Sept. 14, 1965 J. M. CLAPP 3,205,992

AUTOMATIC THROTTLE TORQUE RESPONSIVE POWER TOOL

Filed Jan. 30, 1963 3 Sheets-Sheet 1

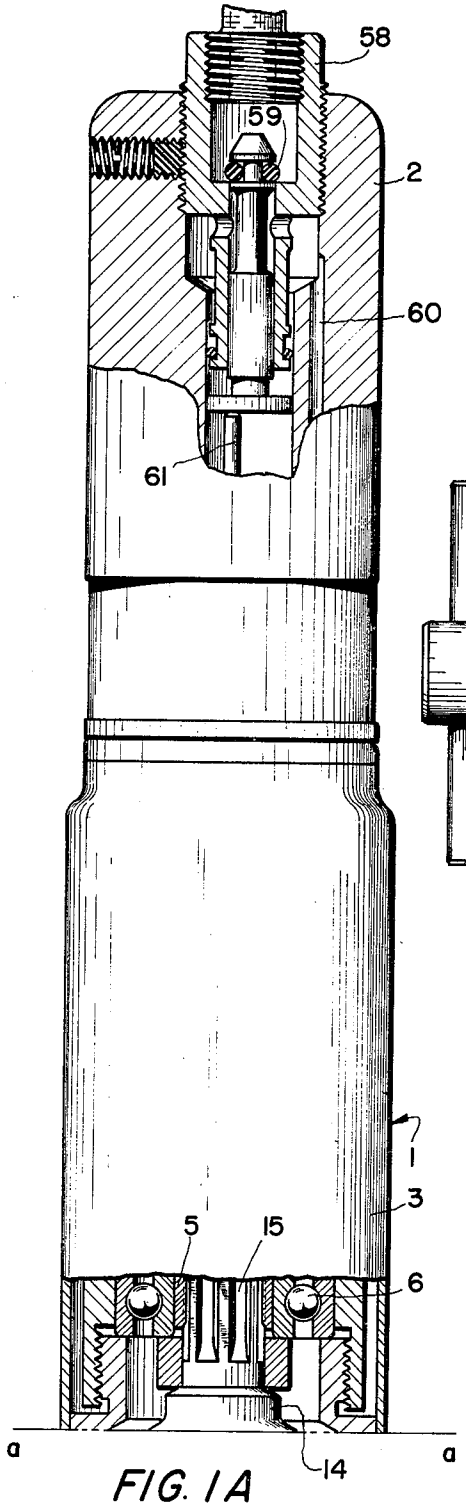


FIG. 1A

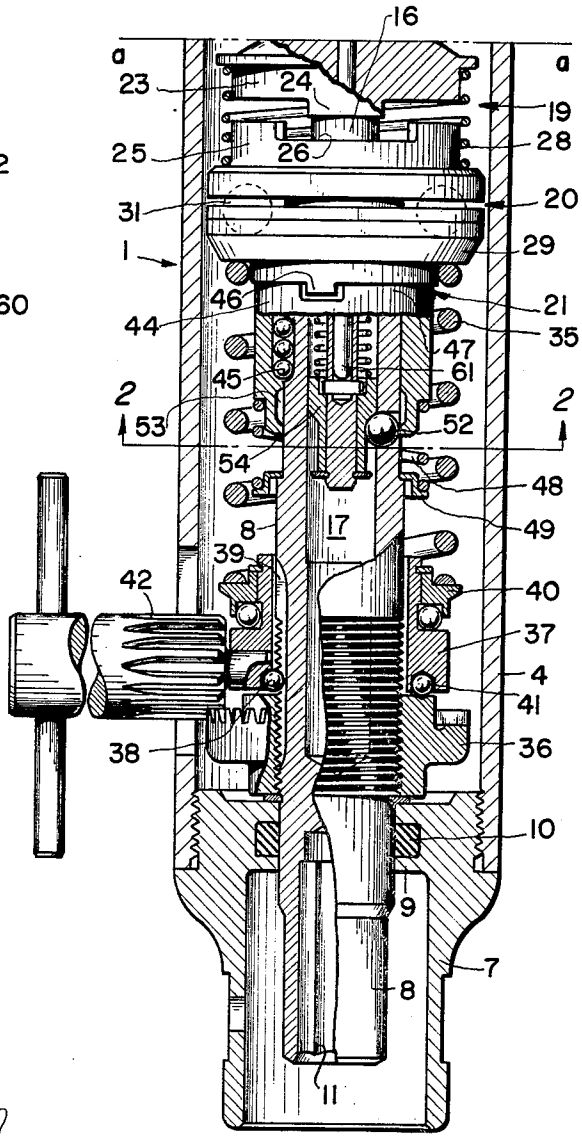


FIG. 1B

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Filed Jan. 30, 1963 3 Sheets-Sheet 2

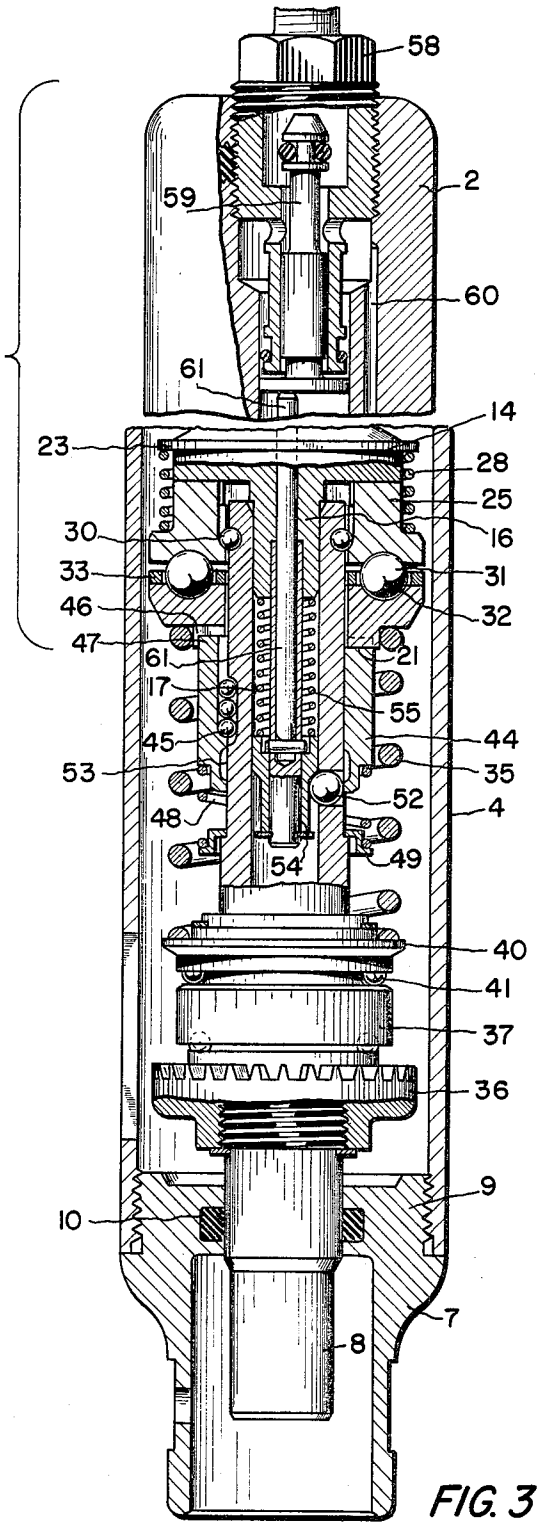


FIG. 3

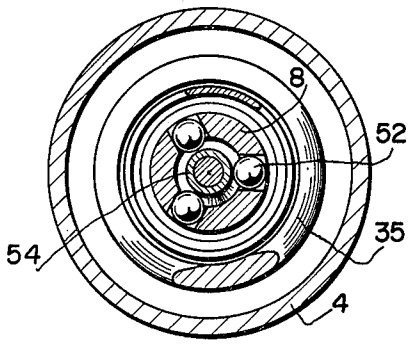


FIG. 2

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Filed Jan. 30, 1963 3 Sheets-Sheet 3

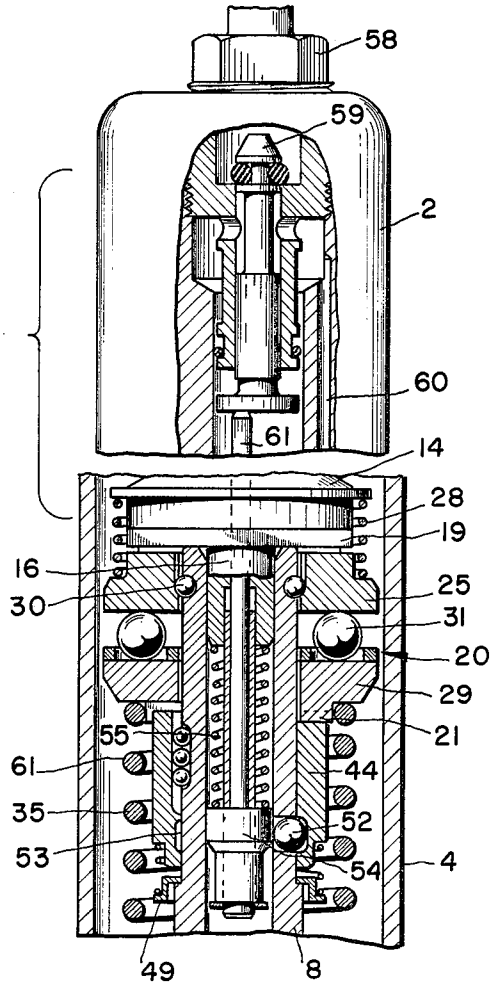


FIG. 4

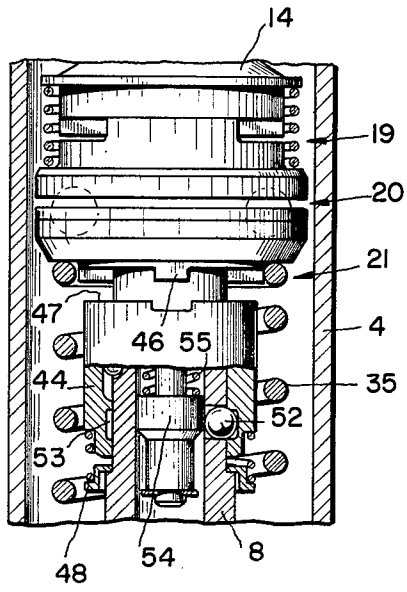


FIG. 5

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AUTOMATIC THROTTLE TORQUE RESPONSIVE POWER TOOL

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8 Claims. (Cl. 192—150)

This invention relates to the art of power-operated rotary tools such as power screwdrivers and power wrenches.

It is conventional to provide a power-operated screwdriver or the like with a torque-controlled clutch which automatically disconnects the tool spindle from its motor when the torque load on the spindle rises to a predetermined value. In addition, it is conventional to provide a compressed air-operated screwdriver with a throttle which automatically opens to start the screwdriver motor when it is pressed against a screw and closes to stop the screwdriver when it is withdrawn from a screw.

The principal object of this invention is to combine a torque-controlled clutch with a motor starting and stopping means whereby a tool using the combination will stop its motor and substantially simultaneously disconnect the motor from the spindle or bit when the torque load on the spindle rises to a predetermined value.

Another object is to combine a torque lock-out clutch with a motor throttle in a manner so that the lock-out means of the clutch moves the throttle between motor starting and stopping positions.

The objects of this invention are carried ont in a compressed air-operated screwdriver by mounting a torque operating clutch between the motor and screwdriver bit so that the clutch automatically opens and locks open when the torque load reaches a predetermined magnitude or value and by interconnecting the lock-out clutch means of the clutch to a throttle for the motor so that the throttle opens when the clutch is manually closed, during initial engagement of the screwdriver with a screw to be driven. When the screw is driven tight and the clutch opens under a selected torque load, the lock-out means of the clutch moves to locking position and simultaneously closes the throttle.

The invention is described in connection with the accompanying drawings wherein:

FIGS. 1A and 1B are broken portions of an elevational view of a screwdriver utilizing an embodiment of the invention, with parts being cut-away and shown in section, said view being broken along line *a—a*;

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

FIG. 3 is a longitudinal sectional and broken view of the tool of FIG. 1 showing the torque clutch closed and the motor throttle open;

FIG. 4 is a fragmentary and broken section showing the torque clutch as it starts to open under a predetermined maximum torque load; and

FIG. 5 is a fragmentary section showing the clutch after it has completed its opening movement.

The power-operated screwdriver 1 shown in the drawings includes a hollow cylindrical casing formed by a rear portion 2, an intermediate portion 3 and a front portion 4 threadedly connected to the intermediate portion 3. The rear casing portion 2 houses a conventional pneumatic motor (not shown) driving an output shaft 5 through a set of reduction gears (not shown) contained in the intermediate portion 3. The output shaft 5 is mounted at its front end on a bearing 6 carried by the front end of the intermediate casing portion 3. The front casing portion 4 includes a reduced diameter nose 7 on its front end. The nose 7 contains a conventional tool holder or spindle 8 which is rotatively mounted in and extends

through an integral partition 9 located at the rear of the nose 7. The tool holding spindle 8 is surrounded by an O-ring 10 for sealing purposes and contains a polygonal socket 11 adapted to receive various types of tools or fastener engaging tips (not shown), such as a screwdriver tip. All of the foregoing structure is conventional and usually found in power-operated screwdrivers.

The torque-release clutch mechanism of this invention provides a drive connection between the output shaft 5 and the tool holding spindle 8. It includes a short drive shaft 14 which extends axially into the rear part of the front casing portion 4 and has a splined rear end 15 seated in a cooperating splined socket in the output shaft 5, thus providing a fixed drive connection between the drive shaft 14 and the motor. The front end of the drive shaft 14 includes a reduced diameter stem 16 which extends forward therefrom and seats in an axial bore 17 in the rear end of the tool holding spindle 8 (as shown in FIG. 3). The reduced diameter stem 16 of the drive shaft 14 is free to slide and rotate in the axial bore 17 relative to the spindle 8.

The drive shaft 14 drives the tool holding spindle 8 through a series of three clutches designated in sequence, proceeding from the drive shaft 14 to the spindle 8, as follows: a "push-engaged" clutch 19, a "cam-thrust" clutch 20 and a "lock-out" clutch 21. These clutches are described hereafter in the above sequence.

"Push-engaged" clutch 19

The front end of the drive shaft 14 carries an enlarged disc 23 and a diametrically extending bar 24 projecting forward from the front face of the disc 23. A rear clutch plate 25 is rotatably mounted on the rear end of the spindle 8 and includes a pair of notches 26 on its rear face adapted to receive the diametrical bar 24 for establishing a driving connection between the drive shaft 14 and the rear clutch plate 25.

This driving connection is accomplished by the tool spindle 8 moving axially rearward in the casing, caused by the operator pushing the screwdriver 1 axially against its workpiece prior to the start of its operation. The "push-engaged" clutch 19 is formed by the notches 26 and the diametrical bar 24.

The tool holding spindle 8 is biased forwardly away from the main drive shaft 14 to keep the "push-engaged" clutch 19 normally disengaged, as shown in FIG. 1. This biasing force is provided by a compression spring 28, located between the drive shaft 14 and the rear clutch plate 25 and abutting annular shoulders provided on both of these elements. In using the screwdriver 1, an operator pushes the tool bit (not shown) axially forward against a workpiece, such as a fastener, with sufficient force to overcome the spring 28 and to force the tool holding spindle 8 axially rearward until the diametrical bar 24 on the drive shaft 14 is engaged in the notches 26 on the rear clutch plate 25, as shown in FIG. 3. This step places the screwdriver in condition for operation. At the end of a fastener turning operation, the operator relaxes the forward axial thrust on the screwdriver 1 and the tool holding spindle 8 moves forwardly to disengage the "push-engaged" clutch elements 24 and 26.

"Cam-thrust" clutch 20

An intermediate clutch plate 29 is rotatively mounted on the rear of the spindle 8 in front of the rear clutch plate 25. The rear clutch plate 25 rotates on ball bearings 30 engaging an annular groove on the rear end of the spindle 8; thus the bearings 30 prevent the rear clutch plate 25 from sliding rearwardly off the spindle 8.

The rear and intermediate clutch plates 25 and 29 are interconnected together by a series of circumferentially spaced balls 31 which seat in cooperating individual con-

cave seats 32 formed in the adjacent surfaces of both clutch plates 25 and 29. The balls 31 and seats 32 provide a driving connection between the two clutch plates 25 and 29 so long as the plates are pressed together and the balls 31 remain in their seats. The balls 31 are angularly spaced about the spindle 8 by a perforated retainer disc 33 located between the clutch plates 25 and 29. The balls 31 and seats 32 form the "cam-thrust" clutch 20.

The intermediate clutch plate 29 is biased against the rear clutch plate 25 by a heavy compression spring 35 which is engaged at its front end by an adjustment mechanism for varying the compression load on the spring 35. The compression force exerted by the heavy spring 35 tends to keep the balls 31 in their seats 32 during the transmission of a torque load through the "cam-thrust" clutch 20. When the torque on the clutch plates 25 and 29 reaches a predetermined magnitude, determined by the load on the spring 35, the balls 31 roll out of their seats 32 and cam-thrust the intermediate clutch plate 29 forwardly, against the spring 35, thus releasing the "cam-thrust" clutch 20. The magnitude of torque at which the balls 31 roll out of their seats 32 is changed by varying the compression load on the spring 35. The torque value at which the "cam-thrust" clutch 20 will release rises as the load on the spring 35 increases and drops as the spring load decreases.

The adjustment mechanism for the spring 35 includes a nut 36 threaded on the front end of the spindle 8, a collar 37 keyed on the spindle by means of a ball 38 sliding in a kerf 39, and a spring seat ring 40 rotatably mounted on the collar 37 by a ball bearing. Turning the nut 36 on the spindle 8 moves the collar 37 and ring 40 rearwardly or forwardly to increase or decrease the tension on the spring 35. The nut 36 is latched in an adjusted position by detent balls 41 mounted in the front face of the collar 37 and engaging detent cavities in the rear face of the nut 36.

The turning of the nut 36 on the spindle 8 is easily performed by means of a gear key 42, shown in FIG. 1, which engages gear teeth formed on the nut 36. The gear key 42 has an axial pin at its geared end which seats in radial holes formed in the collar 37 and is placed in its operative position by inserting it through an access hole in the casing. It will be understood that the key 42 is only used during the adjustment of the load on the spring 35.

"Lock-out" clutch 21

A front clutch sleeve 44 is keyed on the spindle 8 intermediate its ends by a plurality of key balls 45 seating in cooperating longitudinally-extending internal grooves formed in the sleeve 44 and external grooves formed in the spindle circumference. The sleeve 44 is free to slide axially on the spindle 8 for a limited distance and drives the spindle 8 through the key balls 45.

The intermediate clutch plate 29 is slidably and rotatively mounted on the spindle 8 rearwardly of the front clutch sleeve 44 and connected to the front clutch sleeve 44 through a series of interengaging notched or machicolated teeth or jaws 46 and 47 integrally formed on the plate 29 and sleeve 44, respectively. The interengaging jaws 46 and 47 form the "lock-out" clutch 21. The sleeve 44 and plate 29 can slide axially on the spindle 8 between positions wherein the "lock-out" clutch teeth 46 and 47 are engaged and positions wherein they are disengaged. When the teeth 46 and 47 are engaged, the clutch plate 29 drives the sleeve 44 and when disengaged, the clutch plate 29 is free to rotate relative to the sleeve 44.

The clutch sleeve 44 is biased rearwardly by a light spring 48 extending between the front of the sleeve 44 and a washer 49 abutting a circumferential shoulder on the spindle 8.

Means for holding "lock-out" clutch open

When the torque load transmitted by the "cam-thrust" clutch 20 reaches a predetermined value or magnitude, the balls 31 roll out of their seats 32 and force both the intermediate clutch plate 29 and the front clutch sleeve 44 to move forwardly on the spindle 8 to the forward position shown in FIG. 4. After this operation occurs, the front clutch sleeve 44 is locked in a forward position and the intermediate clutch plate 29 again moves rearwardly as the balls 31 drop into other ball seats 32, thus causing the engaged teeth 46 and 47 on the front clutch sleeve 44 and intermediate clutch plate 29 to separate from each other and open or break the drive connection of the "lock-out" clutch 21, as shown in FIG. 5.

The means for locking the rear clutch sleeve 44 in its forwardly clutch-open position shown in FIG. 5 includes a group of lock balls 52 carried in radial holes in the spindle 8 and biased outwardly into an annular groove 53 formed in the interior of the front clutch sleeve 44. The lock balls 52 are biased radially outward by a conical cam 54 sliding on the forward stem 16 of the drive shaft 14 and a compression cam spring 55 carried on the stem 16 and biasing the conical cam 54 forwardly against the lock balls 52.

The conical cam 54 is moved forward relative to the spindle 8 to bias the lock balls 52 outwardly by the relative forward movement of the stem 16 in the spindle bore 17 when the "push-engaged" clutch 19 is engaged (the stem 16 moves relatively in the bore 17 when the spindle 8 moves rearwardly). During the engagement of the "push-engaged" clutch 19, the cam 54 initially engages the lock balls 52 and stops moving forward while further forward movement of the stem 16 compresses the spring 55. When the "push-engaged" clutch 19 is disengaged, the conical cam 54 is moved rearward away from the lock balls 52 by the stem 16 to release its outward biasing force on the lock balls 52. This movement of the cam 54 relative to the stem 16 when the "push-engaged" clutch 19 is engaged and disengaged is accomplished by the cam 54 being mounted on the stem 16 by a limited slip joint. This limited slip joint is arranged to pull the cam 54 away from the lock balls 52 when the "push-engaged" clutch 19 is opened or disengaged.

Push-rod throttle

The tool is fed pneumatic fluid pressure through a supply hose attached to a fitting 58 mounted on the rear casing portion 2 of the tool. The pneumatic pressure flows from the fitting to a throttle valve 59 which controls the admission of the pressure to a motor supply passage 60. When the valve 59 is moved rearwardly to an open position, as shown in FIG. 3, pneumatic pressure flows past the valve 59 to the motor supply passage 60 and then to the motor (not shown). The flow of pneumatic pressure fluid into the passage 60 is stopped by moving the valve 59 forwardly to its seated position, as shown in FIG. 1. The fluid pressure in the fitting 58 acts as an air spring to hold the valve 59 in its closed position until such time that it is forced rearward to its open position.

The throttle valve 59 is opened by means of a push rod 61 which slides in an axial passage extending from the cam 54 through the stem 16, the drive shaft 14, the output shaft 5, the reduction gears and the motor to engagement with the throttle valve 59. The length of the push rod 61 is dimensioned to allow the throttle valve 59 to close when the "push-engaged" clutch is open, as shown in FIG. 1, and to force the throttle valve 59 open when the "push-engaged" clutch 19 is initially closed. When the "lock-out" clutch 21 opens, as shown in FIGS. 4 and 5, the cam 54 moves forward and allows the push rod 61 to move forward, thus releasing the throttle valve 59 whereby it can close and stop the operation of the fluid motor, as shown in FIG. 4.

Operation

Prior to the start of operation, the screwdriver **1** is in the condition shown in FIG. 1. Both of the "lock-out" and "cam-thrust" clutches **21** and **20** are closed and the "push-engaged" clutch **19** is open. The conical cam **54** is withdrawn from the lock balls **52** so that the lock balls **52** are not biased radially outward and the push rod **61** is allowed to move forward whereby the throttle valve **59** is closed; thus the motor of the screwdriver is stopped.

Before using the screwdriver **1**, the gear key **42** is used to turn the nut **36** until the heavy spring **35** is loaded to the desired magnitude, which determines the predetermined magnitude of torque under which the "cam-thrust" clutch **20** will open.

Initially, to tighten a fastener, the tool tip (not shown) is placed against the head of the fastener and the screwdriver **1** is pressed axially forward to force the tool holding spindle **8** axially rearward in the casing **2** and to engage the "push-engaged" clutch **19**.

As the "push-engaged" clutch **19** is initially engaged, the rearward movement of the spindle **8** causes the stem **16** of the drive shaft **14** to move relatively forward in the bore **17** of the spindle. This relative forward movement of the stem **16** moves the conical cam **54** into engagement with the lock balls **52** and compresses the cam spring **55**, thus biasing the lock balls **52** radially outwardly, as shown in FIG. 3. Since the front clutch sleeve **44** is in its rear position at this time, the balls **52** cannot engage the annular groove **53**, in the interior of the sleeve **44**. At this time, the lock balls **52** are "cocked" and ready to lock the sleeve **44** when it moves into its forward "lock-out" position.

During the initial engagement of the "push-engaged" clutch **19**, once the cam **54** engages the lock balls **52** and, as a result, is prevented from moving further forward in the bore **17** of the spindle **8**, further rearward movement of the spindle **8** pushes the cam **54** rearward and moves the push rod **61** rearward to open the throttle valve **59**. The opening of the throttle valve **59** admits fluid pressure to the passage **60** and thence to the operating motor, which begins to drive the drive shaft **14**.

As the drive shaft **14** rotates, its drive torque is transmitted through the "push-engaged" clutch **19**, the "cam-thrust" clutch **20** and the "lock-out" clutch **21** to the tool holding spindle **8**, thus driving the fastener inwardly into its hole. During this step, the parts of the clutch mechanism of the screwdriver **1** are arranged as shown in FIG. 3.

As the fastener is driven into place by the screwdriver **1** and "seated," the torque load on the "cam-thrust" clutch **20** rises rapidly until it reaches a magnitude sufficient to cause the clutch balls **31** to roll out of their seats **32** and, as a result, to cam-thrust the intermediate clutch plate **29** and the front clutch sleeve **44** rearwardly on the spindle **8**.

The magnitude of torque on the "cam-thrust" clutch **20** corresponds to the torque load on the fastener being tightened; hence, the fastener is fully tightened when the "cam-thrust" clutch **20** opens. When the front clutch sleeve **44** arrives at its fully retracted position, shown in FIG. 4, the lock balls **52**, previously placed under an outward biasing force, move outwardly into the annular groove **53**, to lock the clutch sleeve **44** in its forward retracted position.

Thereafter, the "cam-thrust" balls **31** move into other seats **32** and allow the intermediate clutch plate **29**, under the biasing force of the spring **35**, to return to its rearward seated position, thereby opening the "lock-out" clutch **21**, as shown in FIG. 5. In this condition, the drive train between the drive shaft **14** and the tool holding spindle **8** is broken and the drive shaft **14** is free to rotate without a torque load.

As the lock balls **52** move radially outward into the annular groove **53**, the cam **54** springs forward in the bore **17** of the spindle **8** to lock the lock balls **52** in their outer position and to allow the push rod **61** to move forward, as shown in FIG. 4. The forward movement of the push rod **61** closes the throttle valve **59** to shut off fluid pressure to the tool motor. Thus, the tool motor comes to a stop. Hence, the "lock-out" clutch **21** opens substantially simultaneously with the stopping of the tool motor. The opening of the clutch **21** prevents the motor from applying further torque to the fastener even though the motor may continue to turn for a short time after the fluid pressure is shut off.

The stopping of the tool motor signals the operator that the fastener is tightened properly and he removes the screwdriver **1** from the fastener, thus allowing the tool holding spindle **8** to move axially forward and open the "push-engaged" clutch **19**. The forward movement of the spindle **8** is accompanied by a corresponding relative rearward movement of the conical cam **54** away from the lock balls **52**. Thereafter, the lock balls **52** move radially inward and the "lock-out" clutch **21** closes, resulting in the screwdriver **1** returning to the condition shown in FIG. 1.

It will be understood that although only one embodiment of the invention is specifically described, the invention may embrace various other embodiments which are obvious from an understanding of the described embodiment and are embraced within the claims of the invention.

Having described my invention, I claim:

1. A power-operated tool comprising:

(a) a rotary motor;

(b) supply means for conducting motor-driving energy to said motor;

(c) control means having alternate positions and controlling said supply means so that in one position it prevents said energy from being supplied to said motor, and in its other position, it allows said energy to flow to said motor, said control means including biasing means urging said control means to said one position;

(d) a tool spindle adapted to be connected to a workpiece for applying a torque load to the workpiece;

(e) a torque responsive clutch interconnecting said spindle to said motor, said clutch being operative, in response to a predetermined torque load on said spindle, to open and disconnect said spindle from said motor so that said motor is free to continue turning without applying a torque to said spindle;

(f) said clutch including lock means movable to a position wherein it locks said clutch open, said lock means normally holding said control means in its other position during the operation of the tool while said clutch is engaged;

(g) and said lock means being operative, when it moves to a position locking said clutch open, to allow said biasing means to move said control means to said one position preventing said motor-driving energy from flowing to said motor.

2. The tool of claim **1** including:

(a) a normally disengaged clutch located between said spindle and said motor and operative to engage said spindle to said motor when the tool is pressed against a workpiece;

(b) and said lock means being operative, in response to the engagement of said normally disengaged clutch, to move said control means to said other position wherein said motor-driving energy can flow to said motor.

3. The tool of claim **2** wherein:

(a) said lock means is operative, in response to the disengagement of said normally disengaged clutch, to unlock said torque responsive clutch and allow it to return to its normally closed position.

4. A fluid-operated rotary tool comprising:

(a) a housing including a fluid-operated rotary motor;

(b) a supply passage for conducting power fluid to said motor;

(c) a control valve in said passage movable between alternate positions closing and opening said passage, said control valve including biasing means urging said control valve to a closed position;

(d) a tool spindle adapted to be connected to a workpiece for applying a torque load to the workpiece;

(e) a torque responsive clutch interconnecting said spindle to said motor, said clutch being operative, in response to a predetermined torque load on said spindle, to open and disconnect said spindle from said motor so that said motor is free to continue turning without applying a torque load on said spindle;

(f) lock means cooperating with said clutch and movable to a position wherein it locks said clutch open;

(g) said lock means being operative, when it moves to a position locking said clutch open, to allow said biasing means to move said control valve to its closed position wherein the valve prevents the power fluid from driving said motor.

5. The tool of claim **4** including:

(a) a normally disengaged clutch located between said spindle and said motor and operative to engage said spindle to said motor when the tool is pressed against a workpiece;

(b) and said lock means being operative, in response to the engagement of said normally disengaged clutch, to move said control valve to its open position to admit pressure fluid to said motor.

6. The tool of claim **5** wherein:

(a) said lock means is operative, in response to the disengagement of said normally disengaged clutch, to unlock said torque responsive clutch and allow it to return to its normally closed posiiton.

7. The tool of claim **6** wherein:

(a) said tool spindle is axially movable rearward during the engagement of said normally disengaged clutch;

(b) and said lock means includes latch elements mounted on said tool spindle to move axially rearward with it and a cam adapted to engage said latch elements and bias them radially outward when said normally disengaged clutch is closed.

8. The tool of claim **7** wherein:

(a) said cam is connected to said control valve by a rod so that the movement of said cam opens and closes said control valve.

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