

May 6, 1947.

S. E. WOODBURY

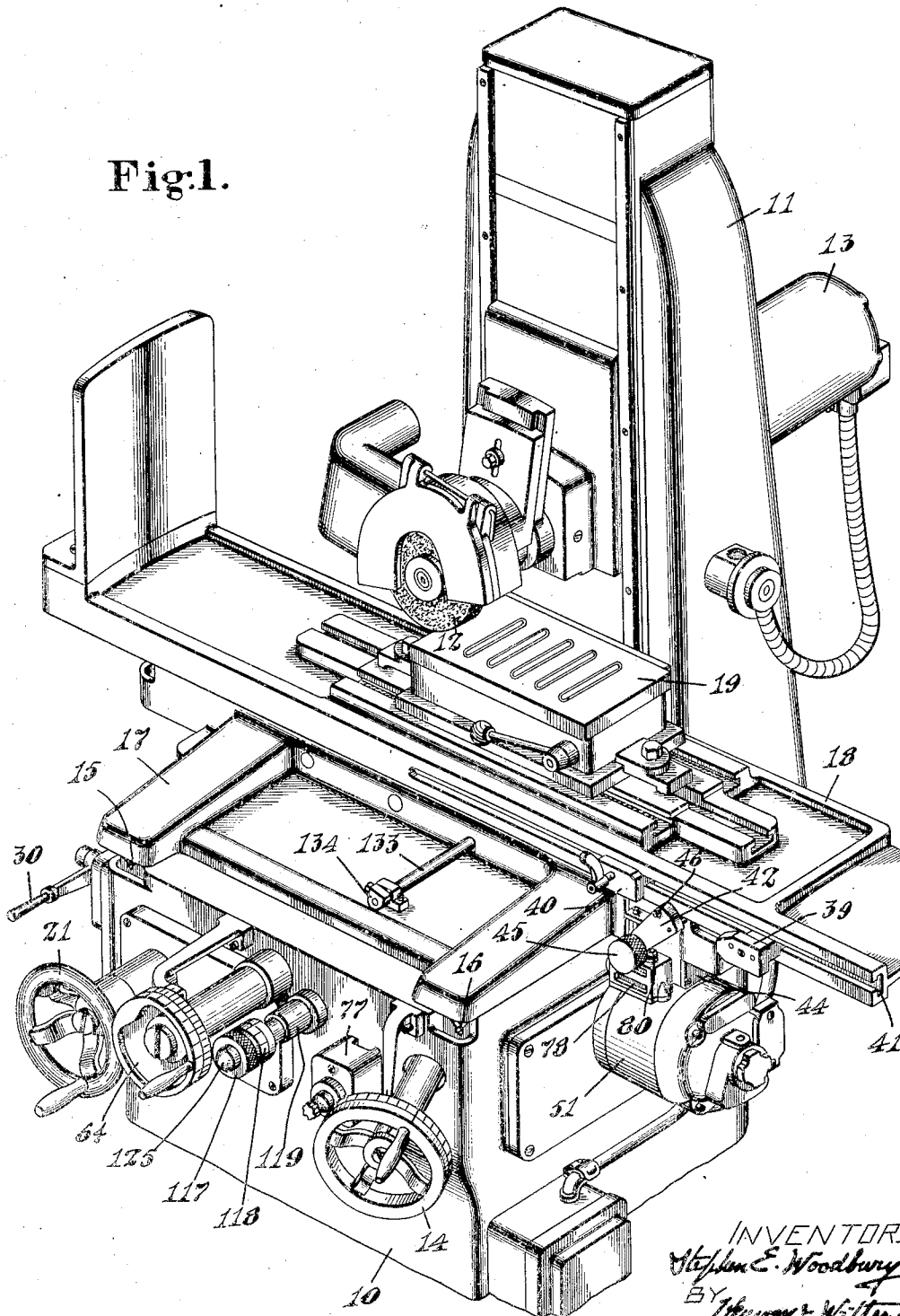
2,420,024

GRINDING MACHINE

Filed Aug. 8, 1945

4 Sheets-Sheet 1

Fig.1.



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4 Sheets-Sheet 2

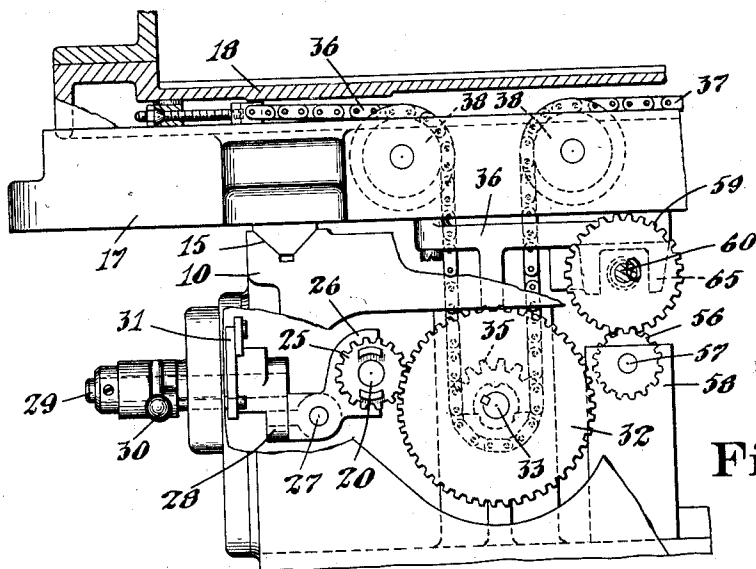


Fig. 2.

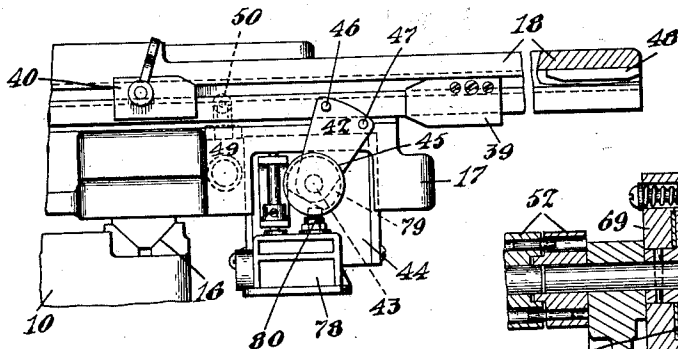


Fig. 3.

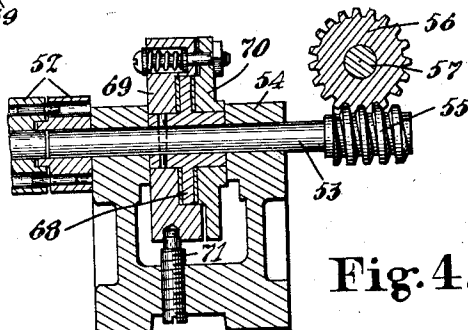


Fig. 4.

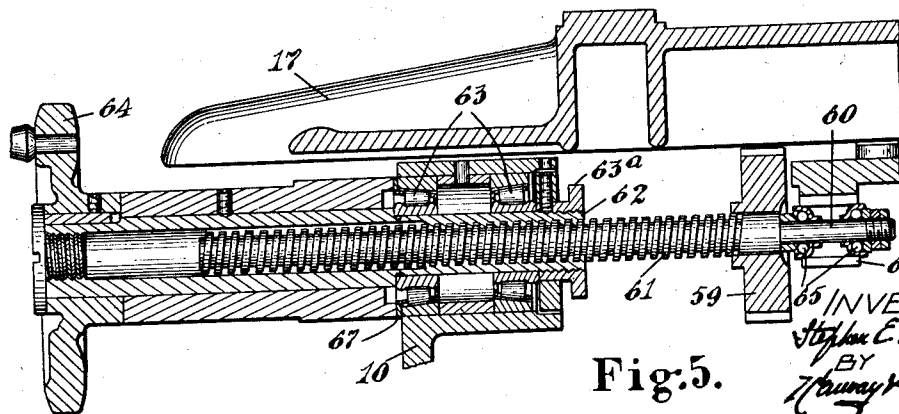


Fig. 5.

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4 Sheets-Sheet 3

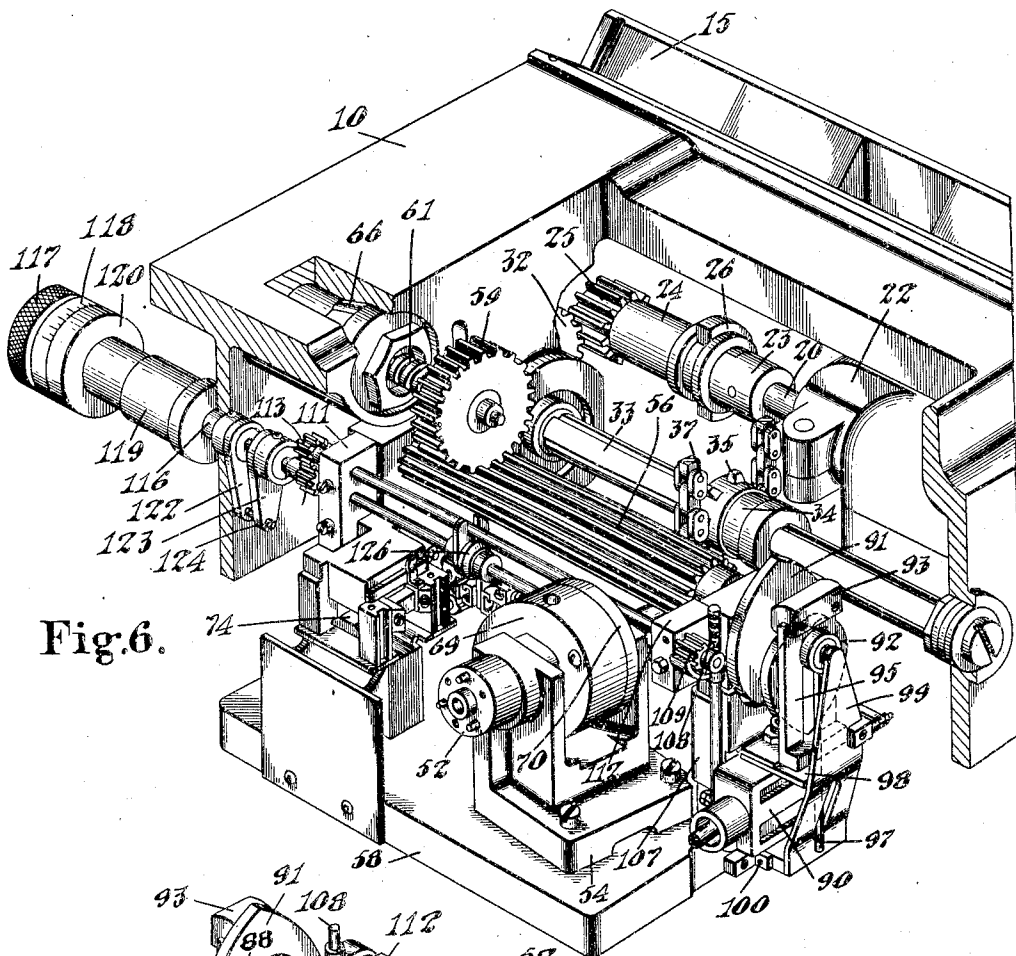


Fig.6.

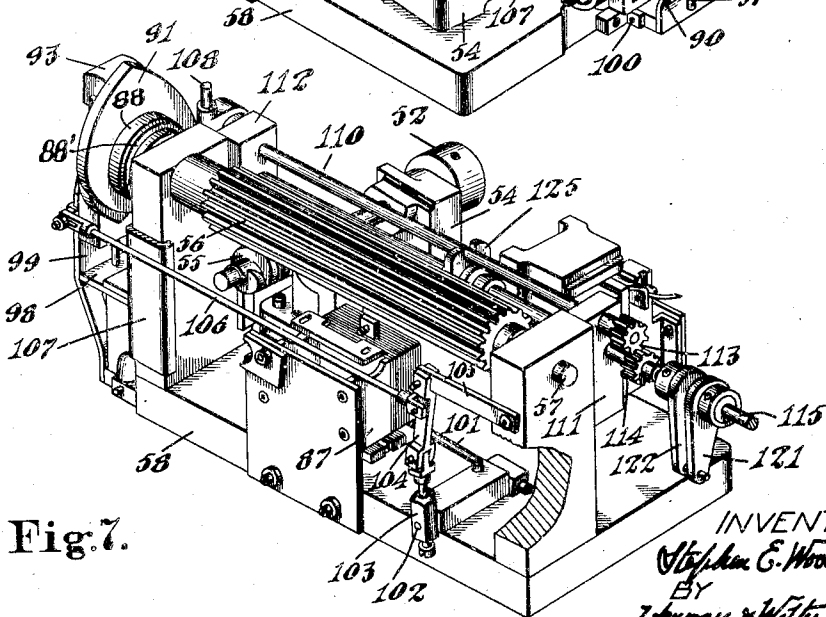


Fig. 7.

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GRINDING MACHINE

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4 Sheets-Sheet 4

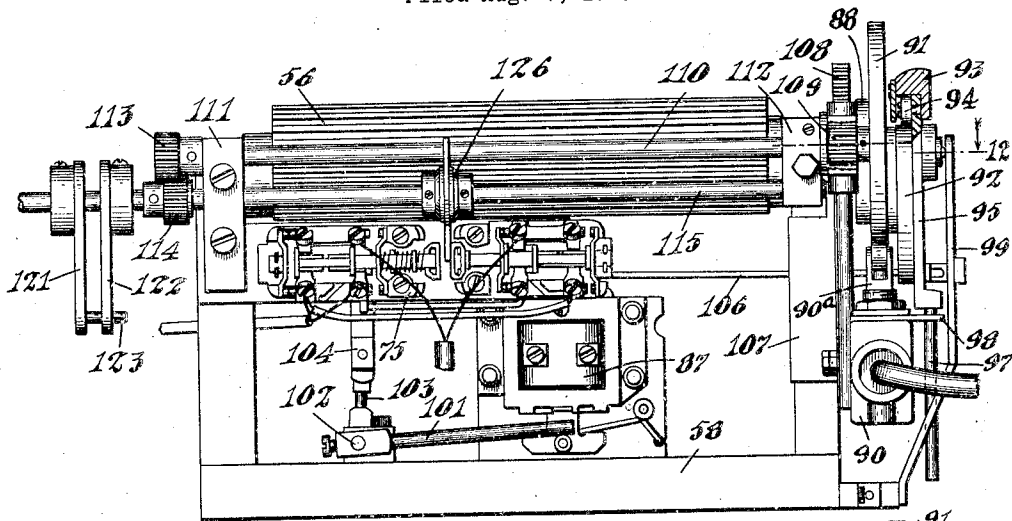


Fig. 8.

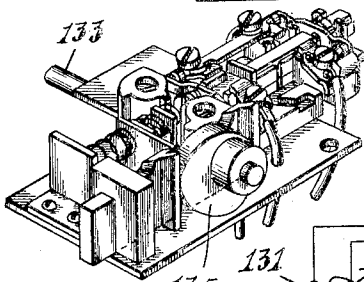


Fig. 10.

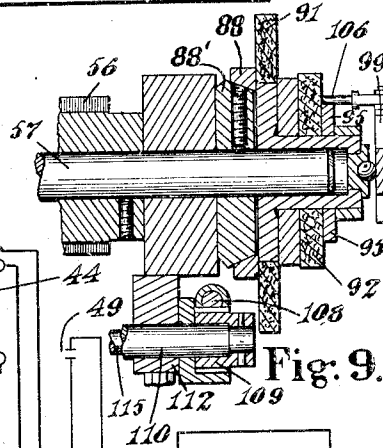


Fig. 9.

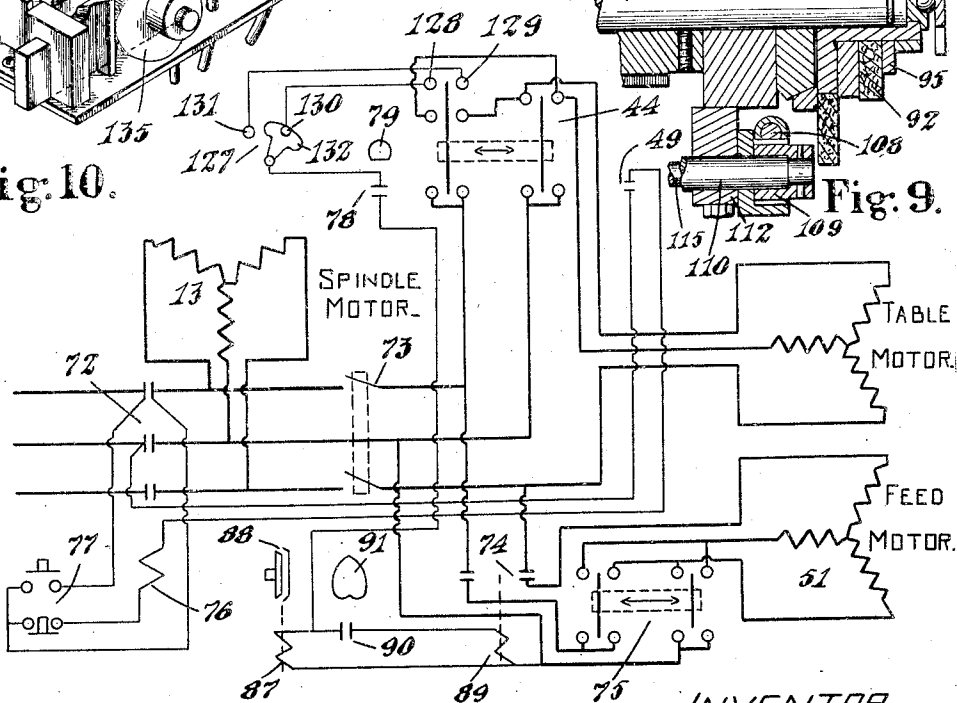


Fig. 11.

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UNITED STATES PATENT OFFICE

2,420,024

GRINDING MACHINE

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Application August 8, 1945, Serial No. 609,522

17 Claims. (Cl. 51—92)

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This invention relates to grinding machines and consists in certain improvements increasing the efficiency, accuracy and safety of such machines in operation and their convenience of control by the operator.

A machine embodying the present invention is in many respects similar to that disclosed in U. S. Letters Patent No. 2,390,973, granted December 11, 1945, on my co-pending application for Grinding machines. The present mechanism, like that disclosed in the application, is constructed and arranged to cause operation of the cross feed mechanism in anticipation of the reversal of the table, at least at one end of the table travel, so that the cross feeding step may be effected at least in part during the final portion of the table travel, after the work leaves the wheel and in any event before the work again engages the wheel. The result is that the work is brought to the wheel in a straight-line movement prior to each grinding stroke of the machine and there is no relative traverse movement between the wheel and the work during actual grinding. The amount of metal removed by the wheel is therefore uniform from one end of the stroke to the other, and conditions are thus created which are most favorable to great accuracy of operation.

In accordance with the invention disclosed in the prior application, the extent of each cross feeding movement is determined by the length of time during which a switch operated by the table remains closed, this length of time being subject to change by mechanism under the control of the operator. The present invention differs essentially in that the extent of each cross feeding movement is determined, independently of the opening of the table operated switch, by a means operated directly by the feed mechanism itself so that feeding is stopped after a predetermined amount of movement of such feed mechanism, this amount of movement being subject to change by mechanism under the control of the operator.

The present invention also relates to various features of mechanism for accomplishing the desired results, all as hereinafter set forth in detail.

While the invention is herein disclosed as incorporated in a surface grinding machine, it will be understood that it is not necessarily limited to this or to any particular type of grinding machine, but may be usefully embodied in other grinding machines having automatic table traverse and cross feed mechanisms.

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The before mentioned and other features of the invention will be best understood and appreciated from the following description of a preferred embodiment, selected for purposes of illustration and shown in the accompanying drawings in which:

Fig. 1 is a view in perspective showing the general organization of the machine;

Fig. 2 is a fragmentary front elevation, partly in section and with a portion broken away, showing the table traverse mechanism;

Fig. 3 is a fragmentary front elevation showing the mechanism for controlling and adjusting the extent of table traverse;

Fig. 4 is a fragmentary view in vertical section through a portion of the cross feed mechanism;

Fig. 5 is a fragmentary view in vertical section through another portion of the cross feed mechanism;

Fig. 6 is a view in perspective taken from the right rear and showing portions of the table traverse and cross feed mechanisms below the cross slide of the machine;

Fig. 7 is a view in perspective taken from the front left and showing portions of the cross feed mechanism but omitting the table traverse mechanism;

Fig. 8 is a view in elevation of a portion of the cross feed mechanism, this view being taken from the left as shown in Fig. 6 and from the rear as shown in Fig. 7, certain parts being omitted in order that others may more clearly appear;

Fig. 9 is a view in vertical section through the mechanism for operating the switch which limits operation of the cross feed mechanism;

Fig. 10 is a rear perspective view of the end feed switch; and

Fig. 11 is a wiring diagram.

In its general organization the illustrated machine includes a box frame 10 from the rear of which rises an upright column or post 11. The grinding wheel 12, together with its spindle and individual driving motor 13, are mounted for vertical adjustment in a slide carrier movably mounted in the post 11. The operative position of the grinding wheel is adjusted and controlled by a hand wheel 14, conveniently projecting from the front wall of the machine frame 10. The connecting mechanism is not herein shown since it forms no part of the present invention but is well known in the industry.

In the top of the machine frame 10 are provided spaced transverse ways 15 and 16, both herein shown as V-shaped, and in these ways 55 rests the cross slide 17. The slide 17 is provided

with longitudinal ways in its upper face toward the rear and in these slides the elongated work table 18 carrying an adjustably mounted magnetic chuck 19 upon which the work to be ground by the wheel 12 is clamped.

Table traverse mechanism

Longitudinal traverse of the work table 18 back and forth on the cross slide 17 is effected through the medium of a transverse shaft 20, see Figs. 2 and 6, actuated either by connections to an individual motor, not shown, or by the hand wheel 21 which projects forwardly through the front wall of machine frame 10 near its left hand side. In Fig. 6 the inner end of the shaft 20 is shown as journaled in a gear reduction unit 22 interposed between it and its driving motor. It is provided with a fast toothed collar 23. Its outer end is suitably journaled in the front wall of the machine frame 10. The shaft carries a loose sleeve 24 formed integral at one end with a pinion 25 and at the other with a grooved ring in which rests a shipper segment 26. The sleeve 24 also has clutch teeth projecting from its opposite ends, those at the front being shown in Fig. 2 and those at the rear being shown in Fig. 6. The segment 26 extends outwardly and downwardly, see Fig. 2, being provided with a shank portion which is guided for transverse movement on a guide rod 27 disposed parallel to the shaft 20. This shank portion in turn has a pin and slot connection with the short inner arm 28 of a bell crank lever pivotally mounted to rock on a short shaft 29 projecting from the left side wall of the machine frame. The other and longer arm of the bell crank lever comprises a handle 30 located outside the wall of the frame. When the handle 30 is swung in one direction the sleeve 24 is shifted toward the right, as seen in Fig. 6, and is positively clutched to the shaft 20 through the collar 23. Under these conditions rotation of the shaft 20 to effect the longitudinal traverse of the work table 18 is carried out by power from the motor. A latch 31 maintains this power connection until released by the operator. On the other hand, when the handle 30 is swung in the opposite direction, the sleeve 24 is shifted toward the left, unclutched from the shaft 20 and clutched to the hub of the hand wheel 21, whereupon longitudinal traverse can be effected as a manual operation.

The pinion 25, notwithstanding its shifting with the sleeve 24, always remains in mesh with a large gear 32 fast on a grooved transverse shaft 33 which is journaled in bearings provided in the front and rear walls of the machine frame 10. Splined on the shaft 33 is a collar 34 formed integral with a sprocket wheel 35. The collar 34 is embraced between the walls of a yoke 36 depending from the lower surface of the cross slide 17, as shown in Fig. 2 but omitted from Fig. 6. When the slide is given a cross feeding movement, as will be presently explained, the yoke 36 shifts the sprocket wheel 35 longitudinally along the splined shaft 33 while operative connection between the two is at all times maintained.

A sprocket chain 37 runs about the sprocket wheel 35, upwardly over idler rolls 38, 38, in the slide 17 and thence in opposite directions to points of connection with the work table 18 adjacent its opposite ends and in its under face. It will be apparent, therefore, that rotation of the shaft 20 either manually or by power will, through the sprocket connections above described, impart a longitudinal traverse movement to the work table

18 in a direction depending on the direction in which the said shaft 20 is rotated.

In the power operation of the machine, the length of work table movement and its points of reversal are determined by a pair of dogs 39 and 40 adjustably mounted in an undercut slot 41 provided in the front edge of the table 18, as shown in Fig. 1. To this end a sector 42 is mounted to rock on a horizontal axis with a shaft 43 projecting forwardly from the casing of a reversing switch 44 secured to one side of the cross slide 17, as shown in Fig. 3. The shaft 43 projects forwardly and is provided with a knurled operating head 45 at its forward end. A pin 46 projects forwardly from one corner of the sector into the path of the dog 39 and a pin 47 projects rearwardly from the other corner of the sector into the path of the dog 40. When either dog 39 or 40 rocks the sector 42 the switch 44 is thrown and the table operating motor is reversed and with it the direction of table movement. The reversing switch 44 has a snap action and it is so constructed and so connected with the sector 42, that it is not thrown until the sector is very near the end of its movement in each direction. Operation of the reversing switch may be effected manually by turning the operating head 45 at any time when the sector 42 is clear of the dogs 39 and 40.

At either end the table 18 carries a wedge cam 48, one only being shown in Fig. 3, which co-operates with a safety switch 49 mounted at one side of the casing of the reversing switch 44. The switch 49 is normally closed and is opened by the depression of a roll-carrying plunger 50 standing in the path of the wedge cams 48. Accordingly, if for any reason the table fails to reverse, one or the other of the cams 48 will depress the plunger 50, throw the switch 49 and stop the table motor, and preferably the entire machine, as will be presently explained. In the normal operation of the machine, of course, the table is reversed before the cams 48 reach the position of the plunger 50.

Cross feed mechanism

The individual cross feed motor 51 is shown as attached to the right hand wall of the machine frame 10. It is connected through a pair of coupling collars 52, see Fig. 4, to a shaft 53 journaled in a bracket 54 mounted within the machine frame 10. The shaft 53 carries a worm 55 which is always in mesh with an elongated pinion 56 mounted on a transverse shaft 57 journaled in the upstanding legs of a yoke 58 within the enclosure of the frame 10.

The elongated pinion 56 is always in mesh with a gear 59 fast on a shaft 60 which carries the cross feed lead screw 61 threaded into an elongated nut 62. The nut 62 is rotatably held in the front wall of the machine frame by means of a roller thrust bearing 63 and is connected to a hand wheel 64 projecting from front in convenient reach of the operator. At its inner end the shaft 60 is connected through ball thrust bearings 65 to a second yoke 66 projecting downwardly from the lower face of the cross slide 17 at the right hand side of the yoke 36 already mentioned. This connection is the point of application of the cross feeding mechanism to the cross slide. In cross feeding in either direction, movement is derived either from manual rotation of the hand wheel 64 and nut 62 or from power rotation in the nut 62 of the screw 61, through

its connections with the shaft 53 and the motor 51.

Means is provided for frictionally resisting the rotation of the nut 62. As shown, there is a friction washer 67 interposed between the nut and the outer race of the adjacent bearing 63. Preferably, the bearings 63 are so arranged that longitudinal pressure can be applied thereto by means of a threaded flanged bushing. The bushing may be so adjusted as to load the bearings to enable them to additionally resist turning of the nut 62, under normal rotation of the screw 61 by power transmitted from the motor 51. However, the resistance offered by the washer 67 and by bearings 63 is not so great as to interfere with rotation of the nut by means of the hand wheel 64. Upon power cross feeding in the forward direction, if the feeding is not otherwise stopped, the gear 59 will be brought into engagement with the nut 62 and the nut will then turn in the bearings 63, thus stopping the feeding and preventing any damage to the machine. Under the condition last mentioned, the hand wheel 63 will turn idly with the nut 62. Upon power cross feeding in the rearward direction, if the feeding is not otherwise stopped, the cross feed slide 17 will reach its rearward limit of movement and thereupon frictional engagement between the shaft 61 and the nut 62 is increased to such an extent that the nut will turn with the shaft in the roller bearings 66, thus permitting continued rotation of the shaft without damage to the machine. In this case also the hand wheel 64 will turn idly with the nut 62.

A friction mechanism is provided for placing a drag on the shaft 53 in order to reduce the tendency of the shaft to spin and cause over-feeding when the motor 51 is cut off. As shown in Fig. 4, the shaft 53 carries for this purpose a friction disc 63 which runs between cylindrical friction members 69 and 70 yieldably and adjustably held together, and locked against rotation by an anchor screw 71 threaded into the base of the bracket 54. The friction on the disc 68 may be adjusted so that the shaft will practically come to a dead stop the instant current is cut off from the motor 51. However, by reducing the friction on the disc 63 to a limited extent, the momentum of the moving parts may be permitted to carry the shaft 53 a few turns ahead after current has been cut off from the motor 51.

It will be understood that the general construction of the machine heretofore described is no part of my invention and is essentially the same as that disclosed in my before mentioned Letters Patent No. 2,390,978, but that the operation and control of its elements and the mechanism therefor now to be described is the subject matter of my invention.

Wiring diagram and control switches

As already stated, the grinding wheel is driven by the spindle motor 13, the table is transversed or reciprocated by a motor not shown, and the cross feed mechanism is operated by the motor 51. These motors are shown diagrammatically in the wiring diagram, Fig. 11. Power is supplied to a main line switch 72, and beyond the switch 72 current is carried directly to the spindle motor 13. Interposed in the line is a table on-and-off switch 73.

Beyond the switch 73 one wire leads directly to the table traverse motor, and the other two wires lead to the table traverse motor through the before mentioned table reversing switch 44.

It will be clear that with the switches 72 and 73 closed the direction of rotation of the table motor can be reversed by the operation of the switch 44 by means of the sector 42 in the manner already described.

From the switch 72 current is conducted to the feed motor 51, two wires being connected through a feed motor control switch 74, the purpose of which will be more fully described, and one of the same wires and another wire being connected through a feed reverse switch 75, the purpose of which will also be more fully described.

The main line switch 72 is operated by a solenoid 76 in a control circuit which includes a start-and-stop switch 77 which is, or may be, of standard construction and which is mounted on the front of the machine, as shown in Fig. 1. The circuit of the solenoid 76 controlling the main switch also extends through the before mentioned safety switch 49, with the result that when the switch 49 is opened by one or the other of the wedge cams 48, the main switch will be opened and operation of the entire machine will be stopped.

The operation of the feed motor is effected at one end, or the other end, or at both ends of the table travel by means of a switch 78 included in an electrical connection extending between two of the main circuit wires. The switch 78 is preferably a micro-switch and it is mounted on the cross feed slide adjacent the rocking sector 42. Connected with the sector 42 to be movable therewith is a cam 79, shown in Fig. 3, having a flat bottom side which is horizontal when the sector is in its mid position. The switch 78 is provided with an upwardly biased plunger 80, the switch being closed when the plunger is in its uppermost position. The cam 79 is so related to the switch 78 that the cam holds the switch open when the sector 42 is in either of its extreme positions. However, when the sector is moved back from either of its extreme positions the plunger 80 rises and the switch 78 is closed, thus starting the feed motor in the manner to be presently described.

Connected in the same control circuit with the switch 78 is a solenoid 81 which serves when energized to cause the engagement of a friction clutch 88—88' the construction and function of which will be hereinafter fully described. Also connected in the same circuit with the switch 78 and in parallel with the solenoid 81 is a solenoid 89 controlled by a space feed limit switch 90 which is preferably a micro-switch. The solenoid 89 serves to operate the before-mentioned feed motor control switch 74.

Space feed limit switch

The space feed limit switch 90 is carried by the rear leg of the yoke 58, as shown in Fig. 6. It is normally closed and it has an upward projecting plunger 90^a which serves to open the switch when it is moved downward. For opening the switch 90 after a predetermined amount of feeding has been effected, there is provided means movable in unison with an element of the feed mechanism. Preferably this means is a rotary cam, and I have shown a uniform motion cam 91 loosely mounted on the shaft 57 which carries the pinion 56. The cam 91 can be connected with the shaft to turn therewith, by means of the said clutch 88—88'. The cam face is preferably at the periphery and the cam is symmetrical and heart-shaped so that rotation in either direction from the position shown in Figs. 6 and 7 will cause

it to engage the plunger 90^a to open the switch 90.

A suitable means is provided for restoring the cam 91 independently of the feed mechanism to its initial position after each movement. For this purpose there is shown a symmetrical cam 92 connected with but spaced from the cam 91, this cam being also heart-shaped and being mounted with its point extending oppositely from that of cam 91. The two cams 91 and 92 are normally held in the positions shown by means of a vertically movable weight 93 provided with a roller 94 which rides on the cam 92. The weight 93 is carried by a member 95 guided for vertical movement between the cam 92 and a collar on the shaft 57 and also guided by a vertical rod 97 extending through a hole in a plate 98 carried by the casing of the switch 90. The cam 92 is preferably of the logarithmic type which has the advantage that the weight acts thereon with uniform rotative force irrespective of the position of the cam. When the shaft 57 is rotated with the clutch 88 engaged, the cams are moved in either direction out of the positions shown, but when they are released by the clutch the weight 93 acting on the cam 92 immediately returns both cams exactly to their normal positions. The exact normal positions are assured by the seating of the roller 94 in the notch in the cam 92.

As already stated, the cams 91 and 92 may be connected with the shaft 57 to rotate therewith by means of the clutch which comprises a friction disc 88 with an annular rim interposed between the cam 91 and a collar 88' fastened on the shaft 57 and having a conical rim. The friction disc constituting the loose member of the clutch can be engaged by means of an arm 99 which is horizontally pivoted at 100 and which can be swung to the left as viewed in Fig. 6 to move the cams endwise along the shaft and thereby exert clutching pressure between the friction disc 88 and the collar 88'. The arm 99 is actuated by the before mentioned solenoid 87 when the solenoid is energized. A pin carried by the solenoid engages a rod 101 to swing it upward about the axis of a horizontal shaft 102 to which the arm 101 is attached. The shaft 102 at its opposite end carries an upward projecting arm 103 which has pivotal connection with a lever 104 pivoted at its upper end to a link 105. A link 106 is pivotally connected with the lever 104 near the center thereof, this link being pivotally connected at its other end to the before-mentioned arm 99. It will be clear that through the mechanism shown, energization of the solenoid 87 will tend to move the arm 99 toward the left, as shown in Figs. 6 and 9. So long as the solenoid remains energized, the friction clutch 88 will remain engaged and the cams 91 and 92 will turn in unison with the shaft 57 and gear 56. Continued movement of the cam 91 will cause it to engage the plunger 90^a to open the switch 90 which in turn causes the deenergization of the solenoid 89 and the opening of the switch 74, thus stopping the feed motor. The stopping of the feed motor stops rotation of the cam 91, but the clutch 88 remains engaged and the cam cannot be returned to its initial position until the clutch is released by the opening of the switch 78 and the resultant deenergization of the solenoid 87.

In order that the space feed limit switch 90 may be used for varying amounts of feeding movement, provision is made for relative adjustment between the cam and the switch. Preferably the switch is bodily movable, and when

there is a peripherally acting cam, such as 91, the switch is adjustable toward and from the cam along a line which passes through the center of the plunger 90^a and the center of the cam 91. Preferably the switch movement is vertical. When the switch is in its uppermost position it is barely held open by the cam 91 in its normal position, and the mounting and adjustment are such that a very slight downward movement of the switch permits the switch to be opened by movement of the cam through a very small angle. Further downward movement of the switch requires increased rotative movement of the cam to effect opening; and with the switch in its lowermost position, it will not be opened until the cam 91 has made nearly a half revolution. The switch 90 is secured to a member 107, which embraces the adjacent leg of the yoke 58 and is vertically slidable thereon. Vertical adjustment of the switch is effected by means of a rack 108 formed on a rod which projects upward from the switch casing and which meshes with a pinion 109 on a shaft 110 journaled in blocks 111 and 112 supported on the legs of the yoke 58. The shaft 110 at its forward end carries a pinion 113, which meshes with a pinion 114 on a shaft 115, parallel with the shaft 110 and journaled in the same blocks 111 and 112.

The shaft 115 at its front end extends through a bushing 116 carrying at its front end a knob 117 and a graduated dial 118, and the shaft is movable both rotatably and endwise with respect to the bushing. The bushing 116 is rotatable in a bearing 119 carrying a collar 120 with a mark thereon to cooperate with the graduations of the dial 118, the said bearing being secured to the front wall of the frame 10. The graduations of the dial 118 are preferably such as to represent thousandths of an inch of feeding. Rotative movement of the knob 117 and of the bushing 116 is transmitted to the shaft 115 by means of two arms 122 and 123 secured respectively to the bushing and to the shaft. These arms are connected by means of a pin 124 which transmits rotative motion while permitting the shaft 115 and the arm 123 to move endwise. The pinions 113 and 114 are of sufficient width to remain in mesh notwithstanding the endwise movement of the shaft 115 and the pinion 114.

The shaft 115 can be manually moved endwise by means of a knob 125 at the front end thereof and this endwise movement of the shaft 115 is utilized to change the position of the feed reversing switch 75 as shown in Fig. 9. A collar 126 is loosely mounted on the shaft 115 between two other collars fast thereto. The collar 126 has an upstanding portion which embraces the shaft 110 to prevent rotation, and it has a depending portion which engages the reversing switch to operate it. When the knob 125 and the various parts movable thereby are in their forward positions, cross feeding is effected in the inward direction, and when the knob 125 and the said parts are in their rearward positions, cross feeding is effected in the outward direction.

From the foregoing description the operation of the cross feed control mechanism will be readily apparent. As already explained, the sector switch 78 is permitted to close as soon as the cam 79 starts to move with the sector 42 and the switch remains closed during substantially the entire time of movement of the sector from one extreme position to the other.

The space feed limit switch 90 is normally closed and the closing of the switch 78 energizes

the solenoid 89 to close the feed motor switch 74 and start the operation of the feed motor 51. The feed motor, acting through the mechanism which has been fully described, causes feeding in the inward direction or in the outward direction according to the position of the feed reverse switch 75.

The closing of the circuit through the sector switch 78 simultaneously energizes the solenoid 87 which serves through the medium of the mechanism described to effect the engagement of the clutch 88 and to cause the cam 91 to rotate in one direction or the other, according to the direction of feeding. Feeding will continue until the cam 91 engages the plunger 90^a of the switch 90 to open the switch and stop the feed motor. The cam 91 is symmetrical and its action is therefore the same, irrespective of the direction of rotation. The opening of the switch 90 deenergizes the solenoid 89 and opens the switch 74, thus stopping the feed motor. Over-running of the motor and connected parts is prevented or limited by the friction disc 88 in the manner already described.

Notwithstanding the stopping of feeding the solenoid 87 remains energized until the sector 42 completes its rocking movement, whereupon the sector switch 78 is again opened, thus deenergizing the solenoid 87 and releasing the pressure on the clutch 88. Then the weight 93, acting on the heart-shaped cam 92, returns both cams to their initial positions. The cam 92 is symmetrical, and the action is therefore the same, irrespective of the direction of rotation.

By vertically adjusting the switch 90 by means of the knob 117, as already described, the switch can be so placed that it is opened after any desired amount of angular movement of the cam 91. As already stated, the cam 91 is of such design that the rise is exactly proportionate to the angular movement. It therefore follows that the amount of angular movement prior to the opening of the switch 90 is exactly proportionate to the amount of vertical adjustment of the switch. Thus the amount of feeding can be accurately controlled by means of the knob 117 with its graduated dial 118.

It will be observed that feeding would be stopped by the reopening of the switch 78 upon completion of movement of the cam 79 to its opposite position, even though the cam 91 had not yet opened the switch 90, as the opening of the switch 78 would deenergize the solenoids 87 and 89. It has been found, however, that even with high table speeds the cam 91 operates to open the switch 90 before the cam 79 reopens the switch 78.

It has been stated that the sector switch 78 is electrically connected between two of the main circuit wires. Preferably this connection is through the reversing switch 44 and also through an end feed switch 127, shown diagrammatically in Fig. 11 and in detail in Fig. 10. When the switch 78 is so connected, the reversing switch has two supplemental stationary contacts 128 and 129 which are adapted to be engaged by a movable contact of the switch so that current is supplied to one or the other of them according to the position of the switch. So far as the contacts 128 and 129 are concerned, the switch 44 may be regarded as having two separate closed positions. The switch 127 has two contacts 130 and 131 which are electrically connected respectively with the contacts 128 and 129 of the reversing switch 44. The switch 127 has a movable

contact member 132 which is electrically connected with the switch 78 and which can be moved to engage the contact 130, as shown in Fig. 11, or can be moved to the left to engage the contact 131 or can be moved to an intermediate position in which it engages both of the contacts 130 and 131. The switch is manually operable by a rock shaft 133 extending to the front of the machine, and having at its front end a handle or finger piece 134 by which it may be turned. At its rear end, as shown in Fig. 10, the shaft 133 carries an eccentric 135 fitted between two upright elements on the movable contact member of the switch. When the shaft is rocked by means of the finger piece 134 at the front end of the shaft 133, the eccentric 135 is turned to move the contact member 132 to any one of its three described positions.

In order that the function and operation of the end feed switch 127 may be more clearly understood, let it be assumed that the table reversing switch 44 serves when in its left hand position, to cause movement of the table toward the left, and serves when in its right hand position to cause movement of the table toward the right. It has already been pointed out that the switch 78 is open when the sector 42 and the cam 79 are in one or the other of the tilted positions to which they are moved by the dogs 39 and 40, but is closed while the sector and cam are moving from one tilted position to the other.

Let it be first assumed that the reversing switch is in its left hand position, and that the table is moving toward the left. The sector 42 and the cam 78 are tilted toward the right, as shown in Figs. 1 and 3, and are ready to be moved toward the left by the dog 39. Under the assumed conditions, the contact 128 of the switch 44 and the contact 130 of the switch 127 are alive, and current will flow through the switch 78 as soon as this switch is closed by movement of the cam 79 toward the left. Current will continue to flow until the cam 79, actuated by the sector 42 and the dog 39, reaches its opposite tilted position to again open the switch 78, at which instant the reversing switch 44 is snapped to the right, thus reversing the table. The closing of the switch 78 starts the feeding as already explained, and thus feeding will be started just prior to the end of table movement toward the left. Feeding is stopped by the cam 91 and the switch 90, as already explained.

The reversing switch is snapped to the right at or about the instant that the switch 78 is reopened by the movement of the cam 79 toward the left, and thereupon the movable contact of the reversing switch disengages the supplementary contact 128 and engages the supplementary contact 129. This serves to open the connection to the switch contact 130 and to close the connection to the switch contact 131. The table will now move toward the right, the switch 78 being held open by the cam 79, which is now in the position opposite to that shown in Fig. 3. When the cam is next tilted toward the right by the dog 40, the switch 78 is again closed, but no current flows therethrough for the reason that the connection to the contact 130 has been broken, and therefore no feeding takes place. From the description given it will be clear that feeding occurs just before the end of each left movement of the table, but that no feeding occurs at or near the end of each right movement of the table.

It will be obvious, without further detailed explanation, that the above described condition

can be reversed by moving the switch member 132 to disengage the contact 130 and to engage the contact 131. Feeding then occurs just before the end of each right movement of the table, but no feeding occurs at or near the end of each left movement. Feeding can be effected just before each end of the table movement by placing the switch member 132 in its intermediate position in which it engages both of the contacts 130 and 131.

As already stated, the construction embodying the present information is in many respects similar to that disclosed in my prior Patent No. 2,390,978. Cross feeding takes place during the interval of table reversal and with the work out of engagement with the wheel. There is usually available for feeding purposes an interval corresponding to about twice three-quarters of an inch of table travel. When all of the feeding is done within this interval, the grinding wheel cuts a new path over the entire length of the work. Without this arrangement the work returns to the wheel along the path already cut and grinding does not start until the work is carried over by the feed of the cross slide perhaps several inches from the leading end of the work. Also when the work approaches the end of its travel the metal that was left during prior reciprocation has to be ground away as an extra amount which is obviously objectionable.

The machine embodying the present invention retains all of the advantages incident to the invention disclosed in the said patent and it will be apparent that the adjustment of the extent of cross feeding can be changed by means of the knob 117 as often and as much as desired in perfect safety while the grinder is running. When hand feeding is desired, this can be readily effected by means of the hand wheel 64 which can be used at any time without giving thought to the automatic cross feed mechanism.

With the construction shown in the aforesaid prior application the amount of feeding was controlled entirely by a sector switch, such as the sector switch 78 of the present application, the amount of feeding being adjusted by moving the switch upward or downward so that it would be permitted by the sector cam to remain closed for a greater or less period of time. This may be referred to as a time anticipative feed. The construction shown in my prior patent is highly meritorious but the present construction has certain additional advantages. One such advantage is that the limitation of feeding is effected directly by a mechanical means, such as the cam 91, which moves in unison of an element of the feed mechanism. This may be referred to as space anticipative feed, and it places a more definite and certain limitation on the amount of feeding than can be effected by means of a sector switch, such as 78, wherein the time of current flow is to some extent affected by other factors such as the speed of table movement.

A further advantage in the present construction is that the feed is always definitely stopped by the feed mechanism itself without the necessity for depending upon the re-opening of the sector switch. In the prior construction, if the sector should be moved accidentally or otherwise to its intermediate position, the sector switch would remain closed and cross feeding would continue indefinitely or until stopped by some additional mechanism specially provided for that purpose.

Having thus disclosed my invention and de-

scribed in detail a specific embodiment thereof for purposes of illustration, I claim as new and desire to secure by Letters Patent:

1. In a grinding machine of the class described, the combination of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means for closing the switch near the end of table movement in one direction to thereby start the motor and for opening the switch after a short predetermined interval, a second normally closed switch in the said control circuit, and means operated by movement of the feed mechanism for opening the second switch after a predetermined amount of feeding to stop the feed motor while the first switch remains closed.

2. In a grinding machine of the class described, the combination of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, a rocking sector operable by the table for reversing the table movement, means operated by the sector for closing the switch at the beginning of each sector movement to thereby start the motor and for opening the switch at the end of each sector movement, a second normally closed switch in the said control circuit, and means operated by movement of the feed mechanism for opening the second switch after a predetermined amount of feeding to stop the feed motor while the first switch remains closed.

3. In a grinding machine, the combination of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start the motor, a second normally closed switch in the said control circuit, a cam advanced by the feed mechanism from a predetermined initial position for opening the second switch to stop the feed motor after a predetermined amount of feeding, means for automatically returning the cam to its initial position regardless of the point to which it has been advanced, and manually operable means for varying the amount of feeding prior to the opening of the second switch.

4. In a grinding machine, the combination of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start the motor, a second normally closed switch in the said control circuit, a cam movable in unison with the feed mechanism for opening the second switch to stop the feed motor after a predetermined amount of cam movement, and means for changing the relationship between the cam and

the second switch to vary the said predetermined amount of cam movement prior to the opening of the switch.

5. In a grinding machine, the combination of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start the motor, a second normally closed switch in the said control circuit, a cam movable in unison with the feed mechanism for opening the second switch to stop the feed motor after a predetermined amount of cam movement, the cam being so formed that the rise thereof is proportionate to the extent of feeding movement, and means for changing the relationship between the cam and the second switch to vary the said predetermined amount of cam movement prior to the opening of the switch.

6. In a grinding machine, the combination of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start the motor, a second normally closed switch in the said control circuit, a cam rotatable in unison with a rotatable element of the feed mechanism, means engageable by the periphery of the cam for opening the second switch after a predetermined amount of cam movement, and means for changing the position of the second switch to vary the said predetermined amount of cam movement prior to the opening of the switch.

7. The combination in a grinding machine, of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start the motor, a second normally closed switch in the said control circuit, a cam movable in unison with the feed mechanism for opening the second switch to stop the feed motor after a predetermined amount of cam movement, means for changing the relationship between the cam and the second switch to vary the said predetermined amount of cam movement prior to the opening of the switch, and means for automatically returning the cam independently of the feed mechanism to its initial position after each feeding movement.

8. The combination in a grinding machine, of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start

the motor, a second normally closed switch in the said control circuit, a cam rotatable in unison with an element of the feed mechanism for opening the second switch to stop the feed motor after a predetermined amount of cam movement, means for moving the second switch toward and from the cam to vary the said predetermined amount of cam movement prior to the opening of the switch by the cam, and means for automatically returning the cam independently of the feed mechanism to its initial position after each feeding movement.

9. The combination in a grinding machine, of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start the motor, a second normally closed switch in the said control circuit, a cam rotatable in unison with an element of the feed mechanism for opening the second switch to stop the feed motor after a predetermined amount of cam movement, means for moving the second switch toward and from the cam to vary the said predetermined amount of cam movement prior to the opening of the switch by the cam, a second cam rigidly connected with the first cam, and a vertically movable weight acting on the second cam and serving to automatically return both cams independently to the feed mechanism to their initial positions after each feeding movement.

10. The combination in a grinding machine, of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means for closing the switch near the end of table movement in one direction to thereby start the motor and for opening the switch after a short predetermined interval, a movable cam, a clutch for causing the cam to move in unison with the feed mechanism, a solenoid for engaging the clutch upon closing of the first switch and for disengaging the clutch upon opening thereof, a second normally closed switch in the circuit adapted to be opened by the cam to stop the feed motor after a predetermined amount of cam movement, means for changing the relationship between the cam and the second switch to vary the said predetermined amount of cam movement prior to the opening of the switch by the cam, a means for automatically returning the cam independently of the feed mechanism to its initial position upon disengagement of the clutch.

11. The combination in a grinding machine, of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start the motor, a second normally closed switch in the said control circuit, a cam movable in unison with the feed mechanism for

opening the second switch to stop the feed motor after a predetermined amount of cam movement, a rack and pinion mechanism for moving the second switch relatively to the cam to vary the said predetermined amount of cam movement prior to the opening of the switch, and a device at the front of the machine for rotating the pinion to move the switch.

12. The combination in a grinding machine, of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a reversing switch for the motor, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start the motor, a second normally closed switch in the said control circuit, a cam movable in unison with the feed mechanism for opening the second switch to stop the feed motor after predetermined amount of cam movement, means including a manually rotatable knob at the front of the machine for moving the second switch toward and from the cam to vary the said predetermined amount of cam movement prior to the opening of the switch, and means for operating the reversing switch including a rod manually movable longitudinally and extending through the aforesaid rotatable knob.

13. The combination in a grinding machine, of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a reversing switch for the motor, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start the motor, a second normally closed switch in the said control circuit, a cam movable in unison with the feed mechanism for opening the second switch to stop the feed motor after a predetermined amount of cam movement, a rack and pinion mechanism for moving the second switch toward and from the cam to vary the said predetermined amount of cam movement prior to the opening of the switch, a rotatable shaft carrying the pinion and also having a second pinion thereon, a second shaft parallel with the first shaft and movable rotatively and longitudinally, the said second shaft having a pinion meshing with the second pinion on the first shaft whereby the second shaft upon rotation will move the switch, and mechanism connecting the second shaft with the reversing switch whereby the second shaft upon longitudinal movement will operate the reversing switch.

14. The combination in a grinding machine, of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a reversing switch for the motor, a control circuit for the motor having a switch therein which is open during the major portion of the table movement, means operated by the table for closing the switch shortly before the end of table movement in one direction to thereby start the motor, a second normally closed switch in the said control circuit, a cam movable in unison with the

feed mechanism for opening the second switch to stop the feed motor after a predetermined amount of cam movement, a rack and pinion mechanism for moving the second switch toward and from the cam to vary the said predetermined amount of cam movement prior to the opening of the switch, a rotatable shaft carrying the pinion and also having a second pinion thereon, a second shaft parallel with the first shaft and movable rotatively and longitudinally, the said second shaft having a pinion meshing with the second pinion on the first shaft whereby the second shaft upon rotation will move the switch, a collar surrounding the second shaft and rotatable therewith but held against longitudinal movement, the said collar being manually rotatable to rotate the shaft, and mechanism connecting the second shaft with the reversing switch whereby the second shaft upon longitudinal movement will operate the reversing switch.

15. In a grinding machine of the class described, the combination of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having openable and closable switch means therein which is mounted for bodily adjustment, means for closing the said switch means near the end of table movement in each direction at a point in the cycle of the machine varied in accordance with the adjusted position of said switch, a switch in the circuit operated by the table so as to occupy two separate closed positions when the table is near the ends of its travel in the respective directions, a switch in the circuit manually operable to connect the switch means with the said table operated switch when the latter is in either of its two closed positions whereby the feed motor is started near one end of the table travel or near the other end thereof, and means for opening the said switch means after a predetermined amount of feeding.

16. In a grinding machine of the class described, the combination of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having openable and closable switch means therein, means for closing the said switch means near the end of table movement in each direction, a switch in the circuit operated by the table so as to occupy two separate closed positions when the table is near the ends of its travel in the respective directions, a switch in the circuit manually operable to connect the switch means with the said table operated switch when the latter is in either of its two closed positions whereby the feed motor is started near one end of the table travel or near the other end thereof, the last said switch being also manually operable to connect the switch means with the last said table operated switch when it is in both of its two closed positions whereby the feed motor is started near each end of the table travel, and means for opening the said switch means after a predetermined amount of feeding.

17. In a grinding machine of the class described, the combination of a work table, power operated mechanism for reciprocating the table, a cross feed slide carrying the table, a feed motor and connected mechanism for causing feeding of the slide, a control circuit for the motor having a switch therein which is open during

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the major portion of the table movement, means for closing the first switch near the end of table movement in each direction and for opening the said switch after a short predetermined interval, a switch in the circuit operated by the table so as to occupy two separate closed positions when the table is near the ends of its travel in the respective directions, a third switch in the circuit manually operable to connect the first said switch with the second said switch when the latter is in either of its two closed positions whereby the feed motor is started near one end of the table travel or near the other end thereof, a fourth normally closed switch in the circuit, and means operated by movement of the feed mecha-

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nism for opening the fourth said switch after a predetermined amount of feeding to stop the feed motor while the first switch remains closed.

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