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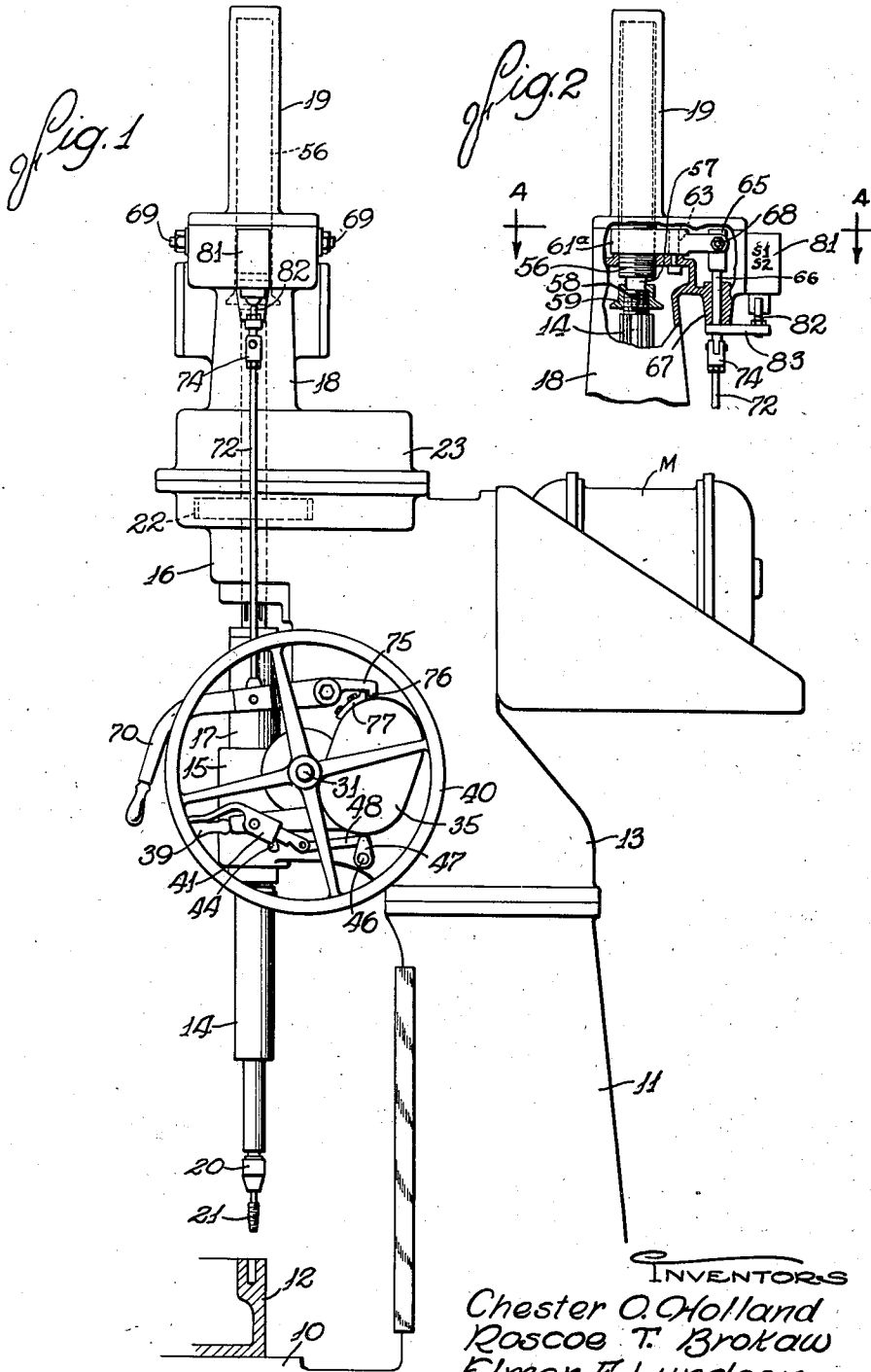
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2,279,462

COMBINED DRILLING AND TAPPING MACHINE

Filed April 1, 1940

4 Sheets-Sheet 1



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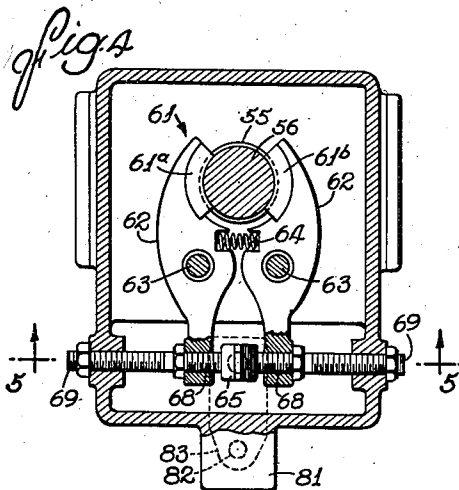
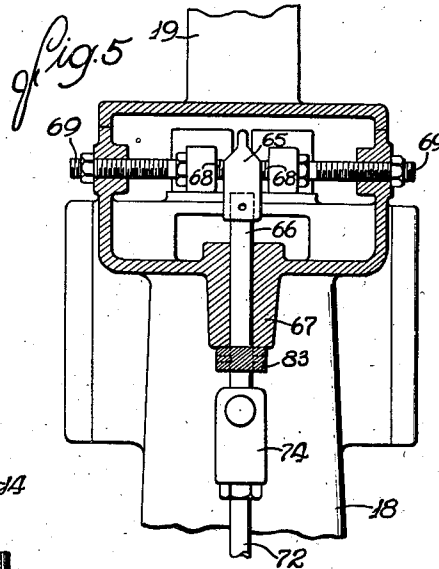
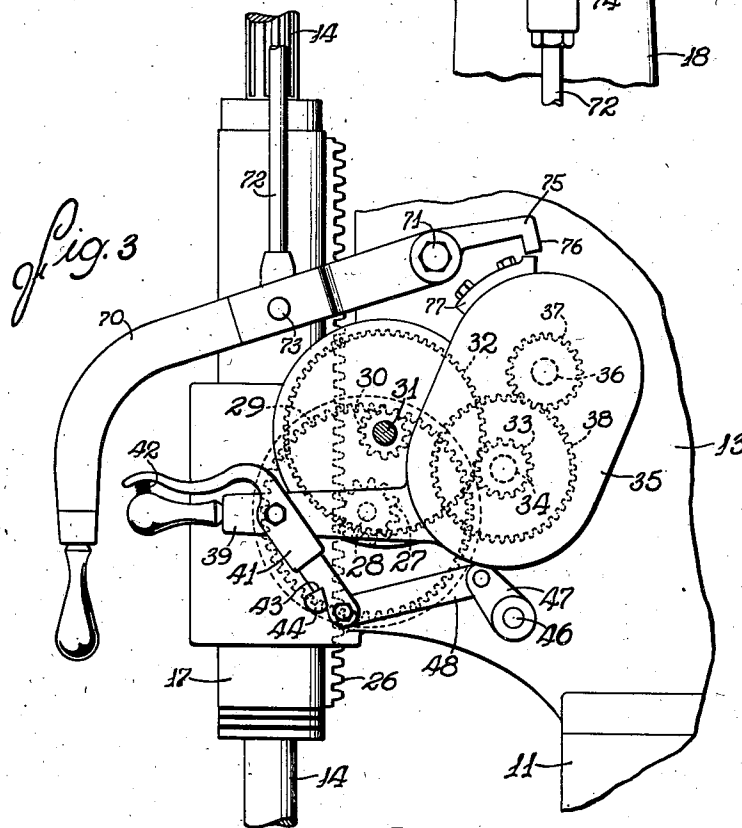
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4 Sheets-Sheet 2



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Fig. 6

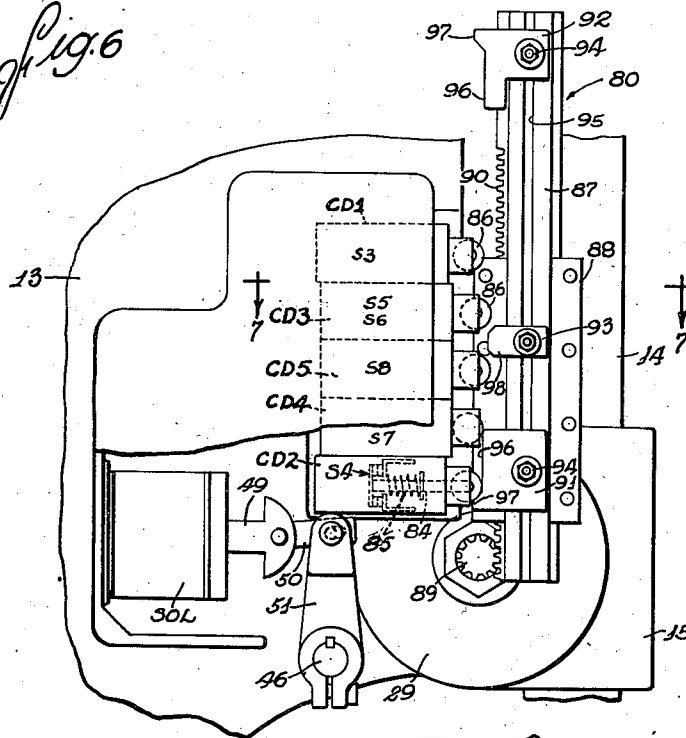
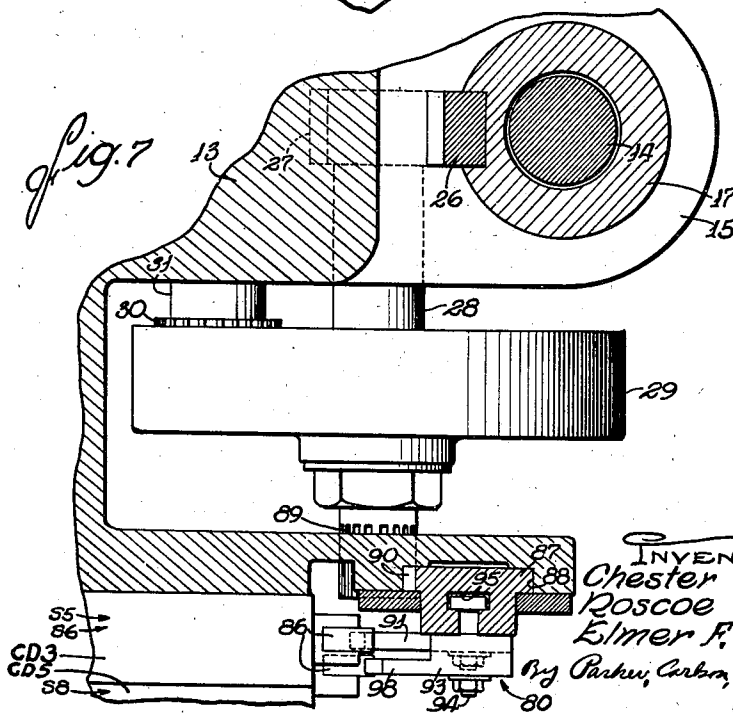


Fig. 7



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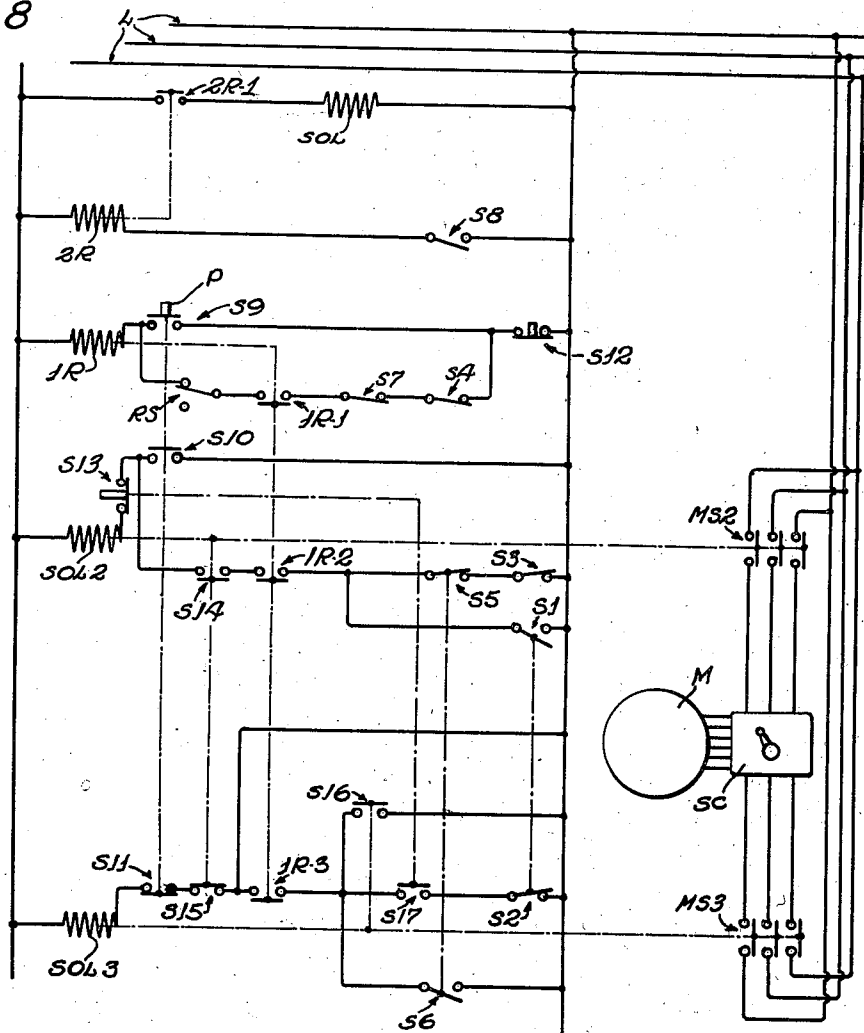
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4 Sheets-Sheet 4

Fig. 8



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UNITED STATES PATENT OFFICE

2,279,462

COMBINED DRILLING AND TAPPING
MACHINE

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Application April 1, 1940, Serial No. 327,132

19 Claims. (Cl. 10—136)

The invention relates to improvements in dual purpose machine tools and has particular reference to an improved machine tool for performing drilling and tapping operations.

One object of the invention is to provide improved spindle feeding mechanism for a drilling and tapping machine of the above general character which is selectively engageable to enable the machine to perform drilling operations with the speed and efficiency required by modern production methods and to perform tapping operations with the highest degree of precision.

Another object is to provide improved interlocking means for combined drilling and tapping machines operative to effectually prevent engagement of more than one feed mechanism at a time.

Another object is to provide novel control means for insuring proper sequence of operations when the machine is used for either drilling or tapping operations and embodying efficient and reliable safety means for preventing movement of the spindle beyond its prescribed limits when the machine is set for tapping operation.

A more specific object is to provide an improved drilling and tapping machine in which the tool spindle is adapted to receive feed movements from either a gear train or a lead screw.

Still another object is to provide a combined drilling and tapping machine of simple and sturdy construction which is efficient and reliable in operation and relatively inexpensive to manufacture.

Other objects and advantages of the invention will become apparent from the detailed description of the preferred embodiment illustrated in the accompanying drawings in which:

Figure 1 is a side elevational view of a combined drilling and tapping machine embodying the features of the invention.

Fig. 2 is a front view of the upper part of the machine with a portion of the housing broken away to show details of the tapping feed mechanism.

Fig. 3 shows a part of the drilling feed mechanism and the mechanical interlock as viewed from the right side of the machine.

Fig. 4 is a sectional view taken along the line 4—4 of Fig. 2 showing details of the tapping feed mechanism.

Fig. 5 is a sectional view taken along the line 5—5 of Fig. 4 showing details of the mechanism for engaging the tapping feed.

Fig. 6 shows a portion of the control mechanism as viewed from the left side of the machine.

Fig. 7 is a sectional view taken along the line 7—7 of Fig. 6.

Fig. 8 is a schematic diagram of the electrical operating and control circuits of the machine.

While we have shown and will hereinafter describe a preferred embodiment of the invention, it is to be understood that the invention is not limited to the particular form shown and that various modifications and adaptations in the machine structure, as well as changes in the form, construction and arrangement of the parts, may be made by those skilled in the art without departing from the spirit and scope of the invention as expressed in the appended claims.

In carrying out the invention, we construct the improved drilling and tapping machine along more or less conventional lines, but provide separate feed mechanisms for drilling and tapping respectively. As the machine is intended for production use, both feed mechanisms are desirably of the positive acting type. A geared feed has been found particularly suitable for drilling operations because of its ability to operate at a high production rate, its efficiency and reliability under such operating conditions, and the ease with which it can be adjusted to provide any desired rate of feed. For precision tapping, however, a more accurate feed is required than is practicably obtainable with a geared feed. The improved machine is accordingly provided with a tapping feed mechanism of the lead screw type which is capable of meeting the most rigid requirements for accuracy encountered under modern protection methods.

As both of the feed mechanisms above discussed are arranged to impart positive feed mechanism to the tool spindle, it is imperative to guard against their simultaneous engagement in order to avoid possible damage to the machine. The invention provides a simple, efficient and reliable interlocking mechanism for accomplishing this result by effectually locking either feed mechanism inoperative when the other mechanism is engaged.

To simplify the work of the operator and thus increase the productive capacity of the machine, the invention provides improved mechanical and electrical controls for governing the spindle feed in either drilling or tapping operations together with means for automatically conditioning the controls for the type of operation indicated by the particular feed mechanism engaged. Any possibility of damage to the lead screw and associated mechanism through overrunning of the spindle is effectually prevented by efficient and

reliable safety means incorporated in the controls. The mechanical portion of the controls is characterized by its wide range of adjustability and the ease and accuracy with which such adjustment may be effected.

Referring now to the drawings, the machine selected to illustrate the invention comprises generally a horizontal base 10 (Fig. 1) from which rises an upright pedestal or column 11. The base 10 in this instance serves as a support for a work piece 12 to be operated on by the machine. Rigidly secured to the top of the column is a head 13 in which a tool spindle 14 is mounted for rotation and for traverse movements toward and from the work support.

The head 13 comprises a hollow metal casting having a pair of vertically spaced extensions 15 and 16 projecting forwardly over the work support. The lower extension 15 constitutes a bearing for a vertically reciprocable sleeve 17 through which the spindle 14 extends. The spindle and sleeve are locked together in well known manner to prevent relative longitudinal movements while permitting the spindle to rotate freely in the sleeve. The upper end of the spindle passes through a suitable bearing in the extension 16 and through a housing 18 bolted or otherwise rigidly secured to the top of the casing 13, the housing being provided at its upper end with an elongated tubular cap 19 for protecting the upper end of the spindle. A suitable chuck 20 for holding a tool 21 such as a drill or tap, is removably secured to the lower end of the spindle.

In the exemplary machine, the tool spindle is adapted to be rotated in either direction through a splined driving connection with a gear 22 (Fig. 1) enclosed in a casing 23 formed by enlargements of the lower portion of the housing 18 and the adjacent portion of the head 13. The gear 22 may be driven in any suitable manner as by a reversible electric motor M through a train of gears enclosed in the head. The gear train may be similar to that shown in the Johnson et al, Patent No. 1,909,766, granted May 16, 1933.

While any suitable means may be utilized to impart feed movements to the spindle 14 for the drilling operation, it is preferred to employ a geared feed mechanism for the reasons hereinbefore explained. In the particular machine illustrated, such movements are imparted to the spindle through the sleeve 17 which, for this purpose, is provided with a longitudinally extending rack 26 (Figs. 3 and 7) meshing with a pinion 27 keyed to a cross feed shaft 28 journaled in the head 13.

The shaft 28 is arranged to be driven by the motor M through a train of gears including an internal gear 29 fast on the shaft which meshes with a pinion 30 fast on a parallel shaft 31 also journaled in the head 13. A gear 32 on the latter shaft is adapted to mesh with a gear 33 keyed to a stub shaft 34 which is journaled on a swinging housing 35 (Fig. 3) pivoted on a cross shaft 36 extending through the head 13 and projecting into the housing. A pinion 37 fast on the projecting end of the shaft 36 meshes with a gear 38 fast on the stub shaft 34 and thus serves to transmit power to the stub shaft and gear 33 without interfering with the movement of the housing about its pivot. The arrangement is such that the housing may be swung from the active position shown in Fig. 3 in which the gears 32 and 33 are in mesh to the inactive position shown in Fig. 1 in which the gear 33 is withdrawn from mesh with the gear 32. These gears thus consti-

tute the driving and driven members of a make-and-break clutch for engaging or disengaging the drilling feed mechanism. To facilitate engagement and disengagement of the clutch gears, the casing is provided with a rigid hand lever 39 projecting forwardly to the front of the machine for convenient access by the attendant.

The shaft 36 is arranged to be driven by the motor M through a suitable gear train which may be similar to that shown in the Johnson et al. patent above referred to. Accordingly the motor acts to impart a positive feed movement to the sleeve 17 and spindle 14 when the clutch gears are engaged. The return of the spindle may be effected either by reversing the motor or by manipulation of a hand wheel 40 (Fig. 1) fast on a shaft 31. When the spindle is returned manually, the clutch gears are disengaged by swinging the housing 35 to inactive position.

Suitable trip means is provided for locking the housing 35 in its active or clutch engaging position. This means, as herein shown, comprises a latch lever 41 pivotally mounted on the handle 39. One arm of the latch lever extends forwardly along the handle and is yieldably urged upwardly therefrom by a suitable spring 42. The other arm of the lever extends downwardly and rearwardly and in its lower edge is cut a notch 43 operative when the handle 39 is raised to the clutch engaging position shown in Fig. 3 to engage a stud 44 rigidly mounted on the head 13 and thus hold the handle in its raised position.

The latch lever 41 may be released from the stud 44 at any time to disengage the clutch gears by manually depressing the upper end of the lever. Means is also provided for automatically releasing the latch lever at the limit of the feed stroke so that the spindle may be quickly returned to its normal withdrawn position by operation of the hand wheel. The automatic releasing means as herein shown comprises a rock shaft 46 (Figs. 3 and 6) journaled in the head 13 and having at one end a rigid arm 47 connected by a link 48 with the lower end of the latch lever. Thus, when the shaft is rocked in a clockwise direction (as viewed in Fig. 3) the latch lever is drawn rearwardly to disengage the notch from the stud 44 and finally the housing 35 is swung to the inactive position in which the parts occupy the positions shown in Fig. 1. For rocking the shaft 46 a solenoid SOL (Figs. 6 and 8) is mounted within the head 13 and its armature 49 is connected by a link 50 with a crank arm 51 fast on the shaft. The means for energizing and deenergizing the solenoid constitutes a part of the control mechanism to be described in detail hereinafter.

While the spindle feed mechanism above described may be utilized for tapping, it is not entirely satisfactory where a high degree of precision is required because of the virtual impossibility of eliminating all backlash from gear trains of this character. This difficulty is avoided in the improved machine by the provision of a separate tapping feed mechanism of the lead screw type. To this end the upper portion of the tool spindle 14 is formed with screw threads 55 having a lead corresponding to that of the thread to be cut in the work.

While the tool spindle may be constructed in one piece, a sectional construction is preferred so that the threaded portion may be interchanged as required for different tapping requirements. As shown in Fig. 2, the screw threads

55 are cut in an elongated member or bar 56 having a reduced end portion 57 fitting into a complementary socket of the upper end of the spindle. The parts may be locked together in any suitable manner as by a key 58 inserted through registering transverse slots in the bar and spindle. A sleeve or nut 59 encircling the upper end of the spindle prevents accidental displacement of the key.

Cooperating with the lead screw is a split nut 61 (Fig. 4) enclosed within the housing 13 and rigidly held against movement longitudinally of the lead screw. The nut, as herein shown, comprises opposed arcuate sections 61a and 61b each carried on the inner end of a lever 62. The levers are arranged with their inner ends disposed on opposite sides of the lead screw and are pivoted intermediate their ends as at 63 for movement only in a plane perpendicular to the axis of the lead screw. A spring 64 interposed between the levers normally tends to spread the inner ends apart so as to open up the nut sections and disengage them from the lead screw.

Suitable means is provided for rocking the levers 62 to close the nut sections together on the lead screw and thus initiate feed of the tool spindle, the direction of such movement depending, of course, upon the direction of rotation of the spindle. This means preferably comprises a generally wedge shaped cam 65 carried on the upper end of a vertically disposed rod 66 slidably supported for endwise movement in a bearing 67 formed in one side of the housing 13. The parts are so positioned that the cam may be inserted between the outer ends of the levers 62 by upward movement of the rod 66 to cam them apart and thus close the nut sections together. Upon withdrawal of the cam by downward movement of the rod, the spring 64 acts to open the nut sections and disengage the feed.

As herein shown, each of the levers 62 is provided at its outer end with a hardened contact member in the form of a screw 68 positioned for engagement by the cam 65. These members tend to minimize wear and provide a convenient means of adjusting the range of movement of the levers. Adjustable stop screws 69 threaded into the housing 13 cooperate with the heads of the screws 68 to limit the closing movement of the nut sections and thus prevent application of excessive pressure to the lead screw so that unnecessary wear of the lead screw and nut is avoided.

In the exemplary machine, the means provided for shifting the rod 66 between feed engaging and disengaging positions comprises a hand lever 70 pivoted as at 71 on the head 13 and projecting toward the front of the machine for convenient access by the attendant. An operative connection between this lever and the rod 66 is provided by a rigid link 72 secured to the lever at its lower end by a pivot pin 73 and to the rod at its upper end by a shackle or connector 74. The arrangement is such that the tapping feed mechanism is engaged when the forward end of the lever is raised and disengaged when the lever is depressed.

A simple and reliable mechanical interlock is provided for preventing movement of the hand lever 70 to feed engaging position when the drilling feed mechanism is engaged and also acting to prevent movement of the drilling feed hand lever 39 to feed engaging position when the tapping feed is engaged. To this end the lever 70 is formed on its inner end with a rigid exten-

sion 75 (Figs. 1 and 3) having a downwardly bent tip constituting a latch finger 76 adapted to cooperate with a latch lug 77 bolted or otherwise rigidly secured to the top of the swinging housing 35. As explained hereinbefore, this housing is swung between active and inactive positions by the hand lever 39 to engage and disengage the drilling feed mechanism. When the hand lever is lowered to shift the housing to the inactive position as shown in Fig. 1, the latch lug 77 is moved forwardly out of the path of the finger 76 so that the hand lever 70 may be raised to engage the tapping feed mechanism. In this movement of the lever 70, the finger is interposed in the path of the lug and thus acts to lock the housing in the inactive position so that the drilling feed mechanism cannot be engaged. Upon depression of the lever 70 to disengage the tapping feed mechanism, the finger 76 is withdrawn from the path of the latch lug so that the housing 35 may be swung to the active position shown in Fig. 3. In this position, the latch lug is disposed in blocking relation to the finger and thus acts to prevent movement of the lever 70 to its raised position. Accordingly, engagement of both the feed mechanisms with the spindle at the same time is positively blocked and damage to the mechanisms or spindle through careless operation or accidental movement of either feed lever is effectually avoided.

While the improved drilling and tapping machine may be operated entirely by manual control if desired, to better adapt it for production use the invention provides a novel control system for governing the movements of the tool spindle in both drilling and tapping operations. To this end there is provided a series of control devices with associated mechanical actuating means 80 (Figs. 6 and 7) operated in synchronism with the movements of the spindle. In addition the invention provides means for automatically conditioning the control system for either drilling or tapping operations in accordance with the particular feed mechanism engaged with the spindle.

The conditioning means in its preferred form comprises a control device herein shown as an electrical contactor including a pair of switches S1 and S2 (Fig. 8) enclosed in a switch box 81 mounted at one side of the housing 13 as shown in Figs. 2 and 4. The switches are arranged to be actuated by an upstanding pin 82 carried by a radially projecting arm 83 rigidly secured to the cam rod 66. As previously explained, the rod is shifted up and down to engage and disengage the tapping feed. With the rod in its upper or feed engaging position, the switch S1 is open and the switch S2 is closed. When the rod is shifted to its lower or feed disengaging position switch S1 is closed and switch S2 is opened.

In the exemplary machine the series of control devices for the control system include two safety control devices CD1 and CD2 for guarding against overrun of the tool spindle at the limits of the working stroke, two limit controls CD3 and CD4 for determining the limit positions of the spindle when the machine is used for tapping and a single limit control CD5 for determining the lower limit position of the spindle when the machine is used for drilling. While these control devices may be of any suitable character, they are herein shown as electrical contactors having one or more switches arranged in a circuit organization as shown in Fig. 8. Each device has a plunger or operating member 84 yieldably held in an unoperated position as by a

spring 85 and having at its outer end a cam follower roller 86 by which it may be shifted to operated position as will appear presently.

The particular type of switches incorporated in the control devices will depend, of course, upon the control functions to be performed. These functions will be described later with reference to the circuit diagram of Fig. 8. To obtain a clear understanding of the mechanism for actuating the devices it will be sufficient to point out at this time that the safety control devices CD1 and CD2 are provided with switches S3 and S4, respectively. Limit control device CD3 is provided with two switches, one switch S5 being normally closed and the other switch S6 being normally open. Limit control device CD4 has a single normally closed switch S7 while limit control device CD5 has a single normally open switch S8. As herein shown, these devices are arranged in a horizontal position one above the other at the left side of the head 13, with their respective operating members facing forwardly. Safety controls CD1 and CD2 are set back slightly so that their cam rollers 86 are normally located rearwardly of the corresponding rollers of the other control devices as shown in Fig. 6. Limit control device CD5 is offset laterally with respect to the other controls so that its cam roller 86 lies in a different vertical plane from that of the other rollers as may be best seen in Fig. 7. The purpose of this arrangement is to enable the actuating mechanism 80 to actuate the various switches at the proper times and under predetermined operating conditions.

The actuating mechanism 80, in its preferred form comprises a reciprocating member in the form of an elongated bar 87 of generally T-shaped cross section slidably supported for endwise movement in a similarly shaped guideway 98 in one side wall of the head 13. Suitable means is provided for shifting the member through a stroke proportioned to the range of movement of the tool spindle 14 and in synchronism therewith. This means, as herein shown, comprises a pinion 89 on the outer end of the cross feed shaft 28 which meshes with rack teeth 90 cut in the inner edge of the member.

Mounted on the member 87 are a plurality of operating elements or stops arranged to coact with the control devices to actuate the same as an incident to the reciprocation of the member. In the particular embodiment illustrated, three such stops are provided, namely upper and lower tapping limit stops 91 and 92 and a drilling limit stop 93. Adjustability is obtained by securing the stops to the member by means of headed bolts 94 engaging in a T-slot 95 extending longitudinally of the member.

The stops 91 and 92 are arranged to project rearwardly of the member 87 and are formed to present cam surfaces 96 and 97 located in different vertical planes. The cam surfaces 96 in this instance are positioned to engage the rollers 86 of the control devices CD3 and CD4, respectively, to control the direction of feed of the spindle in the tapping operation. Due to the offset location of the safety control devices CD1 and CD2, the cam surfaces 96 are ineffective to actuate their respective plungers, such actuation being effected by the cam surfaces 97 in the event that the first mentioned controls fail to function properly. The limit stop 93, as herein shown, is formed with a rearwardly projecting cam portion 98 which is offset laterally with respect to the cam surfaces of the companion stops 91 and 92

so as to cooperate only with the cam roller of the control device CD5.

The control functions of the various control devices will be readily understood by reference to the circuit diagram shown in Fig. 8. Referring to the drawing, it will be observed that current from a power line L is supplied to the motor M through a conventional speed controller SC and either of two motor starting switches MS2 or MS3, actuated respectively by solenoids SOL2 and SOL3. These switches are arranged in circuits so that the motor runs in a direction to feed the tool spindle downwardly when switch MS2 is closed by energization of the solenoid SOL2. Closure of switch MS3 by energization of the solenoid SOL3 causes the motor to run in the reverse direction and feed the tool spindle upwardly.

When the machine is to be used in the performance of a tapping operation, the tapping feed mechanism is engaged by manipulation of the hand lever 70 as above explained. As an incident to the engagement of the tapping feed switch S1 is opened and switch S2 is closed. Limit stops 91 and 92 are set, of course, to define the desired limits of the spindle stroke while stop 93 is either removed or turned to inactive position. The work piece is suitably secured to the work support.

An operating cycle in which the tool spindle is operated through feed and return strokes and then stopped, is initiated by actuation of a manually operable push button P to momentarily close switches S9 and S10 and to open switch S11. Closure of switch S3 completes an energizing circuit by way of a normally closed manually operable stop switch S12 for a cycle control relay 1R. This relay on energizing closes its three switches 1R-1, 1R-2 and 1R-3. The switch 1R-1 completes a holding circuit for the relay, which circuit includes stop switch S12, safety switch S4, limit switch S7, and a running switch RS.

Momentary closure of the switch S10 by operation of the push button P completes an energizing circuit for the solenoid SOL2 in series with a normally closed manually operable switch S13. The solenoid on energizing closes the motor switch MS2. It also closes a holding switch S14 and opens a switch S15 to prevent energization of the solenoid SOL3. Upon release of the push button P the solenoid is maintained energized over a circuit including the safety switch S3, limit switch S5, cycle control relay switch 1R-2, switch S14 and manually operable switch S13.

Closure of the motor switch MS2 starts the motor to feed the spindle downwardly. This feed movement continues until the stop 92 engages the control device CD3 to open the limit switch S5 and close the limit switch S6. Opening of the switch S5 interrupts the holding circuit of the solenoid SOL2 which becomes deenergized and opens the motor switch MS2. Closure of the limit switch S6 completes an energizing circuit for the solenoid SOL3 by way of the cycle control relay switch 1R-3, switch S15 and switch S11. Solenoid SOL3 closes the motor switch MS3 and restarts the motor in the reverse direction. It also completes a holding circuit for itself by closing switch S16.

The motor M accordingly drives the spindle in a direction to impart upward movement thereto, such movement continuing until the stop 91 actuates the control device CD4, thus opening the limit switch S7 which is included in the holding

circuit for the cycle control relay. The relay accordingly becomes deenergized and opens the circuit for the solenoid SOL3 at its switch 1R—3. Thus the motor is stopped with the spindle in its upper position so that the completed work piece may be removed and another one substituted preparatory to another operating cycle.

Means is provided for interrupting the downward feed of the spindle and initiating an upward feed at any point in the cycle. This means comprises the manually operable switch S13 with which is mechanically associated a normally open switch S17. The first of these switches when actuated opens the circuit of a solenoid SOL2 to deenergize the same and open the motor switch MS2. Closure of the switch S17 completes an energizing circuit for the solenoid SOL3 by way of the conditioning switch S2. Solenoid SOL3 locks over the circuit previously described and continues the return feed of the spindle until the limit switch S7 is operated to stop the machine.

In the event that either limit switch S5 or S7 fails in the performance of its function above described, safety switches S3 and S4 take over the control of the machine. Thus, if limit switch S5 fails to open at the end of the downward feed stroke, continued downward movement of the spindle results in stop 92 actuating control device CD1 to open the safety switch S3. This safety switch interrupts the holding circuit for the solenoid SOL2 which becomes deenergized and opens the motor switch MS2 to interrupt the downward feed. If switch S6 has been closed, as would normally be the case under these conditions, solenoid SOL3 is energized to initiate return movement of the spindle. The cycle is interrupted in the usual manner when the spindle reaches its upper limit position by the limit switch S7. In the event that limit switch S7 fails to stop the upward feed of the spindle, stop 91 actuates the control device CD2 to open safety switch S4 and thus interrupt the holding circuit for the cycle control relay 1R. This relay accordingly becomes deenergized and stops the machine as previously explained.

To change the machine over for drilling, the tapping feed is disengaged by means of the hand lever 70, thereby causing change over switch S1 to close and switch S2 to open. Stop 93 is set to define the lower limit position of the tool spindle while stops 91 and 92 may be shifted to positions in which they do not engage their associated control devices in the working stroke and spindle. Closure of the switch S1 completes a shunt circuit around the limit switch S5 and safety switch S3 while the opening of the switch S2 opens the energizing circuit for the solenoid SOL3 and thus prevents energization of this solenoid either under control of the limit switch or under the control of the manually operable switch S17.

The operating cycle for drilling comprises a feed movement of the spindle which is permitted to remain in its lower position without, however, stopping the driving motor. The cycle is initiated by actuation of the push button P to close the switches S9 and S10. Closure of the switch S9 energizes the cycle control relay 1R as previously explained, while switch S10 energizes the solenoid SOL2. The relay and solenoid lock up over the holding circuits previously described and motor M is run in a direction such as to impart downward feed movement to the spindle. When the spindle reaches the lower end

of its working stroke, stop 93 engages the control device CD5 to close the limit switch S8. Switch S8 completes a circuit for a control relay 2R which on energization closes its switch 2R—1 to complete an energizing circuit for the clutch releasing solenoid SOL. This solenoid operates, as previously explained, to withdraw the latch lever 41, and thus disengage the clutch gears 32 and 33. The spindle therefore dwells at the lower end of its stroke and may be quickly returned to its upper position by manipulation of the hand wheel 40. It will be appreciated, of course, that a spring or similar quick acting means may be utilized for returning the spindle if desired.

In setting up the machine for operation, it is sometimes desirable to impart feed movements to the spindle without initiating a full operating cycle. The running switch RS is provided for this purpose. As before explained this switch is included in the holding circuit for the cycle control relay 1R. When the running switch is open, the cycle control relay and solenoid SOL2 are energized only so long as the push button P is held actuated. Accordingly, feed of the spindle is discontinued as soon as the push button is released.

It will be apparent from the foregoing that the invention provides an improved drilling and tapping machine having separate drilling and tapping feed mechanisms which adapt the machine for performing drilling operations with high speed and efficiency as well as for precision tapping. The machine may be conditioned for either type of operation by simple manual operations and, through the medium of novel interlocks, improper engagement of the drilling and tapping feeds is effectually avoided. The invention also provides a novel control system for a combined drilling and tapping machine which is automatically conditioned for the type of operation to be performed in accordance with the particular feed mechanism engaged. The control system materially simplifies work of the attendant and provides safety features which effectually guard against damage to the machine or work by the spindle overrunning either limit of the working stroke.

We claim as our invention:

1. In a machine tool having a rotatable and reciprocable tool spindle, in combination, a power driven shaft for imparting reciprocatory movements to the spindle, control mechanism including an elongated member slidably supported for endwise movement, control devices for governing the movements of the spindle, safety control devices for stopping the machine, positively acting means for reciprocating said member through a stroke proportioned to the stroke of the spindle and in synchronism therewith including a toothed rack on the member, a pinion on said shaft meshing with said rack, and a pair of stops adjustably mounted on the member operable in the normal movements of the member to actuate said first control devices alternately to determine the limits of the working stroke of the spindle, said stops operating to actuate one or the other of said safety control devices upon movement of the spindle beyond the limits determined by said first devices.

2. In a machine tool having a rotatable and reciprocable tool spindle, the combination of a control mechanism including an elongated member slidably supported for endwise movement, means for reciprocating said member through a

stroke proportioned to the stroke of the tool spindle and in synchronism therewith, a pair of electrical switches for controlling the direction of movement of the spindle, a pair of safety switches for stopping the machine, a pair of switch actuating members adjustably supported on said member for operating the switches of said first pair alternately to determine the limits of the working stroke of the spindle, and means on said actuating members for actuating one or the other of said safety switches in the event that the spindle moves beyond either limit position.

3. In a machine tool having a rotatable and reciprocable tool spindle, the combination of a control mechanism including an elongated member slidably supported for endwise movement, means for reciprocating said member through a stroke proportioned to the stroke of the tool spindle and in synchronism therewith, a pair of control devices for controlling the direction of movement of the spindle, a pair of safety control devices for stopping the machine, and a pair of stops adjustably mounted on said member operable to actuate said first control devices alternately as the spindle approaches opposite ends of its working stroke, said stops additionally serving to actuate one or the other of said safety control devices in the event that the spindle moves beyond either limit of its working stroke.

4. In a machine tool having a rotatable and reciprocable tool spindle, the combination of a control mechanism including an elongated member slidably supported for endwise movement, means for reciprocating said member through a stroke proportioned to the stroke of the tool spindle and in synchronism therewith, a series of electrical switches for governing the movements of the spindle, and adjustable means carried by the member for actuating said switches as an incident to the movements of the member.

5. In a machine tool having a rotatable and reciprocable tool spindle, the combination of a control mechanism including an elongated member slidably supported for endwise movement, means for reciprocating said member through a stroke proportioned to the stroke of the tool spindle and in synchronism therewith, control devices for governing the movements of the spindle, and a plurality of stops adjustably mounted on said member operable to actuate the devices in response to the reciprocation of the member.

6. In a machine tool of the class described, in combination, a tool spindle, a lead screw rigid with the spindle, a stationary nut cooperating with the lead screw, power driven means for rotating the spindle in either direction, control devices operable alternately to reverse the direction of rotation of the spindle and thereby determine the limit positions of the spindle, and means operable to stop the machine in the event that the spindle passes either limit position.

7. In a machine tool having a rotatable and reciprocable tool spindle, in combination, a power driven shaft for imparting reciprocatory movements to the spindle, control mechanism including an elongated member slidably supported for endwise movement, control devices for governing the movements of the spindle, means carried by said member for actuating said devices, means for reciprocating said member in synchronism with the reciprocation of the spindle including a toothed rack rigid with the member, and a pinion fast on said shaft meshing with said rack.

8. In a combined drilling and tapping ma-

chine, in combination, a rotatable and reciprocable tool spindle, tapping feed mechanism for imparting feed movements to the spindle, drilling feed mechanism for imparting feed movements to the spindle, a control system for controlling the movements of the spindle by either mechanism including control devices operable in different orders for drilling and tapping respectively, manually operable means for engaging either feed mechanism with the spindle selectively, and means actuated by said manually operable means for conditioning the control devices for operation in the order corresponding to the feed mechanism engaged.

9. In a combined drilling and tapping machine, in combination, a rotatable and reciprocable tool spindle, tapping feed mechanism for imparting feed movements to the spindle, drilling feed mechanism for imparting feed movements to the spindle, a control system for controlling the movements of the spindle by either mechanism including a control device for governing the direction of spindle rotation, manually operable means for engaging the first feed mechanism, other manually operable means for engaging the second feed mechanism, and control means actuated by said first manually operable means for conditioning the control system for either a drilling or a tapping operation.

10. In a combined drilling and tapping machine, in combination, a rotatable and reciprocable tool spindle, tapping feed mechanism for imparting feed movements to the spindle including a lead screw, drilling feed mechanism for imparting feed movements to the spindle including a train of gears, manually operable means for engaging said tapping feed mechanism, other manually operable means for engaging the drilling feed mechanism, and a mechanical interlock associated with said manually operable means for preventing engagement of more than one feed mechanism at a time.

11. In a combined drilling and tapping machine, in combination, a rotatable and reciprocable tool spindle, tapping feed mechanism for imparting feed movements to the spindle including a lead screw rigid with the spindle, a stationarily supported split nut cooperating with the lead screw, means tending to hold said nut disengaged from the lead screw, manually operable means for closing the nut to engage the lead screw and thereby initiate feeding of the spindle, a drilling feed mechanism including a make-and-break clutch operative when engaged to impart feed movements to the spindle, manually operable means for engaging and disengaging said clutch, and mechanical interlocking means effective to prevent operation of said first manually operable means when said clutch is engaged and to prevent operation of said second manually operable means when said nut is closed.

12. In a machine tool of the class described, in combination with an upright frame, a head mounted on said frame, a spindle having a sleeve mounted for endwise movement in the head, a rack on said sleeve, a cross feed shaft journaled in the head and having a pinion meshing with said rack, power driven means for rotating said shaft, a clutch interposed between said shaft and said power driven means, manually operable means for engaging said clutch, latch means for holding the clutch engaged, said clutch being disengaged upon release of said latch, latch releasing means, a control device for initiating op-

eration of said latch releasing means, an actuator for said control device including a member mounted for reciprocation on said head, means for reciprocating said member in synchronism with the reciprocation of said spindle including a rack on the member, and a pinion on said cross feed shaft meshing with said rack.

13. In a machine tool of the class described, in combination, an upright frame, a head mounted on said frame, a spindle having a sleeve mounted for endwise movement in the head, a rack on said sleeve, a cross-feed shaft journaled in the head and having a pinion meshing with said rack, a train of gears including a clutch for driving said shaft, a hand lever for engaging and disengaging the clutch, a lead screw rigid with said spindle, a nut having oppositely facing sections disposed on opposite sides of the lead screw, a pair of levers supporting said nut sections for movement only in a plane perpendicular to the axis of the lead screw, spring means acting on said levers to urge the nut sections out of engagement with the lead screw, a cam operable to close the nut sections together on the feed screw, a hand lever for operating said cam, and interlocking means effective to prevent operation of both hand levers at the same time.

14. In a machine tool of the class described, in combination, an upright frame, a head mounted on said frame, a spindle having a sleeve mounted for endwise movement in the head, a rack on said sleeve, a cross-feed shaft journaled in the head and having a pinion meshing with said rack, a train of gears including a clutch for driving said shaft, a hand lever for engaging and disengaging the clutch, a lead screw rigid with said spindle, a nut having oppositely facing sections disposed on opposite sides of the lead screw, a pair of levers supporting said nut sections for movement only in a plane perpendicular to the axis of the lead screw, spring means acting on said levers to urge the nut sections out of engagement with the lead screw, a cam operable to close the nut sections together on the feed screw, a hand lever for operating said cam, and latch members movable with the respective hand levers, said members coacting to hold either hand lever inoperative when the other hand lever is operated.

15. In a machine tool of the class described, in combination, an upright frame, a head mounted on said frame, a rotatable tool spindle having a sleeve supported for endwise movement in the head, a rack on said sleeve, an elongated control member slidably supported for endwise movement, a cross feed shaft journaled in the head having pinions meshing with said racks to reciprocate the spindle and the control member in timed relation, a plurality of control devices mounted on the head adjacent said member, an operating member for each device, certain of said devices being disposed in offset relation to the other devices with their respective operating members located in different planes, and a stop mounted on said control member for reciprocation therewith having offset cam surfaces engageable respectively with the operating members in the different planes.

16. In a machine tool of the class described, in

combination, an upright frame, a head mounted on said frame, a rotatable tool spindle having a sleeve supported for endwise movement in the head, a rack on said sleeve, an elongated control member slidably supported for endwise movement, a cross feed shaft journaled in the head having pinions meshing with said racks to reciprocate the spindle and the member in timed relation, a first pair of control devices each having an operating member disposed in a common plane parallel to the reciprocating path of the control member, a second pair of control devices located on opposite sides of said first pair, said second pair of control devices having operating members disposed in a common plane parallel to but spaced from said first plane, a pair of stops mounted on the control member and reciprocable therewith, a cam surface on each stop engageable with the operating member of one of said first control devices as the tool spindle approaches opposite ends of its working stroke, and another cam surface on each stop engageable with the operating member of one of said second control devices when the tool spindle moves beyond the end of its working stroke.

17. A machine tool having, in combination with a reciprocable tool spindle, power driven means for reciprocating the spindle, control devices operative to determine the direction of movement of the spindle by said power driven means, a reciprocable member operable to actuate said control devices, means for positively driving said member in synchronism with the movements of the spindle comprising, a cross shaft arranged to be driven by the spindle in its reciprocation, and means providing a positive driving connection between said cross shaft and said member.

18. A machine tool of the class described having, in combination, a reciprocable tool spindle, a cross shaft geared to said spindle, a first feed mechanism for imparting feed movements to the spindle through said cross shaft, a second feed mechanism for imparting feed movements to the spindle independently of said cross shaft, control means for controlling the movements of the spindle by either mechanism, and means operated by said cross shaft for actuating said control means.

19. A machine tool of the class described having, in combination, a reciprocable tool spindle, a first feed mechanism for imparting feed movements to the spindle, a second feed mechanism for imparting feed movements to the spindle, an electrical control system operative to control the movements of the spindle by either mechanism, a first member operable manually to engage said first feed mechanism, a second member operable manually to engage said second feed mechanism, interlocking means associated with said members for preventing operation of both members at the same time, and switch means actuated by one of said members for conditioning said control system for operation with the particular feed system engaged.

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