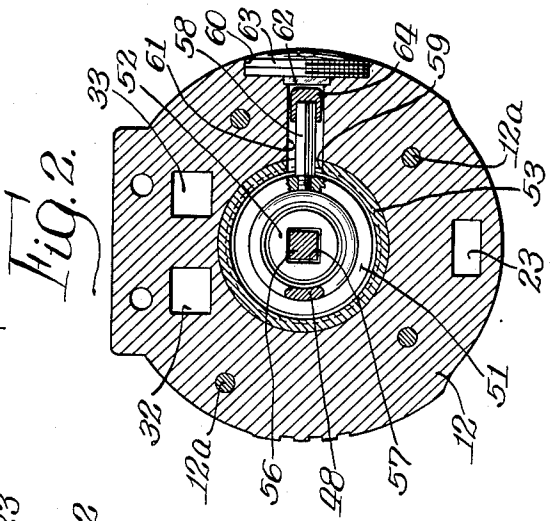


Fig. 2.

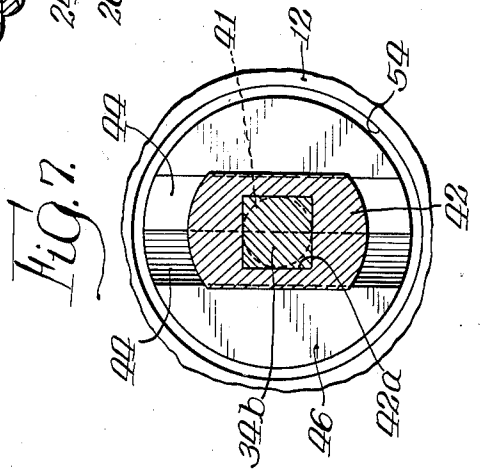


Fig. 7.

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Fig. 3.

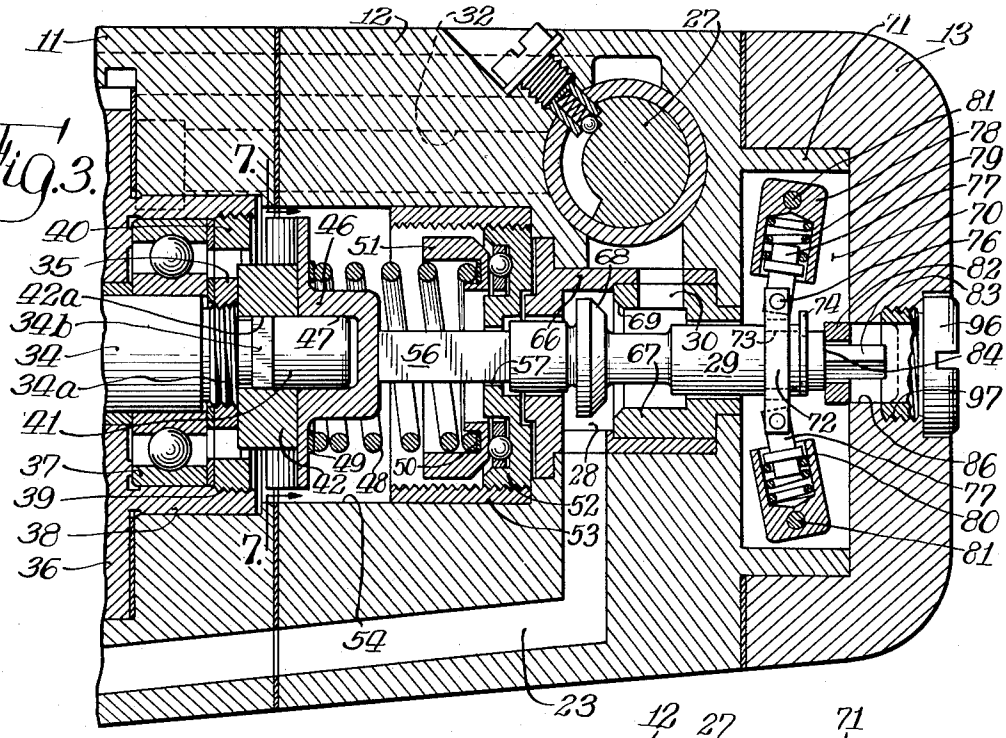
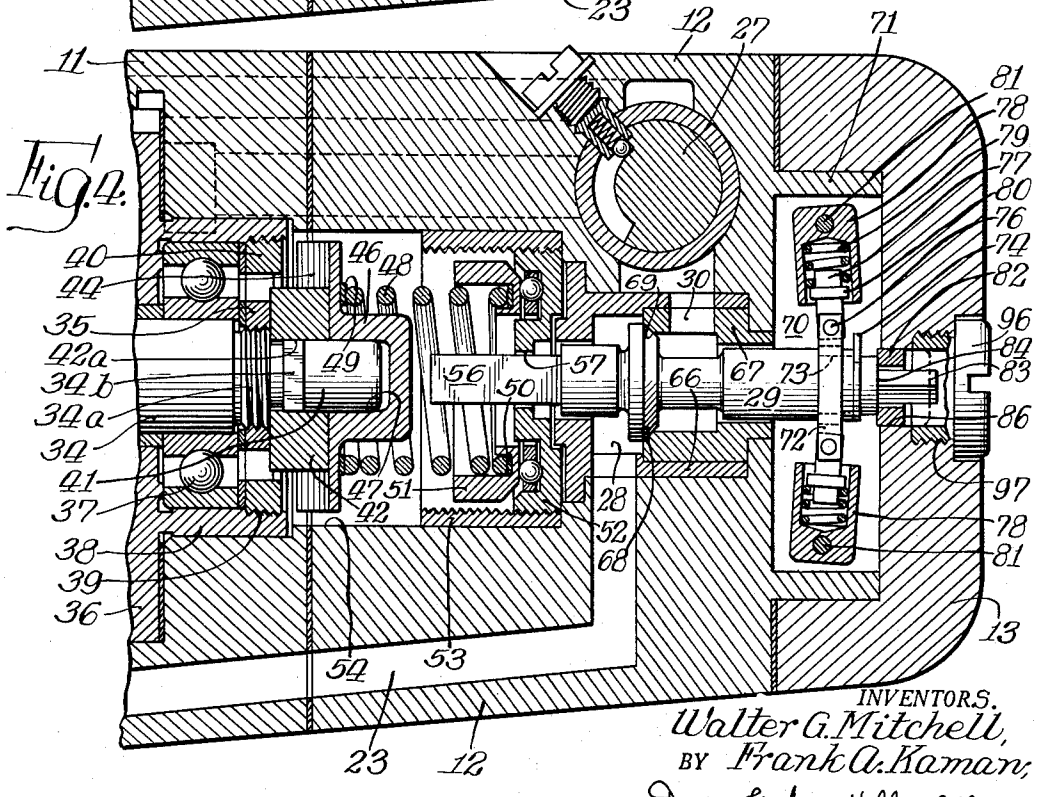


Fig. 4.



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Fig. 5.

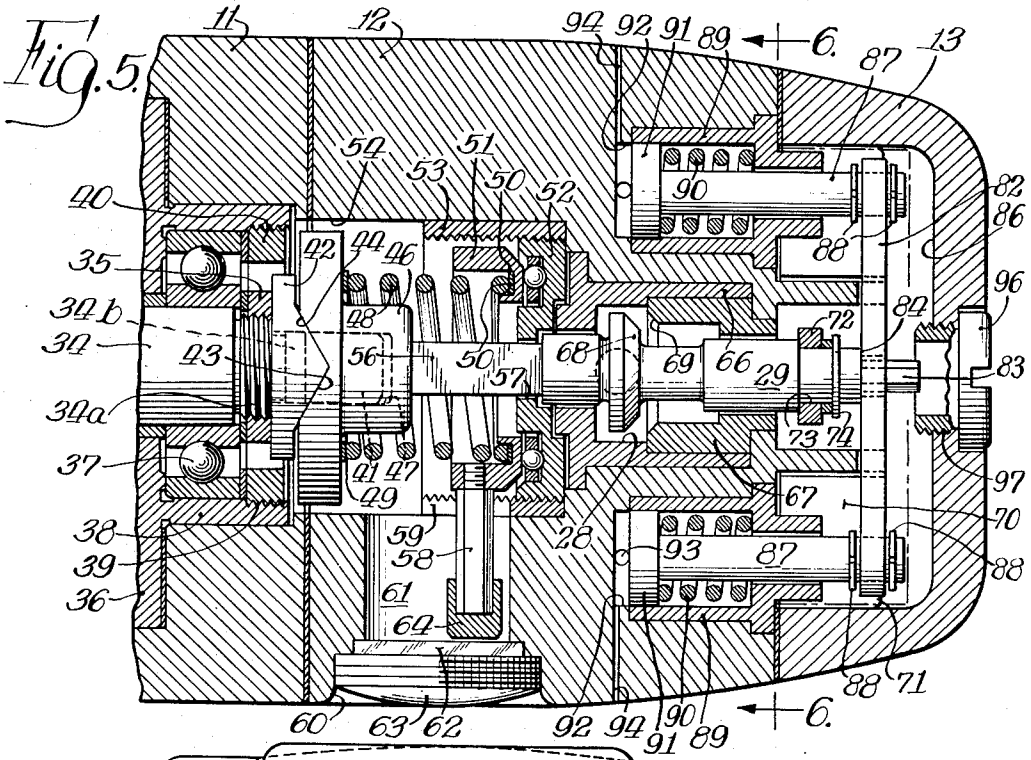
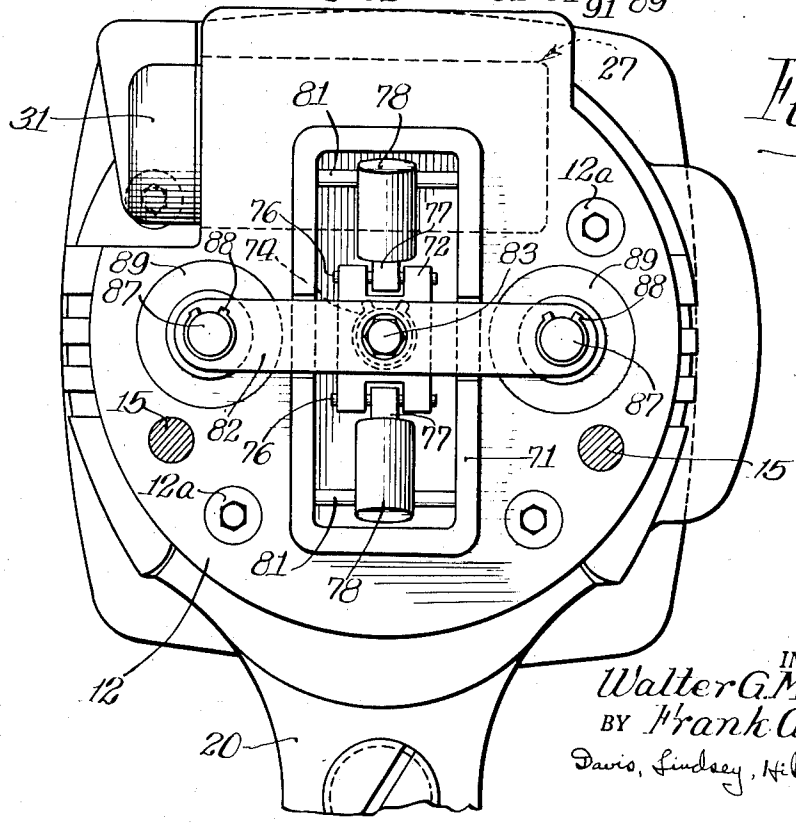


Fig. 6.



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IMPACT WRENCH TORQUE CONTROL

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Application October 22, 1951, Serial No. 252,556

23 Claims. (Cl. 192—.034)

This invention relates to impact wrenches and more particularly to a torque limiting or controlling device in accordance with which the operation of the wrench may be automatically controlled or stopped when the work, such as a nut or bolt, has been tightened to a predetermined degree.

One inherent disadvantage that has been present in the use of commercial impact wrenches for many years, has been the inability of an operator of average ability and skill to determine when the work has been tightened to the desired degree so that he could then cause the wrench to cease operation before the nut or bolt was twisted off or the threads thereof damaged. The operator merely applied the wrench to the work, turned on the power and unwittingly permitted the wrench to continue impacting beyond safe limits, the powerful torque of the wrench being more than sufficient to overcome the resistance offered by the metal of the fully set work. A further defect was that such wrenches could not be adjusted to set up work to varying degrees of tightness as dictated by the particular conditions of use and even an operator of more than average skill was unable to remove the wrench from the work precisely at such varying degrees. As a result of such disadvantage and defect, work has been either tightened beyond the desired limits or has been left in relatively loose condition and in many instances much time has been lost and damage occasioned by breakage of the nut or bolt. Moreover, because of their lack of adjustability, the impact wrenches were not acceptable for use in many different commercial fields where human judgment could not be relied upon.

It is, therefore, one of the objects of the present invention to provide impact wrenches with a mechanism or device for automatically limiting or controlling the application of the driving torque on the nut or bolt being driven.

Another object of the invention is to provide a torque controlling or limiting device for application to an impact wrench comprising means controlling or stopping wrench operation in response to a sudden deceleration of said tool resulting from a predetermined increased resistance of said work to the driving torque upon impact.

Still another object is to provide a torque controlling or limiting device for impact wrenches whereby the motor is caused to cease operation in response to a sudden deceleration of said tool resulting from a predetermined increased resistance of said work to the driving torque of the wrench upon impact.

A further object of the invention is to provide a torque controlling or limiting device of the foregoing character comprising a control means for limiting the supply of motive energy to the motor and operable in response to said sudden deceleration of the wrench resulting from a predetermined increased resistance of the work upon impact.

Another further object is to provide a torque controlling or limiting device comprising a motor energy limiting means movable to and from energy limiting position and

inertia means operably engaged between said energy limiting means and a rotatable part of said wrench subject to a sudden reduction in speed of rotation upon impact, said inertia means being adapted to effect movement of said energy limiting means upon impact at a predetermined increased resistance of the work.

Still another further object is to provide a torque controlling or limiting device described in the next preceding object wherein a cam member is rigidly secured to said rotatable wrench part and is engageable with said inertia means which is mounted for rotation with said cam and for rotative and axial movement ahead of said cam upon impact to effect movement of said energy limiting means to limiting position upon impact at a predetermined increased resistance of the work to the driving torque.

Another object is to provide a torque controlling or limiting device for an impact wrench comprising control means movable to and from torque controlling position, inertia means operably engaged between said control means and a rotating part of the wrench subject to a sudden reduction in speed of rotation upon impact and adapted to effect movement of said control means to torque limiting position upon impact at a predetermined increased resistance of the work, and means for retaining said control means in torque limiting position.

Another further object is to provide a torque controlling or limiting device of the character defined in the preceding object in which there is additional means for releasing said control retaining means for recycling the wrench for reoperation.

A specific object is to provide a torque controlling device for an impact wrench wherein an inertia element is rotatably carried by a cam-shaped surface on the upper end of the motor rotor and an axially slidable valve element engageable with said inertia element is moved to closed position to cut off the air supply to the pneumatic motor upon impact when the rotor is decelerated at a high rate, the inertia element rotating ahead of the rotor upon impact and being cammed rearwardly to close said valve element.

Another object is to provide an adjusting mechanism whereby the point or degree of resistance of the work to the driving torque at which the wrench operation is limited or stopped may be varied.

Other and further objects and advantages of the present invention will become apparent as this description progresses, reference being had to the accompanying drawing in which:

Figure 1 is a side elevational view of a pneumatic impact wrench to which the torque limiting device comprising the invention may be applied;

Fig. 2 is a vertical sectional view taken on the line 2—2 in Fig. 1 looking rearwardly of the tool;

Fig. 3 is a vertical, longitudinal sectional view of the rearward portion of the wrench shown in Fig. 1 illustrating in detail a preferred embodiment of the torque limiting device comprising the present invention;

Fig. 4 is a view similar to Fig. 3 but showing the automatic torque limiting valve in closed position;

Fig. 5 is a horizontal, sectional view of the structure shown in Figs. 3 and 4;

Fig. 6 is a vertical cross sectional view taken on the line 6—6 in Fig. 5 looking in the direction of the arrows; and

Fig. 7 is a sectional view taken on the line 7—7 in Fig. 3 looking rearwardly of the tool in the direction of the arrows.

As shown generally in Fig. 1 of the drawings, the impact wrench to which the torque limiting or controlling mechanism comprising the present invention is applied, comprises an impact clutch housing 10 at the forward end thereof, a rotary pneumatic motor housing 11 cen-

trally thereof, a valve block **12** on the rear of said motor housing and a rear valve block cap **13** at the rear end of the tool. A spindle **14** projects from the front end of the impact clutch housing **10** and carries a socket **16** adapted to drivingly engage a bolt **17**, for example, for connecting together two pieces of work **18** and **19**. The rear cap **13** is secured to the valve block **12** by screws **15** and the valve block **12** is secured to the rear end of the motor housing **11** by screws **12***a*.

The impact clutch mechanism (not shown) which is contained within the housing **10** may be of the general type disclosed in a copending application, Serial No. 660,348, filed on April 8, 1946, now Patent No. 2,564,224 issued August 14, 1951, to Walter G. Mitchell and Louis P. Fosnot. Such impact mechanism therein disclosed is of the cam-centrifugal type having a rotatable hammer member in which impact rods are mounted for slidable axial movement downwardly beyond the lower face of the hammer into impacting engagement with jaws formed in the upper surface of the spindle **14** by means of arcuate slots. The impact rods are engaged at their upper or rearward ends by centrifugal flyweights pivotally supported on the hammer and adapted to move the impact rods into engagement with the abutments on the spindle **14** upon acceleration of the hammer. A driving cam disk, secured to the lower end of the rotor of the pneumatic motor, drivingly engages the upper ends of the flyweights so that rotary motion of the motor is imparted to the hammer and the rods through the flyweights. By reason of the cam connection between the driving disk and the flyweights, the impact rods are withdrawn from engagement with the spindle **14** upon impact by the camming action whereas after such impact and withdrawal, the impact rods are returned into impacting engagement with the spindle upon renewed rotation of the hammer. Upon impact, the hammer and rods cease rotation due to the resistance of the work to the motor torque whereas the motor continues to operate but at a very greatly reduced speed, the speed of rotation of the motor upon said impact being suddenly and rapidly decelerated.

As shown more particularly in Fig. 1 of the drawings a grip handle **20** is secured to the under side of the motor housing **11** and at its lower end is provided with a fitting **21** whereby an air supply hose (not shown) may be connected with the tool. The supply of fluid pressure from the handle passage **22** to the air passage **23** in the valve block **12** is controlled by a spring biased throttle valve **24** mounted in the handle **20** and operable by a finger piece **26** slidably mounted in the upper forward portion of the handle **20**. The valve **24** is the main stopping and starting valve of the tool.

The air supply passage **23** is connected to a reverse valve **27** (Figs. 2 and 3) of the conventional type through a valve chamber **28** of a torque control valve **29** and through a short air passage **30**. The reversing valve **27** is cylindrical in form and extends horizontally of the valve block **12** and its rotary motion from one position to another is controlled by a finger piece **31** on the outer side of the valve block **12**. The reverse valve **27** is connected to the rotor chamber of the pneumatic motor by means of air passages **32** and **33** (Fig. 2), one of the passages supplying air to the motor for driving it in a clockwise direction and the other passage supplying air to the motor for driving it in a counterclockwise direction. Selection of the air passages **32** or **33** is accomplished by means of the reverse valve **27**.

The motor contained within the motor housing **11** may be of the conventional rotary pneumatic type comprising a plurality of slidable vanes mounted on a rotor **34** and adapted to rotate in a cylinder to which air may be supplied through either of the passages **32** or **33**. Inasmuch as the details of the rotary air motor comprise no part of the present invention, they are not shown in detail, and in Figs. 3, 4 and 5 of the drawings only the upper or rearward end of the rotor **34** is shown.

The rotor chamber is closed by an end plate **36** and the upper end of the rotor **34** extends therethrough and is supported by a bearing **37**. The end plate **36** has a rearwardly directed annular flange **38** having internal threads **39** to which is threadedly engage a retaining nut **40** which bears against the outer bearing race. Another retaining nut **35** is threadedly secured to a threaded portion **34***a* of the rotor **34** and bears against the inner race of the bearing **37**.

In the operation of the impact clutch mechanism contained within the housing **10** and described generally above, the impact rods remain in continuous engagement in the arcuate slots of the spindle at all times while the bolt is being run up to tightened position. However, when the resistance of the bolt to the motor torque increases, the impacting operation then begins and the impact rods are withdrawn by the cam action above described and, after acceleration, are returned into impacting engagement with the spindle **14** by the centrifugal flyweights. These impacting blows by the rods against the spindle are continued until the bolt approaches the desired degree of tightness. As the bolt gets tighter and tighter in the pieces of work, the greater will be the impacting shock, the greater will be the resistance of the work to the driving torque and the more sudden and rapid will be the deceleration of the tool. It is to be noted that with the impact clutch mechanism of my copending application that the rotor of the pneumatic motor does not entirely cease its rotation but its rotation is suddenly and quickly reduced from a high to a very low speed as the impact blow is given. In order to prevent the tool from operating and imparting impact blows against a bolt beyond the desired degree of tightness which would twist off the bolt head or destroy the threads or otherwise damage the parts being joined, there is provided a torque limiting or controlling device comprising a preferred embodiment of the present invention which is contained within the valve block **12** and the rear cap **13**. Such torque limiting mechanism will now be described.

Rearwardly of its threaded portion **34***a*, the rotor **34** is square as at **34***b* which is engaged in a square central opening **42***a* of an inertia cam **42** for driving the same. As shown more particularly in Fig. 5 of the drawings, the inertia cam **42** is provided with inverted V-shaped cam surfaces **43** on its rearward face which are in engagement with V-shaped cam surfaces **44** of an inertia ring or cap **46** having a central bore **47** in which is received the extreme rearward circular end **41** of the rotor **34**. The inertia ring **46** is adapted to rotate with the inertia cam **42** through interengagement of the cam surfaces **43** and **44**, respectively. But upon sudden and rapid reduction in the speed of rotation of the inertia cam **42** upon impact due to sudden and rapid deceleration of the rotor **34**, the inertia ring **46** is adapted to continue its rotation. However, as the inertia ring **46** continues in its rotation independently of the inertia cam **42** it is cammed rearwardly or to the right as viewed in Figs. 3, 4 and 5, being guided in this rearward movement by its slidable engagement on the more slowly rotating end **41** of the rotor **34**. Thus when the speed of rotation of the rotor **34** is suddenly reduced, the inertia ring **46** due to its inertia and the camming action suddenly jumps or is thrust rearwardly relative to the rotor and serves to actuate an auxiliary torque limiting valve **29**.

It is to be understood that upon each impact the inertia ring **46** jumps or is thrust a limited distance to the right and as the force or shock of the impacting blows become greater and greater, the distance to the right or rearwardly which the inertia ring moves as a result of such impacts will be correspondingly greater and greater. The inertia ring **46** is constantly urged to its forward or left-hand position as viewed in Figs. 3, 4 and 5 by a coil spring **48** which encircles the upper end of the inertia ring and bears against a thrust washer **49** in contact with the rear-

ward face of the inertia ring. The rearward end of the coil spring 48 seats against a thrust washer 50 disposed against the inner face of an annular spring ring 51 seated within an adjusting ring 52, the adjusting ring 52 being threadedly secured within an annular internally threaded insert 53. The threaded insert 53 is secured within a central bore or chamber 54 of the valve block 12 which contains the other parts of the torque limiting device aforementioned. The forward end 56 of the torque control valve 29 is in the form of a square and projects through a square opening 57 in the adjusting ring 52, the ring 52 being adapted for slidable movement relative to the squared valve end 56 upon axial adjustment of the ring 52 relative to the valve block insert 53 and permitting slidable movement of the valve 29 relative thereto. By threaded adjustment of the ring 52 the tension of the spring 48 against the inertia ring 46 may be varied so as to vary the desired degree of tightness at which the torque limiting device may become operable. The extreme forward end face of the end 56 of the valve 29 bears against the rearward end face of the inertia ring 46.

As shown more particularly in Figs. 2 and 5 of the drawings, a calibration arm 58 is secured to the annular ring 51 and projects radially therefrom through a slot 59 in the valve block insert 53 toward an opening 60 in the side of the valve block 12. The valve block 12 is cut away to provide a slot 61 in alignment with the opening 60 and in which the calibrating arm 58 may move axially of the tool upon adjustment of the ring 52. The outer end of the arm 58 has a cap 64 in alignment with a lens 62 having calibrations thereon indicating the tension to which the spring 48 has been set or, in other words, the desired degree of tightness of a bolt to which the torque limiting device comprising the present invention shall operate. The calibration lens 62 is covered by a transparent cover 63 threadedly secured in the opening 60 which also serves to seal the tool against the entry of dirt and dust.

In the rearward end of the valve block chamber 54 there is secured a bushing 66 and a valve stem bushing 67, such bushings forming the valve chamber 28 and supporting the torque control valve 29 for slidable axial movement. Inasmuch as the forward squared end 56 of the torque control valve 29 constantly bears against the rearward surface of the inertia ring 46 during the impacting operation of the tool, the valve 29 will correspondingly move rearwardly or to the right to a limited extent as viewed in Figs. 3, 4 and 5, every time the inertia ring 46 jumps or is thrust to the right a limited extent, and consequently when the desired degree of tightness of the bolt 17 is attained, the inertia ring 46 due to the sudden and rapid deceleration will thrust the torque control valve 29 the entire distance rearwardly until the valve shoulder 68 seats against the valve seat 69 formed in the forward end of the valve stem bushing 67. When the valve shoulder 68 of the valve 29 is so seated, incoming air from the air supply passage 23 is cut off from the reverse valve 27, and therefore no motive energy or operating air is supplied to the pneumatic motor. Thus, the tool ceases operation when the impacting blow is of sufficient severity or force, or in other words the deceleration is sudden and rapid enough due to increased resistance of the work to the driving torque, to cause the inertia ring 46 to move sufficiently far to close the torque control valve 29. When the tool motor is automatically shut off as aforesaid the operator thereby knows that the bolt has been set to the desired degree of tightness, he thereupon removes the tool from engagement with the bolt.

In order to retain the torque control valve 29 in closed position so that the air supply will be continued to be shut off from the motor until disengagement of the work may be accomplished, there is provided an over-the-center latching mechanism operably engaged with the rearward stem of the control valve 29 within a chamber 70 formed by the rear cap 13 and a rearwardly extending annular flange 71 of the valve block 12. This over-the-center mechanism, as shown more particularly in Figs. 3, 4 and 6 of the drawings, comprises an H-shaped plate 72 having a central opening 73 through which the valve stem extends. The valve control plate 72 is maintained against rearward longitudinal movement relative to the valve 29 by means of a retainer ring 74 secured to the stem of the valve 29. Cross pins 76 are secured in the bifurcated ends of the valve plate 72 and serve as pivotal supports for short connecting rods or pins 77 which are slidably mounted within small cylindrical housings 78. These housings 78 as shown in the drawings are disposed on diametrically opposite sides of the torque control valve 29 and contain coil springs 79 which are compressed between the inner ends of the housing 78 and an annular flange 80 on the connecting rods 77. The outer closed ends of the spring housings 78 are pivotally supported on the pins 81 projecting inwardly from the annular flange 71 of the valve block 12.

With this construction, the over-the-center units, comprising the spring housing 78 and the connecting pin 77, are pivoted at their respective ends so that upon movement of the valve control plate 72 and the valve 29 rearwardly, the units may assume the rearward position shown in Fig. 4. In this rearward position, the combined pressure of the springs 79 serves to hold the plate 72 and the torque control valve 29 beyond the center in rearward or valve closing position. When the over-the-center mechanisms are in the normal forward position of Fig. 3, the springs 79 maintain the units in that position so as to hold the valve 29 in open position, permitting operation of the motor. Thus, when the bolt 17 attains the desired degree of tightness, the inertia ring 46 will jump or be cammed rearwardly a sufficient distance and with sufficient force to overcome the spring tension of the over-the-center mechanism and to cause the same to be pivoted to the position of Fig. 4, in which condition the operator may remove the tool from the work without resumption of tool operation. The valve 29 remains in closed position until returned to normal position by the recycling mechanism which will now be described.

The recycling mechanism for restoring the valve 29 to normal open position is shown more particularly in Figs. 5 and 6 of the drawings and comprises a cross arm 82 slidably mounted on the hexagonal rearward end 83 of the torque control valve 29. The cross arm 82 on its forward side abuts against a shoulder 84 of the stem of the control valve 29 so that upon forward longitudinal movement of the cross arm 82 the valve 29 will be moved forwardly to normal open position. The connecting arm 82 is slidable on the hexagonal valve end 83 and is slidable from the forward position shown in Fig. 3 of the drawings to rearward position shown in Fig. 4 of the drawings, being in the latter position disposed within a cross slot 86 in the valve cap 13. The respective ends of the connecting arm 82 have the rearward ends of the stems of recycling valves or pistons 87 extending therethrough and they are operably engaged therewith by a pair of retainer rings 88 secured adjacent the ends of the valves 87. The recycling valves 87 are thus disposed in diametrically opposite positions on each side of the torque control valve 29 and they each are reciprocably mounted in bushings 89 secured in the valve block 12 and projecting rearwardly therefrom into the chamber 70. In each bushing 89 there is a coil spring 90 compressed between a rearward shoulder of the bushing 89 and the head 91 of the valve 87. The springs 90 thus constantly urge the recycling valves 87 and the connecting crossarms 82 forwardly so as to constantly urge the valve 29 to normal open position.

The valve chamber 92 in which the recycling valve 87 is reciprocable is connected to the main air supply passage 23 by means of a small air passage 93 which enters the valve chamber 92 between the forward end face there-

of and the head of the valve 87. The chamber 92 is also vented to the atmosphere by means of a more restricted air passage 94 which is cut through the side of the valve block 12. As shown in Fig. 5 of the drawings, the diameter of the restricted passage 94 is considerably smaller than the diameter of the small air passage 93 so that an air pressure may be built up within the chamber 92. When the tool is not in operation and the main air supply valve 24 is closed, the recycling mechanism is in the position shown in Figs. 3 and 5 of the drawings. However, when the main valve 24 is open and air passes through the air supply passage 23 to the rotor chamber, a portion of the air passes from the supply passage 23 into the valve chambers 92 of the recycling mechanism and forces the valves 87 rearwardly so as to move the cross connecting arm 82 away from the shoulder 84 of the valve 29 and into the rearward position in the cross slot 86 of the valve cap 13. Thereafter, while the air motor is in operation and air is passing through the supply passage 23 so as to maintain a pressure against the valve heads 91 of the valves 87, the cross arm 82 is held in its rearward position and remains there as long as the main air supply valve 24 is open.

However, after the over-the-center mechanism has moved under the thrusting force of the inertia ring 46 to its rearward position as shown in Fig. 4 to hold the valve 29 in closed position, the retainer ring 74 will engage the cross arm 82. When the tool thus ceases operation due to closing of the valves 29 as above described, the operator then removes the tool from the bolt, and as the next step, releases pressure from the finger piece 26 so as to permit the main air supply valve 24 to close. When this occurs, air pressure is cut off from the recycling valve chambers 92 permitting the springs 90 to return the recycling valves 87 to their forward positions. The valves 87 pull the connecting arm 82 forwardly which forces the torque control valve 29 also forwardly to open the same. As the valve 29 moves forwardly the over-the-center mechanism also is forced to assume the normal position shown in Fig. 3, and thereafter retains the valve 29 in open position.

As explained above, the torque to which the tool is to be adjusted to cease operation may be varied by the adjusting ring 52 which is threadedly engaged with the valve block insert 53 adapted for axial movement by rotation thereof. Rotation of the adjusting ring 52 is accomplished by rotation of the torque control valve 29 through the engagement of the square stem 56 of the valve 29 in the square opening 57 in the adjusting ring 52. Rotation of the torque control valve 29 may be accomplished by engagement of a hand tool (not shown) with the hexagonal rearward end 83 of the valve 29 upon removal of a screw cap 96 threadedly engaged in a central opening 97 in the rear cap 13. Thus as the valve 29 is rotated by the hand tool when adjustment of spring tension is desired, the ring 52 will move axially to effect axial movement of the spring plate 51 and consequently effect axial movement of the calibration arm 58. Thus when the adjusting ring 52 is moved forwardly by rotation of the valve 29, the tension of the spring 48 will be increased with the result that a greater thrust pressure will be required of the inertia ring 46 to effect rearward axial movement of the valve 29 to closed position. Because greater force is required for the inertia ring before the valve 29 is so closed, a greater impacting force against the bolt, or in other words a greater resistance of the work to the driving torque or a more rapid deceleration of the rotating parts, must be attained before the tool is shut off.

From the foregoing description of the structure and operation of the impact wrench shown in the drawings, it is apparent that a torque limiting or controlling device or mechanism has been provided which will cause automatic cessation of operation of the tool, even in the hands of an inexperienced operator and which will prevent the application of excessive destructive torque on a bolt, nut or other work. Not only is the torque limiting or controlling device entirely automatic in its operation for effecting cessation of tool operation, but the device is also capable of restoring automatically to normal position for normal tool operation. Furthermore, means are provided by which the torque limit may be varied in accordance with the requirements of the work being done so that bolts, nuts and the like may be set up to varying degrees of tightness.

It is to be understood, however, that the torque limiting mechanism, although shown and described in operable connection with the rotor spindle 34, could with equivalent results be operably engaged with any of the other moving parts of the wrench, including the various parts of the impact clutch mechanism, whose speed of rotation is also suddenly and rapidly reduced upon impact. The inertia cam could be operably connected with such other moving parts whose speed of rotation decelerates rapidly and suddenly upon increased resistance to the driving torque upon impact, and the thrust movement of the inertia ring to operate the control valve could be in a similar manner. Furthermore, the inertia member could be operably connected to a declutching mechanism whereby the motor could be declutched from the impact clutch when the proper degree of tightness is achieved. In addition, it is also apparent that the supply of motive energy to the motor need not be cut off entirely but could be reduced to a degree sufficient to reduce the driving torque of the motor but to permit continued operation thereof. It is likewise to be understood that the present invention could be quite readily adopted and applied to electrically operated impact wrenches wherein the inertia ring 46 could be utilized to actuate a cutoff switch rather than an air valve in order to cut off the supply of electricity or motive energy to the motor.

Although there has been described in detail above and illustrated in the drawings a preferred embodiment of the present invention, it is to be understood that changes and modifications may be made in the details of construction and operation thereof without departing from the spirit and scope of the appended claims.

We claim:

1. In a power actuated impact tool of the character described, a driving motor, a rotary impact clutch driven by said motor for transmitting the driving torque of the motor to tighten work engaged by the tool, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact and control means for limiting the application of the driving torque and operably responsive to a sudden deceleration of said rotating member resulting from a predetermined increased resistance of said work to said driving torque upon impact when said work is tightened to a predetermined degree, said control means including an element for forward rotation with said rotating member and for continued forward rotation relative to said member upon sudden deceleration of said rotating member for operation of said control means.

2. In a power actuated impact tool of the character described, a driving motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact and control means for stopping motor operation and operably responsive to sudden deceleration of said rotating member resulting from a predetermined increased resistance of said work to the driving torque of the motor upon impact when said work is tightened to a predetermined degree, said control means including an element for forward rotation with said rotating member and for continued forward rotation relative to said member upon sudden deceleration of said rotating member for operation of said control means.

3. In a power actuated impact tool of the character described, a driving motor, a rotary impact clutch driven

by said motor for tightening work engaged by the tool, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact and control means for stopping operation of the impact clutch and operably responsive to sudden deceleration of said rotating member resulting from a predetermined increased resistance of said work to the driving torque of the motor upon impact when said work is tightened to a predetermined degree, said control means including an element for forward rotation with said rotating member and for continued forward rotation relative to said member upon sudden deceleration of said rotating member for operation of said control means.

4. In a power actuated impact tool of the character described, a driving motor, means for supplying energy to said motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact and control means for limiting the supply of motive energy to said motor and operably responsive to sudden deceleration of said rotating member resulting from a predetermined increased resistance of said work to the driving torque of the motor upon impact when said work is tightened to a predetermined degree, said control means including an element for forward rotation with said rotating member and for continued forward rotation relative to said member upon sudden deceleration of said rotating member for operation of said control means.

5. In a power actuated impact tool of the character described, a driving motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, control means for limiting the application of the driving torque, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact and inertia means operably engaged between said control means and said rotating part member and adapted for forward rotation with said rotating member and for continued forward rotation ahead of said member upon impact at a predetermined increased resistance of the work to the driving torque to effect operation of the control means.

6. In a power actuated impact tool of the character described, a driving motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, control means for limiting the application of the driving torque and movable to and from torque limiting position, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact cam means rigidly connected with said rotating member, and inertia means operable between said cam means and said control means and engaged by said cam means for forward rotation therewith and for continued forward rotation ahead of said cam means and for movement in another direction upon impact at a predetermined increased resistance of the work to the driving torque to effect movement of the control means to torque limiting position.

7. In a power actuated impact tool of the character described, a driving motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, control means for limiting the application of the driving torque and movable to and from torque limiting position, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact cam means rigidly connected with said rotation member, and inertia means operable between said cam means and said control means and engaged by said cam means for forward rotation therewith and for continued forward rotation ahead of said cam means and for movement in an axial direction upon impact at a predetermined increased resistance of the work to the driving torque to effect movement of the control means to torque limiting position.

8. In a power actuated impact tool of the character described, a driving motor, means for supplying motive energy to said motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact and control means for limiting the supply of motive energy to said motor and responsive to a sudden deceleration of said tool resulting from a predetermined increased resistance of said work to the driving torque of the motor upon impact when said work becomes tightened to a predetermined degree, said control means comprising limiting means for limiting the supply of motive energy to said motor and inertia means operably engaged between said energy limiting means and said rotatable member for forward rotation with said rotatable member and continued forward rotation ahead of said member upon impact and adapted upon movement thereof to effect operation of said energy limiting means upon impact at said predetermined increased work resistance.

9. In a power actuated rotary impact tool of the character described, a driving motor, means for supplying energy to said motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, and control means for limiting the supply of motive energy to said motor and responsive to a sudden deceleration of said tool resulting from a predetermined increased resistance of said work to the driving torque of the motor upon impact when said work becomes tightened to a predetermined degree, said control means comprising limiting means for limiting the supply of motive energy to said motor, inertia means operably engaged with said limiting means and adapted to effect operation thereof upon impact, and rotary cam means subject to a sudden reduction in speed of forward rotation upon impact and having a cam element engaging said inertia means for driving the same but permitting continued forward rotation of said inertia means upon impact to effect operation of said energy limiting means.

10. In a power actuated impact tool of the character described, a driving motor having a rotor adapted to be reduced in speed of rotation upon impact, means for supplying motive energy to said motor, an impact clutch driven by said motor for tightening work engaged by the tool, and control means for limiting the supply of motive energy to said motor and responsive to a sudden deceleration of said rotor resulting from a predetermined increased resistance of said work to the driving torque of the motor upon impact when said work becomes tightened to a predetermined degree, said control means comprising limiting means for limiting the supply of motive energy to said motor and rotatable inertia means operably connected between said energy limiting means and said rotor and adapted upon impact to continue its forward rotation to effect operation of said energy limiting means at said predetermined increased work resistance.

11. In a power actuated rotary impact tool of the character described, a driving motor having a rotor adapted to be reduced in speed of rotation upon impact, means for supplying motive energy to said motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, and control means for limiting the supply of motive energy to said motor and responsive to a sudden deceleration of said rotor resulting from a predetermined increased resistance of said work to the driving torque of the motor upon impact when said work becomes tightened to a predetermined degree, said control means comprising limiting means for limiting the supply of motive energy to said motor and adapted to move to and from energy limiting position, inertia means operably connected with said limiting means and adapted to effect movement thereof upon impact, and cam means rigidly connected with said rotor and having a cam element engaging said inertia means for driving the same but permitting continued forward

rotation of said inertia means and movement thereof in another direction upon impact to effect movement of said energy limiting means.

12. In a power actuated impact tool of the character described, a driving motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact, control means for limiting the application of the driving torque and movable to torque limiting position, inertia means operably engaged between said control means and said rotating member and adapted for forward rotation with said rotating member and for continued forward rotation ahead of said member upon impact when said work becomes tightened to a predetermined degree to effect movement of said control means to torque limiting position and holding means for maintaining said control means in torque limiting position upon movement thereto.

13. In a power actuated impact tool of the character described, a driving motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact control means for limiting the application of the driving torgue and movable to torque limiting position, inertia means operably engaged between said control means and said rotating member and adapted for forward rotation with said rotating member and for continued forward rotation ahead of said member upon impact when said work becomes tightened to a predetermined degree to effect movement of said control means to torque limiting position, a holding means for maintaining said control means in torque limiting position upon movement thereto, and recycling means for returning said control means to torque limiting position.

14. In a power actuated rotary impact tool of the character described, a pneumatic motor, means for supplying a fluid under pressure to said motor for operation thereof, a rotary impact clutch driven by said motor for tightening work engaged by the tool, valve means movable to and from closed position for limiting the supply of fluid pressure to said motor, a rotating member adapted for forward rotation prior to impact and subject to sudden deceleration upon impact and inertia means operably engaged between said valve means and said rotating member and adapted for continued movement relative to said rotating member upon impact to effect closing movement of said valve when said work becomes tightened to a predetermined degree.

15. In a power actuated rotary impact tool of the character described, a pneumatic motor having a rotor adapted to be suddenly decelerated upon impact, means for supplying fluid under pressure to said motor for operation thereof, a rotary impact clutch driven by said motor for tightening work engaged by the tool, valve means movable to and from closed position for limiting the supply of fluid pressure to said motor, cam means rigidly connected with said rotor and rotatable therewith, and inertia means operably engaged with said cam means and engageable with said valve and adapted to be rotated forwardly by said cam means prior to impact and to rotate forwardly ahead of said cam means and to be cammed thereby in another direction upon impact to effect closing movement of said valve means.

16. In a power actuated rotary impact tool of the character described, a pneumatic motor having a rotor adapted to be decelerated upon impact, means for supplying fluid under pressure to said motor for operation thereof, a rotary impact clutch driven by said motor for tightening work engaged by the tool, valve means movable axially to and from closed position for limiting the supply of fluid to said motor, cam means rigidly connected with said rotor and rotatable therewith, and inertia means operably engaged with said valve and having a cam portion engageable with said cam means and adapted to be rotated by said cam means prior to impact and to rotate ahead of said cam means and to be cammed axially thereby upon impact to effect closing movement of said valve means.

17. In a power actuated rotary impact tool of the character described, a pneumatic motor having a rotor adapted to be decelerated upon impact, means for supplying fluid under pressure to said motor for operation thereof, a rotary impact clutch driven by said motor for tightening work engaged by the tool, valve means movable axially to and from closed position for limiting the supply of fluid to said motor, cam means rigidly connected with said rotor and rotatable therewith, inertia means operably engaged with said valve and having a cam portion engageable with said cam means and adapted to be rotated by said cam means prior to impact and to rotate ahead of said cam means and to be cammed axially thereby upon impact to effect closing movement of said valve means, and spring means urging said inertia means axially into engagement with said cam means and opposing axial movement of said inertia means.

18. In a power actuated rotary impact tool of the character described, a pneumatic motor having a rotor adapted to be decelerated upon impact, means for supplying fluid under pressure to said motor for operation thereof, a rotary impact clutch driven by said motor for tightening work engaged by the tool, valve means movable axially to and from closed position for limiting the supply of fluid to said motor, cam means rigidly connected with said rotor and rotatable therewith, inertia means operably engaged with said valve and having a cam portion engageable with said cam means and adapted to be rotated by said cam means prior to impact and to rotate ahead of said cam means and to be cammed axially thereby upon impact to effect closing movement of said valve means, and yieldable over-the-center retaining means for holding the valve means in closed position or in open position.

19. In a power actuated rotary impact tool of the character described, a pneumatic motor having a rotor adapted to be suddenly decelerated upon impact, means for supplying fluid under pressure to said motor for operation thereof, a rotary impact clutch driven by said motor for tightening work engaged by the tool, valve means movable to and from closed position for limiting the supply of fluid pressure to said motor and having a valve stem, cam means rigidly connected with said rotor and rotatable therewith, and inertia means operably engaged with said cam means and engageable with the stem of said valve and adapted to be rotated forwardly by said cam means prior to impact and to rotate forwardly ahead of said cam means and to be cammed thereby in another direction against the valve stem upon impact to effect closing movement of said valve means.

20. In a power actuated rotary impact tool of the character described, a pneumatic motor having a rotor adapted to be decelerated upon impact, means for supplying fluid under pressure to said motor for operation thereof, a rotary impact clutch driven by said motor for tightening work engaged by the tool, valve means movable axially to and from closed position for limiting the supply of fluid to said motor, cam means rigidly connected with said rotor and rotatable therewith, inertia means operably engaged with said valve and having a cam portion engageable with said cam means and adapted to be rotated by said cam means prior to impact and to rotate ahead of said cam means and to be cammed axially thereby upon impact to effect closing movement of said valve means, spring means urging said inertia means axially into engagement with said cam means and opposing axial movement of said inertia means, and yieldable retaining means for holding said valve means in open position and opposing movement thereof to closed position.

21. In a power actuated rotary impact tool of the character described, a pneumatic motor having a rotor adapted to be suddenly decelerated upon impact, means

for supplying fluid under pressure to said motor for operation thereof, a rotary impact clutch driven by said motor for tightening work engaged by the tool, valve means movable to and from closed position for limiting the supply of fluid pressure to said motor, cam means rigidly connected with said rotor and rotatable therewith, inertia means operably engaged with said cam means and engageable with said valve and adapted to be rotated by said cam means prior to impact and to rotate ahead of said cam means and to be cammed thereby in another direction upon impact to effect closing movement of said valve means, yieldable over-the-center retaining means for holding the valve means in closed position or in open position, and recycling means for returning said retaining means to valve opening position.

22. In a power actuated rotary impact tool of the character described, a pneumatic motor, a rotary impact clutch driven by said motor for tightening work engaged by the tool, means for supplying air under pressure to said motor for operation thereof, and including a manually operable air supply valve, automatic control means for limiting the supply of fluid pressure to said motor and responsive to sudden deceleration of the tool resulting from a predetermined increased resistance of said work to the driving torque of the motor upon impact when said work becomes tightened to a predetermined degree, said control means comprising a control valve movable to fluid limiting position upon said sudden deceleration, holding means for retaining said control valve in said fluid limiting position after impact, and recycling means for returning said control valve from limiting position comprising a member movable in one direction under fluid pressure upon opening of said manual air supply valve and movable in the other direction under spring pressure upon closing of said manual valve to effect opening of said control valve.

23. In a power actuated impact tool of the character described, a driving motor, a rotary impact clutch driven by said motor in a forward direction for tightening work engaged by the tool, control means for limiting the application of the driving torque and movable to and from torque limiting position, inertia means adapted for forward rotation prior to impact and for continued forward rotation and in an axial direction against said control means upon impact at a predetermined increased resistance of the work to the driving torque to effect movement of the control means to torque limiting position, spring means opposing movement of said inertia means toward said control means, and means for adjusting the tension of said spring means.

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