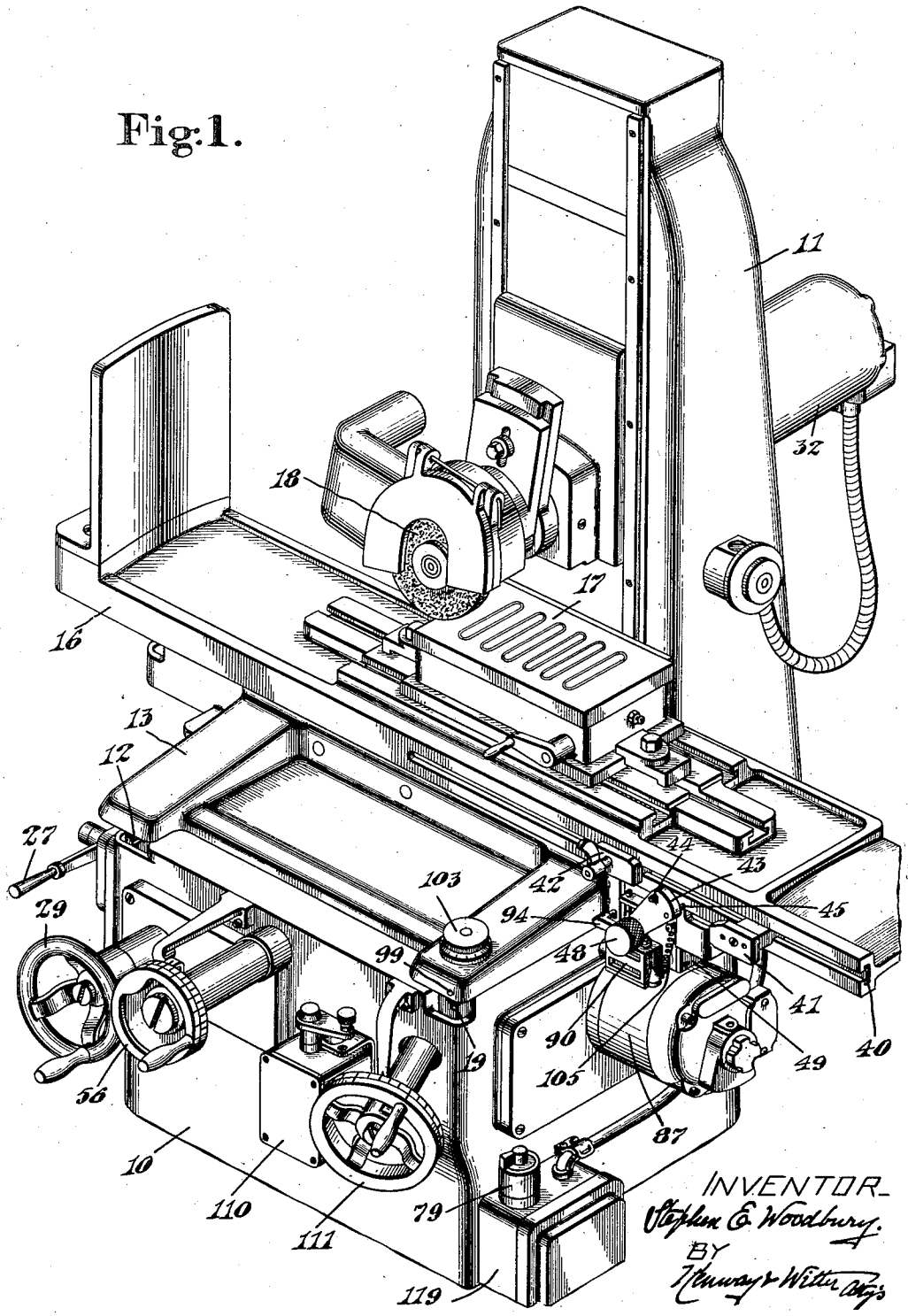
Dec. 11, 1945. S. E. WOODBURY 2,390,978

GRINDING MACHINE

Filed Aug. 26, 1943 4 Sheets-Sheet 1

Fig. 1.



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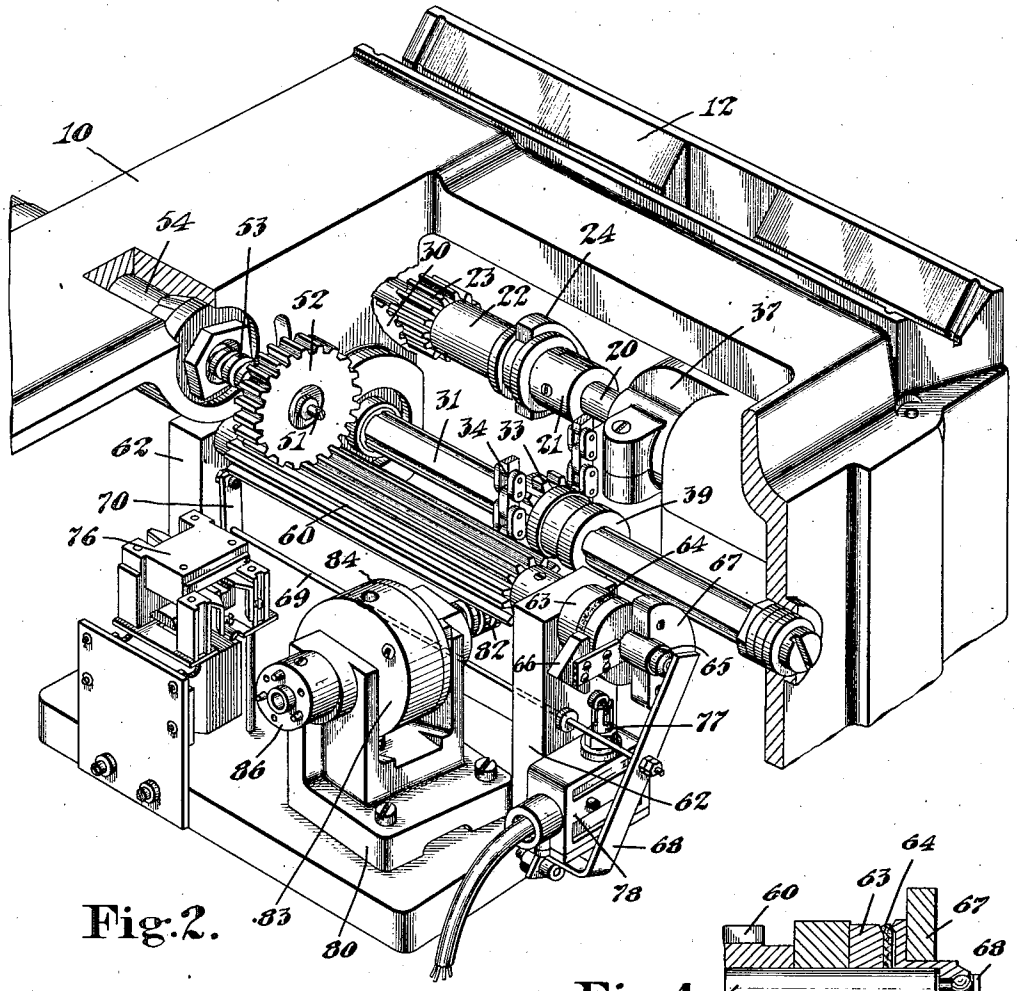


Fig.2.

Fig.4.

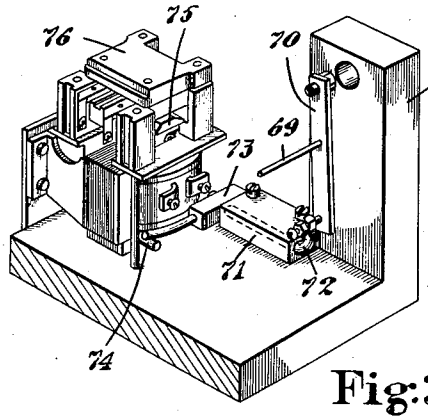


Fig.3.

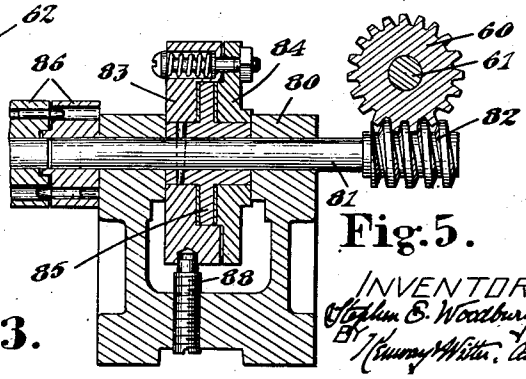


Fig.5.

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GRINDING MACHINE

Filed Aug. 26, 1943 4 Sheets-Sheet 3

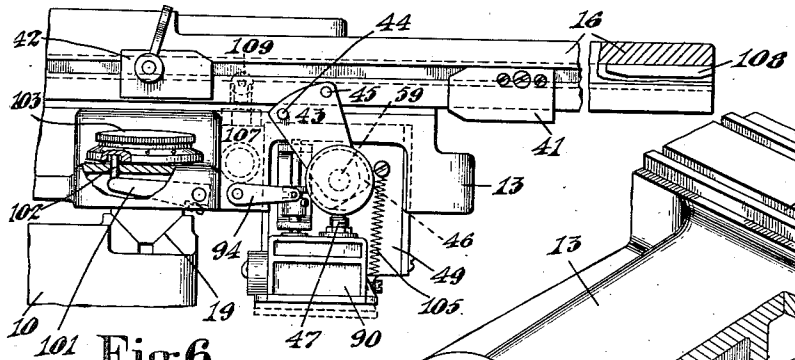


Fig:6.

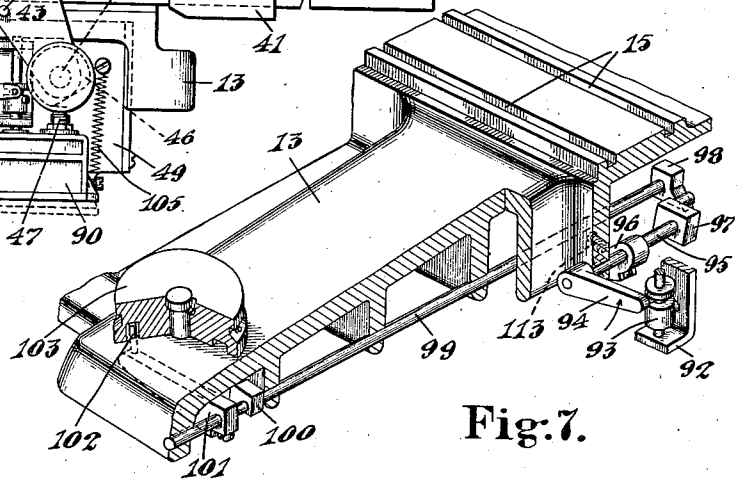


Fig:7.

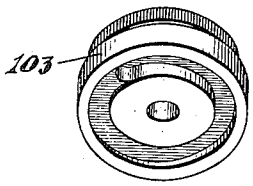


Fig:8.

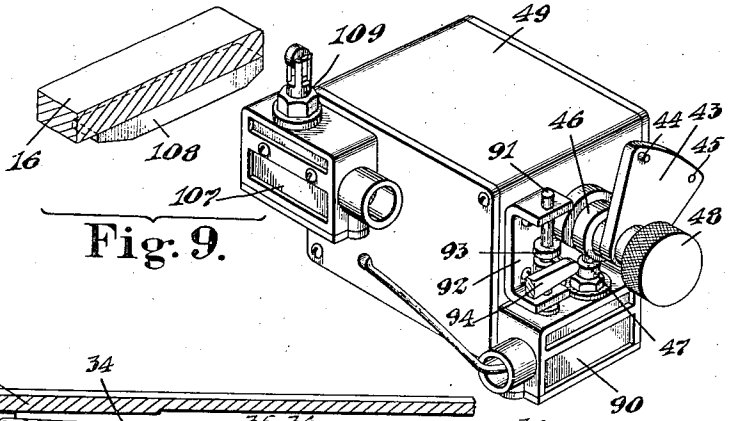


Fig:9.

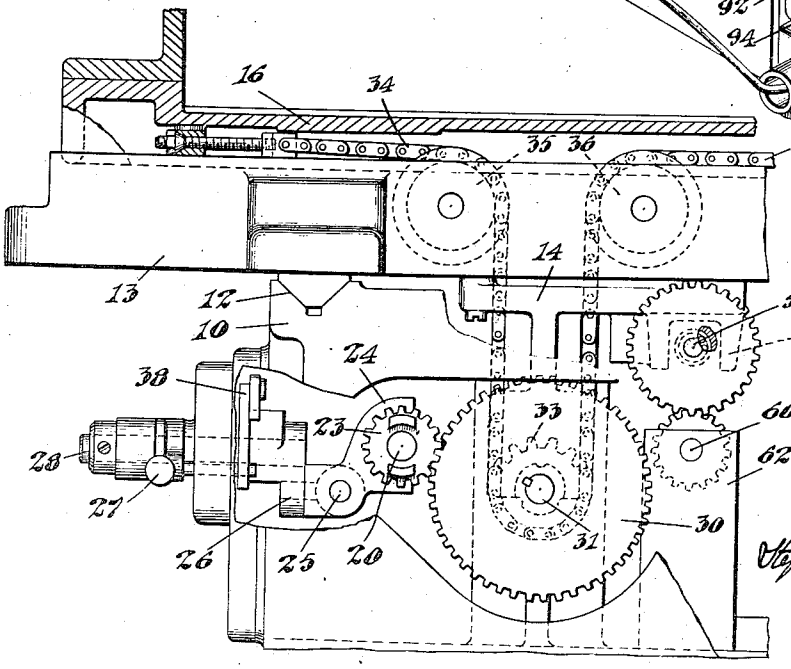


Fig:10.

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GRINDING MACHINE

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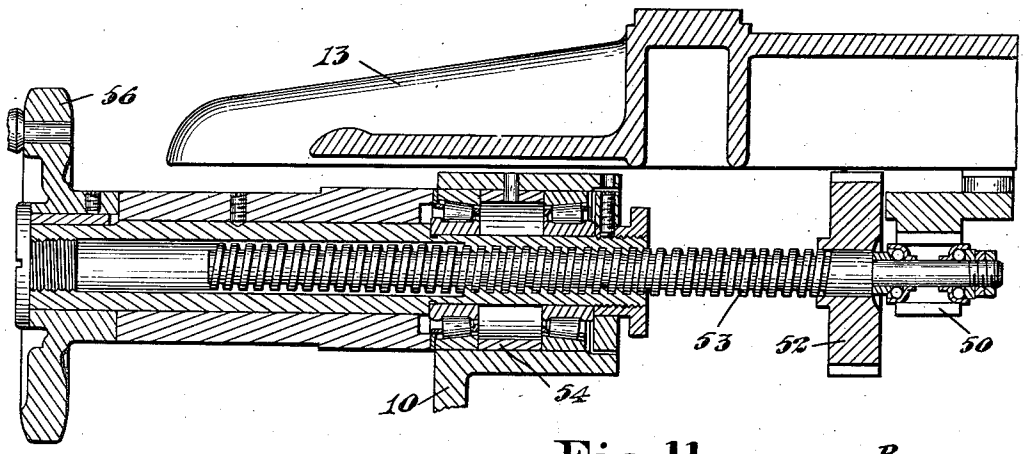


Fig. 11.

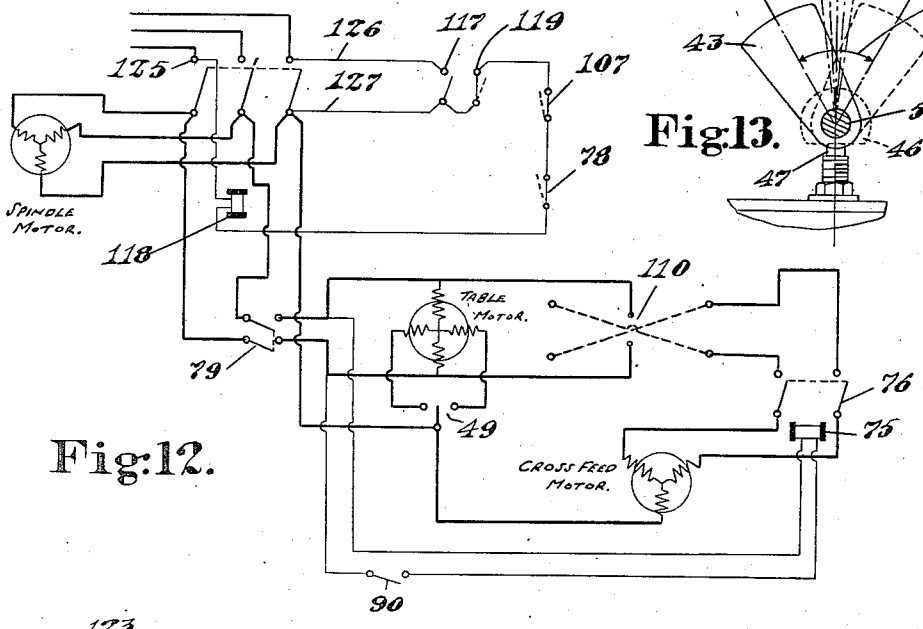


Fig. 12.

Fig. 13.

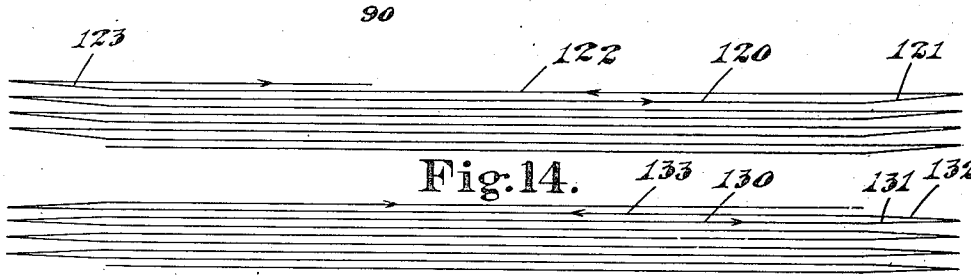


Fig. 14.

Fig. 15.

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UNITED STATES PATENT OFFICE

2,390,978

GRINDING MACHINE

Stephen E. Woodbury, Beverly, Mass., assignor to Reid Brothers Company, Inc., Beverly, Mass., a corporation of Massachusetts

Application August 26, 1943, Serial No. 500,078

18 Claims. (Cl. 51—92)

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

Surface grinders as heretofore constructed have included a work-carrying slide or table arranged to travel back and forth longitudinally beneath the grinding wheel, and cross feed mechanism for shifting the path of the table transversely after each reversal of its longitudinal travel.

An important feature of the present invention consists in mechanism constructed and arranged to cause operation of the cross feed mechanism in anticipation of each such point of reversal of the table, so that the cross feeding step may be effected during the final portion of the table travel, after the wheel leaves the work and before the direction of table travel is reversed. 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 traverse movement of the wheel and work during the grinding stroke. The amount of metal removed by the wheel is therefore substantially uniform from one end of the stroke to the other, and conditions are thus created which are most favorable for great accuracy of operation.

The efficiency of the machine is also improved because this mode of operation utilizes for the cross feeding operation, time that would otherwise be wasted between consecutive grinding strokes. On the contrary, my invention anticipates the point of table movement reversal and initiates the cross feeding operation as soon as the wheel passes off the work. To this end I employ an oscillatory sector which is swung through a predetermined angle by the work table itself near each end of its stroke for controlling the reversing mechanism and I utilize an intermediate portion of the sector movement for throwing the cross feed mechanism into and out of operation.

Another important feature of my invention consists in utilizing and controlling the momentum of the cross feed mechanism to extend the cross feeding operation into the initial portion of the reverse travel of the work table after each point of reversal. The full interval of time available for cross feeding in accordance with my invention is from the instant the work is carried beyond the grinding wheel in one direction to the instant the wheel encountered the work in movement of the table in a reverse direction. In accordance with the present invention I supply operating current to the cross feed motor during a predetermined, but variable interval immediately prior to the instant of actual reversal and provide means for regulating the interval of over running by momentum so that the cross feeding operation may extend somewhat into the period of reverse travel of the table, although of course never up to the point in which the work meets the grinding wheel.

Another important feature of my invention consists in safety mechanism for terminating the cross feeding operation independently of its regular automatic control in the normal operation of the grinding machine, and restricting the cross feeding operation under all conditions to an amplitude that will prevent possible damage to the work or disorganization of the machine. To this end I provide an actuating member, shown as a rocker, which is arranged to assume a predetermined initial position at the end of every cross feeding operation and to be clutched or connected to the cross feeding mechanism at the beginning of each operation. A safety switch is provided in position to be engaged by this actuating member to break the circuit and stop the cross feed motor in case the cross feeding operation is unduly extended by any accident or oversight.

While the invention is herein disclosed in this application to a surface grinding machine, it will be understood that it is in no sense limited to this or to any particular type of grinding machine but may be usefully embodied in any other grinding machines having automatic longitudinal and cross feeding mechanisms.

These and other features of the invention will be best understood and appreciated from the following description of a preferred embodiment thereof 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 view in perspective of mechanism below the table of the machine,

Fig. 3 is a view in perspective of safety mechansim for limiting the extent of cross feed,

Fig. 4 is a view in longitudinal section of another portion of the same mechanism,

Fig. 5 is a similar view of a portion of the motor driven cross feed shaft,

Fig. 6 is a view in elevation of portions of the machine showing mechanism for controlling and adjusting the extent of cross feed,

Fig. 7 is a fragmentary view in perspective of the same mechanism,

Fig. 8 is a view in perspective of the controlling disk as seen from beneath,

Fig. 9 is a view in perspective of mechanism supplementing that shown in Fig. 7,

Fig. 10 is a fragmentary view in front elevation illustrating the longitudinal feed mechanism,

Fig. 11 is a view in elevation of portions of the cross feed mechanism,

Fig. 12 is a wiring diagram of the machine,

Fig. 13 is a diagrammatic view illustrating the timing of the cross feed operation, and

Figs. 14 and 15 are diagrams of the table movements.

In its general organization the illustrated machine includes a box frame 10 from the rear side of which rises an upright column or post 11. The grinding wheel 18, together with its spindle and individual driving motor 32, 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 111, 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 12 and 19, both herein shown as V-shaped, but not necessarily so, and in these ways rests the cross slide 13. The slide 13 is provided with longitudinal ways 15 in its upper face toward the rear and in these slides the elongated work table 16 carrying an adjustably mounted magnetic chuck 17 upon which the work to be ground by the wheel 18 is clamped.

Longitudinal feed

Longitudinal feed of the work table 16 back and forth on the cross slide 13 is effected through the medium of a transverse shaft 20, see Fig. 2, actuated either by connections to an individual motor, not shown, or by the hand wheel 29 which projects forwardly through the front wall of machine frame 10 near its left hand side. In Fig. 2 the inner end of the shaft 20 is shown as journalled in a gear reduction unit 37 interposed between it and its driving motor. In this location it is provided with a fast toothed collar 21. Its outer end is suitably journalled in the front wall of the machine frame 10. The shaft carries a loose sleeve 22 formed integral at one end with a pinion 23 and at the other with a grooved ring in which rests a shipper segment 24. The sleeve also has clutch teeth projecting from its opposite ends. The segment 24 extends outwardly and downwardly being provided with a shank portion which is guided for transverse movement on a guide rod 25 disposed parallel to the shaft 20. This shank portion in turn has a pin and slot connection with the short inner arm 26 of a bell crank lever (see Fig. 10) pivotally mounted to rock on a short shaft 28 projecting from the left side wall of the machine frame. The other and longer arm of the bell crank lever comprises a handle 27 located outside the wall of the frame. When the handle 27 is swung in one direction the sleeve 22 is shifted toward the right as seen in Fig. 2 and is positively clutched to the shaft 20 through the collar 21. Under these conditions rotation of the shaft 20 to effect the longitudinal feed of the work table 16 is carried out by power from the motor. A latch 38 maintains this power connection until released by the operation. On the other hand, when the handle 27 is swung in the opposite direction, the sleeve 22 is shifted toward the left, unclutched from the shaft 20 and clutched to the hub of the hand wheel 29, whereupon longitudinal feed can be effected as a manual operation.

The pinion 23, notwithstanding its shifting with the sleeve 22, always remains in mesh with a large gear 30 fast on a grooved transverse shaft 31 which is journalled in bearings provided in the front and rear walls of the machine frame 10. Splined on the shaft 31 is a collar 33 formed integral with a sprocket wheel 34. The collar 33 is embraced between the walls of a yoke 14 depending from the lower surface of the cross slide 13, as shown in Fig. 10. When the slide is given a cross feeding movement, as will be presently explained, the yoke 14 shifts the sprocket wheel 33 longitudinally along the splined shaft 31 while operative connection between the two is at all times maintained.

A sprocket chain 34 runs about the sprocket wheel 33, upwardly over idler rolls 35 and 36 in the slide 13 and thence in opposite directions to points of connection with the work table 16 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 feeding movement to the work table 16 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 41 and 42 adjustably mounted in an undercut slot 40 provided in the front edge of the table 16, as shown in Fig. 1. To this end a sector 43 is mounted to rock on a horizontal axis with a shaft 59 projecting forwardly from the casing of a reversing switch 49 secured to one side of the cross slide 13. The shaft 59 projects forwardly and is provided with a knurled operating head 48 at its forward end. A pin 44 projects forwardly from one corner of the sector into the path of the dog 41 and a pin 45 projects rearwardly from the other corner of the sector into the path of the dog 42. When either dog 41 or 42 rocks the sector 44 the switch 49 is thrown and current in the longitudinal feed motor is reversed and with it the direction of feeding movement of the table. The same result may be obtained manually by turning the operating head 48 at any time when the sector 43 is clear of the dogs 41 and 42.

At either end the table 16 carries a wedge cam 108, one only being shown in Figs. 6 and 9, which cooperates with a limit switch 107 mounted on one side of the casing of the reversing switch 49. The switch 107 is normally closed and is opened by the depression of a roll-carrying plunger 109 standing in the path of the wedge cams 108. Accordingly, if for any reason the table fails to reverse, one or the other of the cams 108 will depress the plunger 109, throw the switch 107 and stop the table motor, as will be presently explained. In the normal operation of the machine, of course, the table is reversed before the cams 108 reach the position of the plunger 109.

It will be understood that the general construction of the machine heretofore described is no part of my invention but that the operation and control of its elements and the mechanism therefor now to be described is the subject matter of my invention.

Cross feed

The individual cross feed motor 87 is shown as attached to the right hand wall of the machine

frame 10. It is connected at a slight angle through a pair of coupling collars 86 to a shaft 81 journaled in a bracket 80 mounted within the machine frame 10. The shaft 81 carries a worm 82 which is always in mesh with an elongated pinion 60 mounted on a transverse shaft 61 journaled in a yoke 62 within the enclosure of the frame 10.

The elongated pinion 60 is always in mesh with a pinion 52 fast on a shaft 51 which carries the cross feed lead screw 53 threaded into an elongated nut 54. The nut 54 is rotatably held in the front wall of the machine frame and is connected to a hand wheel 56 projecting from the wall in convenient reach of the operator. At its inner end the shaft 51 is connected through thrust bearings to a second yoke 50 projecting downwardly from the lower face of the cross slide 13 at the right hand side of the yoke 14 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 from manual rotation of the hand wheel 56 and nut 54 or from power rotation in the nut 54 of the screw 53, through its connections with the shaft 81 and the motor 87.

Wiring diagram

The grinding wheel 17, the work table 16, and the cross feed slide 13 are all operated by individual motors connected and controlled by the system of wiring shown in the diagram of Fig. 12. Three phase power is supplied on the line switch 125 from whence it is tapped direct to the spindle motor 32. From the line switch three wires also lead to the table motor, two of them through a hand controlled two pole switch 79. The reversing switch 49 is included in two of three wires of the table motor and this switch is operated by the sector 43.

A pilot or relay circuit extends between the two outside terminals of the line switch. This includes a connection 126 to the starting switch 117. When the switch 117 is closed current flows in the relay circuit through the normally closed stopping switch 119, the normally closed safety switch 107, the normally closed feed limiting switch 78 and the solenoid 118. The solenoid 118 automatically closes the line switch whereupon the table motor may be started by closing the hand operated switch 79. Meanwhile current in the relay circuit flows in the branch 127 and the starting switch 117 remains open. Under operating conditions, therefore, the line switch may be opened automatically by throwing the stopping switch 119, or by the opening of the safety switch 107 by action of the dog 108, or by operation of the feed limiting switch 78 by the safety cam 66.

Three wires, two of them led through a relay controlled switch 76, also lead to the cross feed motor 87. In this circuit is included the hand operated reversing switch 110 for controlling the direction of cross feeding.

The wiring includes a second relay circuit for controlling the cross feed switch 76. This second relay circuit includes the switch 90 operated by the cam 46 and the solenoid 75 which when energized closes switch 76 to the cross feed motor. Current flows in this circuit only during the short interval of power cross feeding operation.

Cross feed control mechanism

The cross feed motor 87 has in its circuit a double pole switch 76 under the control of a solenoid 75 in a pilot or relay circuit which includes a normally closing switch 90. When the switch 76 is closed the motor 87 operates and the cross feeding operation occurs. The switch 76 is held closed only while the plunger 47 of the pilot switch 90 is allowed to remain in its uppermost position. The plunger 47 is controlled by a cam 46 keyed to the shaft 59 and moving with the sector 43. It has a flat side in its periphery and is arranged symmetrically with respect to the sector, that is, when the sector stands vertically the flat side of the cam 46 is disposed horizontally, permitting the plunger 47 to rise to its fullest extent in the cycle, tending to close the relay circuit and close the switch 76. When the cam 46 is swung in either direction out of its mid position the pilot switch plunger 47 is depressed at a time and for an interval depending upon the vertical position of the pilot switch 90, which, as will presently be explained, is mounted for vertical adjustment under the very sensitive control of the operator. The mode of operation thus explained is illustrated diagrammatically in Fig. 13. The movement of the sector 43 to effect a complete reversal of table movement takes place through the angle A. The cam 46 permits the cross feed motor to operate during the angle B, for an intermediate setting of the pilot switch 90. If, however, the pilot switch is adjusted downwardly, the closed interval of the switch is increased to a period correspondingly to the larger angle C. The power cross feed takes place during only that fraction of the swing of the sector 43 (represented by the angle B or C) on each side of its mid position in which the plunger 47 is allowed to remain undepressed. A very slight depression of the plunger 47 is sufficient to break the circuit in the switch 90 and all further movement of plunger 47 is merely idle overtravel.

The switch 90 has a vertical guide pin 91 projecting upwardly from its casing and arranged to slide in the horizontal arms of a guide bracket 92 fast to the casing of the switch 49. The guide pin 91 carries a grooved collar 93 into which projects a pin carried by a substantially horizontal arm 94. The arm 94 is keyed to the forward end of a short shaft 95 which is journaled to rock in the webs of the cross feed slide 13 as shown in Fig. 7. At an intermediate point the shaft 95 carries a short arm 96 against which presses a spring 113 tending at all times to rock the shaft 95 in a counter-clockwise direction and to raise the switch 90. A tension spring 105 is secured to the rear of the switch 90 and to the side of the casing of the switch 49 also tends to lift the switch 90. The spring 105 is best shown in Fig. 6. At its rear end the shaft 95 carries a block 97 having a rearwardly projecting pin which engages a short arm 98 fast to the rear end of a long horizontal shaft 99 also journaled in webs of the feed slide 13. The shaft 99 goes through to the front edge of the feed slide and just within the front flange thereof is provided with a limit stop 100 and an arm 101 extending in a substantially horizontal direction toward the left as seen in Figs. 6 and 7. A pin 102 rests upon the free end of the arm 101 and passes upwardly freely through an aperture in the feed slide. It is received in a circular groove with a spiral bottom surface cut in the under face of a graduated disk 103 which is mounted to rotate freely in the forward right hand corner of the feed slide, as shown in Fig. 1, where it may be conveniently reached by the operator.

It will be seen that rotation of the disk 103

gives the operator quick and delicate control of the vertical position of the switch 90. When the disk is turned to its zero position the pin 102 is located in the deep end of the spiral groove. The arm 101 therefore occupies its uppermost position and the switch 90 will therefore also occupy its uppermost position as shown in full lines in Fig. 6. In this position of the switch 90 the plunger 47 is not permitted to reach its most elevated position and no cross feed occurs. In other words the angle B has become zero. Now, when the disk 103 is turned to some such reading as 0.005 the switch 90 is slightly lowered. Accordingly when the cam 46 is rocked the plunger 47 is elevated to its switch closing position for only an instant during the swing of the sector 43. This might be represented by the small angle B in the diagram of Fig. 13.

From this it will be seen that the pilot switch is allowed to close only just before the sector reaches its mid position and is again opened just after the sector passes its mid position. The full power cross feed is therefore effected just prior to and in anticipation of the reversal of the table movement. This action is indicated by the diagram of Fig. 14 where the line 120 indicates the movement of the table 16 toward the right and the line 122 its movement toward the left after reversal. The cross feed is effected prior to the actual point of reversal, while the table movement is represented by the line 121. As the table approaches the point of reversal in its movement toward the left the cross feed is represented as taking place in the line 123.

Now if the operator desires to increase the amplitude of the cross feed he has only to turn the graduated disk 103 forcing downwardly the pin 102. This has the effect of rocking the arm 101 downwardly and moving the switch 90 downwardly against the action of the springs 113 and 105 into some such position as indicated in dotted lines in Fig. 6. The effect of this adjustment is to increase the interval of cross feed because the cam 46 has to rock less before it releases the plunger 47 for movement into its upper or closed-switch position and further before it depresses it to break the relay circuit. The further the disk 103 is turned the greater is the extent of the cross feed and the steeper the angle of the lines 121 and 123 in the diagram of Fig. 12. The switch 90 cannot be set so low that the corner of the flat side of the cam in the extreme positions cannot rest on plunger 47, therefore the cross feed cannot be set to run continuously but must feed only near the ends of the table travel.

Hitherto it has been assumed that the cross feed takes place only during the power operation of the motor 87 and it is a fact that this is a desirable and satisfactory mode of operation. However, I increase the range of usefulness of the machine by providing in some cases for a further cross feed which is effective after the motor is cut off by the controlled momentum of the parts it has set in operation.

The shaft 81 carries a friction disk 85 which runs between cylindrical friction members 83 and 84 yielding and adjustably held together, and locked against rotation by an anchor screw 88 threaded into the base of the bracket 80. The purpose of this friction mechanism is to provide a drag on the shaft 81 that will reduce the tendency of the shaft to spin when its actuating current is cut off, that is, to limit over-running in the cross feeding operation.

The friction on the disk 85 may be adjusted so that the shaft will practically come to a dead stop the instant the switch 90 is opened and under such conditions the table movement is that shown in the diagram of Fig. 14. However, by relaxing the friction on the disk 85 to a limited extent the momentum of the moving parts may be permitted to carry the shaft 81 a few turns ahead after power has been cut off from the motor 87. In this way a portion of the cross feed may be carried beyond the point of actual table reversal and take place during the initial portion of its reverse longitudinal travel.

This mode of machine operation is indicated in the diagram of Fig. 15 where 130 indicates table movement toward the right, power cross feed occurs while the table moves in the line 131 and momentum cross feed occurs while the table moves toward the left in the line 132 prior to its straight line feed toward the left in the line 132. It is plain that the momentum cross feed balances the power cross feed in the cycle of the machine, both occurring while the grinding wheel is off the work.

Cross feed safety stop

The shaft 61, which is driven by the worm 82 and is mounted in the bearing bracket 62, has a collar 63 fast thereto as shown in Fig. 4 and this is provided with a leather friction facing 64 and constitutes one member of a clutch. A rocking member 65 is mounted to turn freely on the outer end of the shaft 61. This member has an inner friction face corresponding to the leather friction face 64. It also carries a triangular safety cam 66 and a counterweight 67 which holds the cam 66 normally in upright position. In the hub of the friction member 65 is carried a hardened ball adapted to be engaged by an upstanding spring arm 68 fast to the machine frame. The arm 68 is oscillated to apply clutching engagement to the rocking member 65 through a horizontal rod 69 which is connected at its left hand end, as shown in Figs. 2 and 3, to a vertical arm 70 loosely mounted in the left hand branch of the bracket 62.

In a bearing block 71 carried by this bracket is journalled a horizontal shaft having a short upstanding arm 72 carrying an adjustable contact screw which engages the arm 70. At the other end of this shaft is a long arm 73 which rests on a pin 74 projecting outwardly from the plunger of a solenoid 75 which is primarily controlled by the relay switch 90 as already described in detail, but which is also controlled indirectly by the before mentioned limiting relay switch 78. As already stated, the switch 78 controls the solenoid 118 which operates the main switch 125, with the result that the opening of the switch 78 opens the main circuit, thus de-energizing the solenoid 75, even though the switch 90 should remain closed. The switch 78 is located with its operating plunger 77 beneath and in operative relation to the triangular cam 66. The triangular cam 66 is normally caused to stand in vertical position by its counterweight 67 and the relay current flowing in the solenoid 75 normally holds the arm 74 in its elevated position so that the arm 68, through the connections described, is pressed against the end of the rocker member 65 which is thus clutched to the friction member of the shaft 61. Accordingly, as the long pinion 61 is rotated in the cross feeding operation, the safety cam 66 is carried down toward the plunger 77 of the safety switch 78. In Fig. 2 it is shown in its mid position. Upon

completion of each cross feeding step, the switch 80 is opened as already described and the solenoid 75 is de-energized, thus releasing the rocker member 65 from the shaft 61 and permitting the cam 66 to return by gravity to its elevated position. Since the longest single cross feed step ever utilized in practice does not require more than one-half a revolution of the pinion 60 the safety cam does not usually reach the plunger 77, and merely rocks back and forth during each cross feeding operation without performing any function. If, however, for any reason the cross feeding movement is not properly terminated, current continues to flow in the relay circuit and the cam 66 continues to travel till it depresses the plunger 76 and breaks the circuit at the switch 78 allowing the line switch to open and bringing the table to an immediate stop.

The shaft 53 as shown in Fig. 11 is mounted in ball thrust bearings in the yoke 50 on the under side of the cross slide. The pinion 52 is fast on this shaft having a press fit thereon. The threaded portion of the shaft turns in the long nut 54. When it has been turned enough to move up and engage the inner end of the nut, then the nut begins to spin with the pinion and the shaft 53 so that no cross feed takes place. The hand wheel 56 is fastened to the nut 54 by a set screw so that the hand wheel 56 will spin idly when no cross feed is taking place. Under these circumstances the inside races of the roller bearings in the frame 10 turn with the shaft. The shaft itself is shouldered down to present a thrust collar for the ball thrust bearings. When the threaded shaft 53 has been turned in the other direction sufficiently to bring the cross slide 13 to its rearward limit of movement, frictional engagement between the shaft and the nut is increased to such an extent that the nut turns with the shaft in the roller bearing, thus permitting continued rotation of the shaft 53 without damage.

The advantages of my invention will be more fully appreciated when it is remembered that in surface grinders now available on the market the table carrying the work reverses its motion at the end of the stroke in order that the cross-slide may be fed over so the grinding wheel will cut a new path. Therefore, the cross feeding takes place after the work has returned under the wheel for several inches, whereas it should preferably have occurred before the work arrived at the wheel.

My improvement consists in utilizing the time after the work has left the wheel up to when it returns to the wheel to do the cross-slide feeding. This is usually about twice three-quarters of an inch of table travel. When all the feeding is done in this space, the wheel cuts a new path over the entire length of the work. Without this improvement the wheel returns to the work along the path already cut and so does not grind until the work is carried over by the feed of the cross slide several inches from the beginning. Also, as the work comes out from the wheel the metal that has been left is now ground away as an extra amount. This loads the wheel to its limit, for no reason other than that this metal was not removed on the previous pass.

My invention enables the grinder to do finer work because all paths of cutting are the same throughout their entire length, and also the invention enables the grinder to produce more work because it is always cutting under full load, and is never overloaded at any point.

My improved grinder has also outstanding safety and convenience features. To enumerate a few, all controls are now arranged so that the operator can adjust the machine while it is running without needing to touch any moving part. The adjustment for extent of cross feed can be changed as often and as much as desired in perfect safety while the grinder is running, whereas previously this required that the grinder must be stopped and the adjustment made on parts that are normally in motion. The hand feed is retained in such a way that it is not active until needed and then can be used without giving any thought to the automatic anticipative cross feed. Moreover the automatic cross feed automatically goes out of commission at each end of the limit of travel of the cross slide in either direction.

Having thus disclosed my invention and described in detail a specific embodiment thereof for purposes of illustration, I claim as new and desire to secure by Letters Patent:

1. A surface grinding machine having a grinding wheel and a work table movable longitudinally back and forth and transversely with respect to the wheel, means on the work table for determining the points of reversal in its longitudinal movement, a cross feed electric motor, means for directing an operating current to said motor for starting it, and mechanism thereupon operated by said motor for imparting a transverse feeding step to the table in anticipation of and before its reversal and for stopping said motor at the conclusion of each cross feeding step.

2. A surface grinder having a grinding wheel and a work table, cross feed mechanism for the table, longitudinal feed mechanism for the table, means for periodically reversing the longitudinal feed mechanism, a cross feed electric motor for operating the cross feed mechanism, and means timed to act prior to and in anticipation of the reversals of the longitudinal feed mechanism for starting said motor and stopping it at the conclusion of each cross feeding step.

3. A surface grinder having a grinding wheel and a work table, cross feed mechanism for the table, a cross feed electric motor for operating the same, longitudinal feed mechanism for the table, mechanism timed in its operation by the longitudinal movement of the table for reversing the longitudinal feed mechanism, for starting said cross feed motor to initiate the action of said cross feed mechanism and for stopping it at the conclusion of each cross feeding step, and means adjustable by the operator for regulating the extent of each cross feed operation.

4. A surface grinder having a grinding wheel and a work table, cross feed mechanism for the table, a cross feed electric motor for operating the same, longitudinal feed mechanism for the table, a sector oscillated by the longitudinal movement of the table for reversing the longitudinal feed mechanism, a cam symmetrically disposed with respect to said sector and movable therewith for starting said cross feed motor to initiate the action of said cross feed mechanism in anticipation of and before the reversal of the table in each stroke, and means adjustable by the operator for regulating the action of said cam.

5. In a grinder, a cross feed slide, mechanism for feeding the slide transversely in the machine, a cross feed electric motor, a work table movable longitudinally back and forth on the cross slide and arranged to start said cross feed motor at

predetermined points in its travel before the end of each reciprocation, and a controlling device located on the cross slide in convenient reach of the operator for advancing or delaying the action of the work table on the cross feed mechanism.

6. In a grinder, a cross feed slide, an electric motor for operating the cross feed slide, a work table and electrically operated mechanism for moving said table longitudinally back and forth on the cross slide, spaced dogs carried by the work table, a rocker member located in the path of said dogs and movable by them for reversing said work table mechanism, a cam operated by said rocker member, electrical means under the control of said cam for throwing the cross slide motor into and out of operation, and manually operated means located on the cross feed slide for modifying the action of said cam.

7. In a grinder, a cross feed slide and a work table carried thereby, electrically operated mechanism for moving said table back and forth in said feed slide, cross feed mechanism, an electric motor connected to operate the cross feed mechanism and arranged to be thrown into periodic action by the work table prior to each reversal, a graduated disk located on the cross feed slide within convenient reach of the operator, and means operated thereby for controlling the length of time the cross feed motor remains in operation at each reversal.

8. In a grinder having a table mounted to reciprocate on a movable cross feed slide and motor operated mechanism for effecting table reciprocation and cross feed movements, a rocker oscillated by the table prior to each reversal of its reciprocation, a switch for throwing into operation the cross feed mechanism operated by said rocker, and means under control of the operator for bodily moving the switch to vary its time of action.

9. In a grinder having a table mounted to reciprocate on a movable cross feed slide, and motor operated mechanism for effecting table reciprocation and cross feed movements, a rocker oscillated by the table prior to each reversal of its reciprocation, a switch operated by said rocker for timing the cross feed movement, spring means tending to move said switch and rocker toward each other, a graduated disk located in the grinder within convenient reach of the operator, and connections between the disk and switch for positively moving the said switch away from the rocker.

10. In a grinding machine having a reciprocatory table, a cross feed slide carrying the table, and individual motors and connecting mechanism for the table and cross feed, an oscillatory sector mounted to be swung by the table and controlling the reversal thereof, and means for throwing the cross feed motor and its connections into operation during a predetermined fractional part of the sector movement.

11. In a grinding machine having a reciprocatory table, a cross feed slide carrying the table, and individual motors and connecting mechanisms for the table and cross feed slide, an oscillatory sector mounted to be swung in opposite directions by the table from an inclined position on one side of a perpendicular mid-position to an inclined position on the other side thereof and to effect reversal of the table motor in its said movement, and cam-controlled mechanism for throwing the cross feed motor into operation while the sector is moving through its said mid-position and throughout an angle less than that of its full oscillation.

12. In a grinding machine having a reciprocatory table, a cross feed slide carrying the table, and individual motors and connecting mechanisms for the table and cross feed, means for supplying operating current to the cross feed motor at a predetermined but variable interval before the point of table reversal and for cutting off its current before actual reversal takes place, and adjustable means for timing the over-running of said motor, whereby the cross feeding operation may extend into the initial portion of the reverse travel of the table.

13. In a grinding machine having a reciprocatory table, a cross feed slide carrying the table, and individual motors and connecting mechanisms for the table and cross feed slide, a switch for controlling the flow of operating current to the cross feed motor arranged to be closed and opened in anticipation of the table reversal at each end of the table travel, and adjustable means acting on the connecting mechanism of the cross feed motor to limit over-running of the motor to a time of travel of the table in reverse no greater than its travel prior to reversal.

14. In a grinding machine having a reciprocatory table, a cross feed slide carrying the table, and individual motors and connecting mechanisms for the table and cross feed slide, a switch for controlling the flow of operating current to the cross feed motor, connections including a motor driven shaft for transversely moving the cross feed slide, means for closing the switch during a short interval before each point of table reversal for effecting cross feeding under power, a disk fast to said driven shaft, and means for applying an adjustable friction to said disk to limit over-running of the shaft to permit cross feed under momentum to take place during the initial portion of the movement of the table after each reversal.

15. In a grinding machine having a reciprocatory work table, a cross feed slide carrying the table and individual motors for operating the table and slide, an operating member movable freely to a predetermined initial position at the beginning of each cross feeding operation, power operated means for moving said member progressively during the operation of the cross feed motor, and a safety switch arranged to be tripped by said member to cut off current to the cross feed motor when the cross feeding operation has exceeded a predetermined extent.

16. In a grinding machine having a reciprocatory work table, a cross feed slide carrying the table and individual motors for operating the table and slide, a rocker carrying a cam and arranged to occupy a predetermined initial position at the beginning of each cross feeding movement of the feed slide, automatic mechanism for starting the cross feed motor prior to each reversal of the table and for initiating rotation of the said rocker, and a normally closed switch arranged to be tripped by said cam after a predetermined interval of operation by said motor.

17. In a grinder having a cross feed slide, a reciprocatory work table thereon and motor driven operating mechanism for the slide and table, a rocker on the cross feed slide oscillated by the table and determining in its movements the points of reversal of table movement, a cam movable directly by the rocker, a switch in the cross feed circuit located adjacent to the cam and having a plunger engaged thereby whereby

the cross feed operating mechanism is thrown into action prior to and in anticipation of each reversal of table movement, and means on the cross feed slide for adjusting the relative positions of the cam and switch whereby the extent of cross feeding movement may be regulated while the machine is in operation.

18. In a grinder having a cross feed slide, a reciprocatory work table thereon and motor driven operating mechanism for the cross slide including a motor-driven shaft and a worm-driven shaft at right angles thereto carrying an elongated pinion, an adjustable friction device associated with said motor driven shaft for regulating overrunning of the motor under momentum and thereby controlling the duration of cross feeding movement, and safety switch mechanism associated with said worm-driven shaft for limiting excessive cross feeding movement of the slide.

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