

Nov. 10, 1936.

S. J. HARLEY

2,060,438

GRINDING MACHINE

Filed March 22, 1935

9 Sheets-Sheet 1

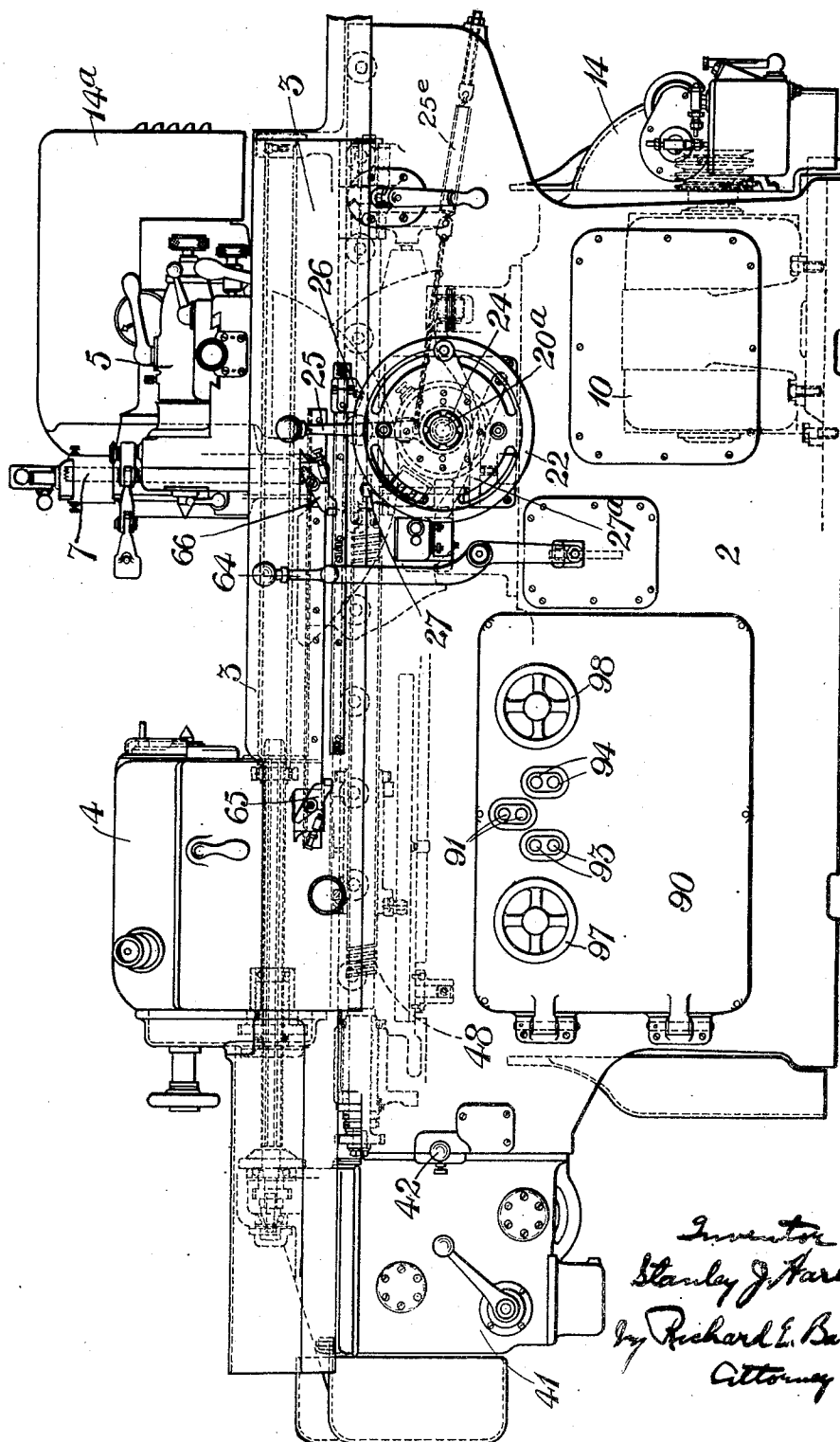


Fig. 1.

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9 Sheets-Sheet 2

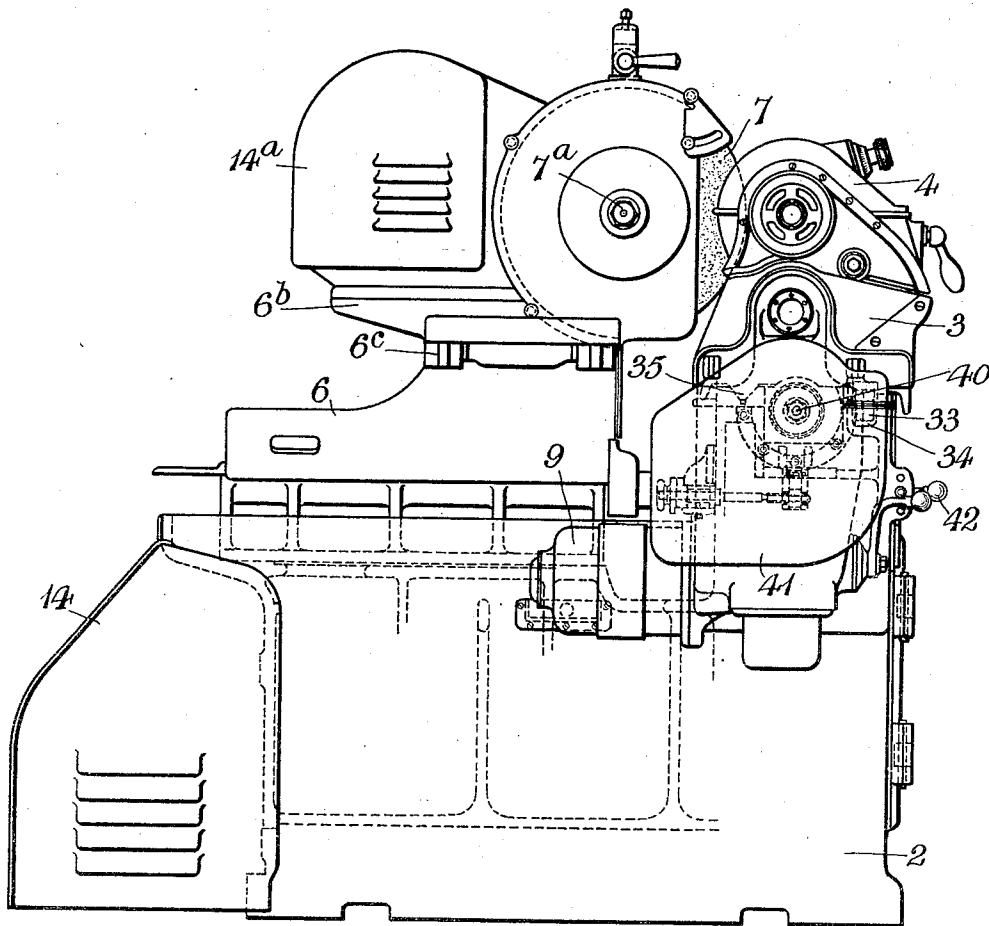


Fig. 2.

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9 Sheets-Sheet 3

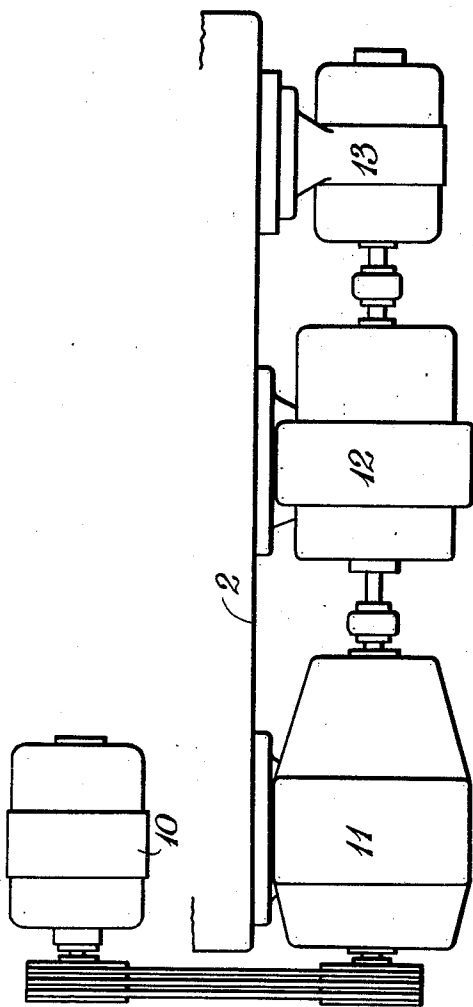


Fig. 3.

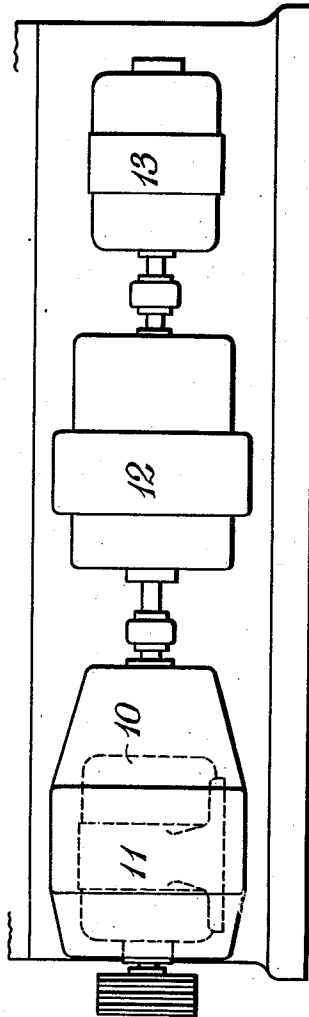


Fig. 4.

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9 Sheets-Sheet 4

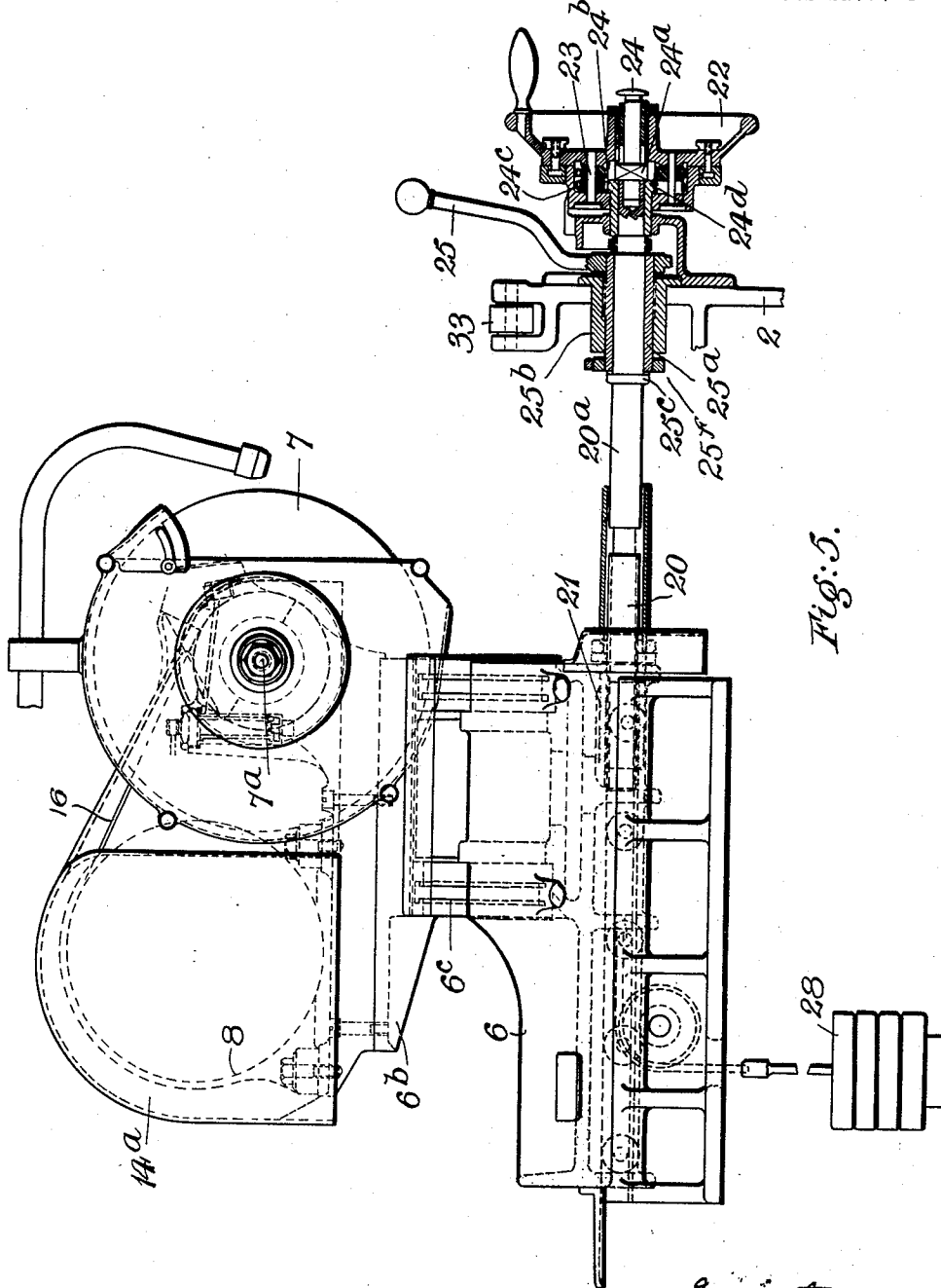


Fig. 5.

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9 Sheets-Sheet 5

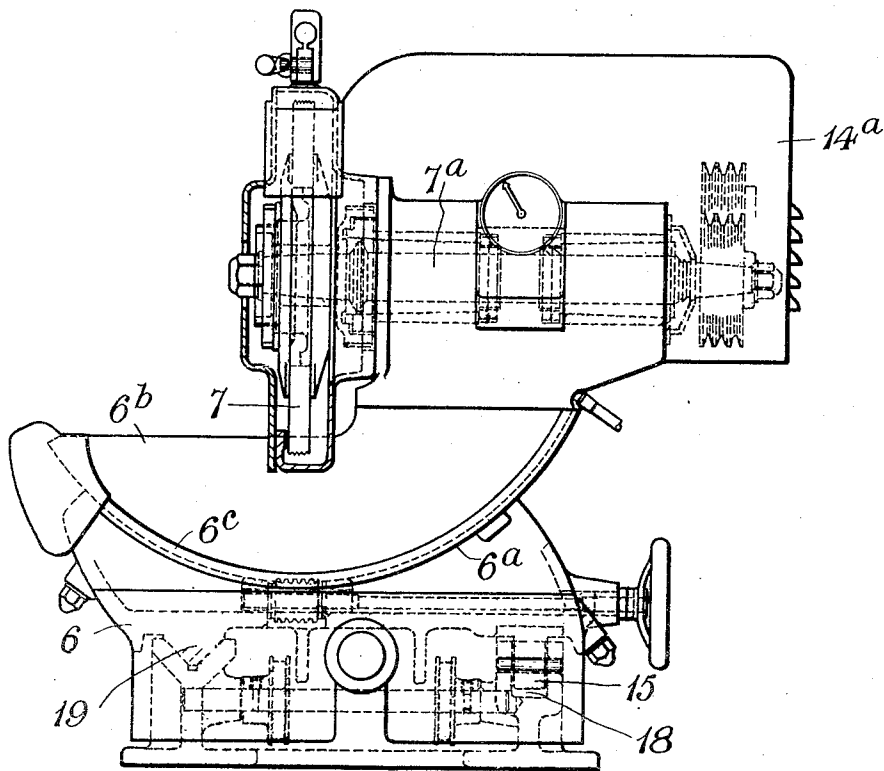


Fig: 6.

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GRINDING MACHINE

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9 Sheets-Sheet 6

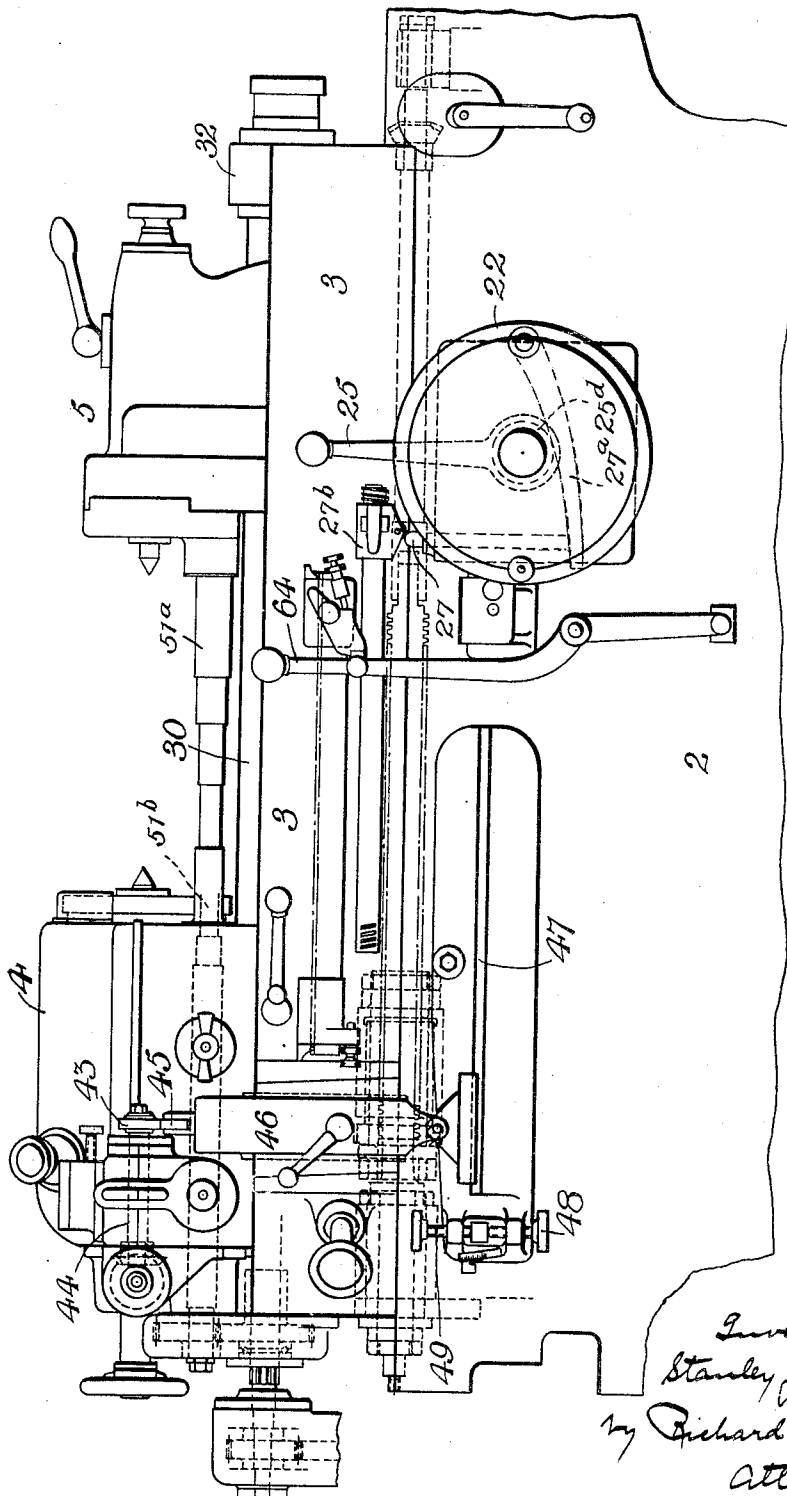


Fig. 7.

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2,060,438

GRINDING MACHINE

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Fig. 8.

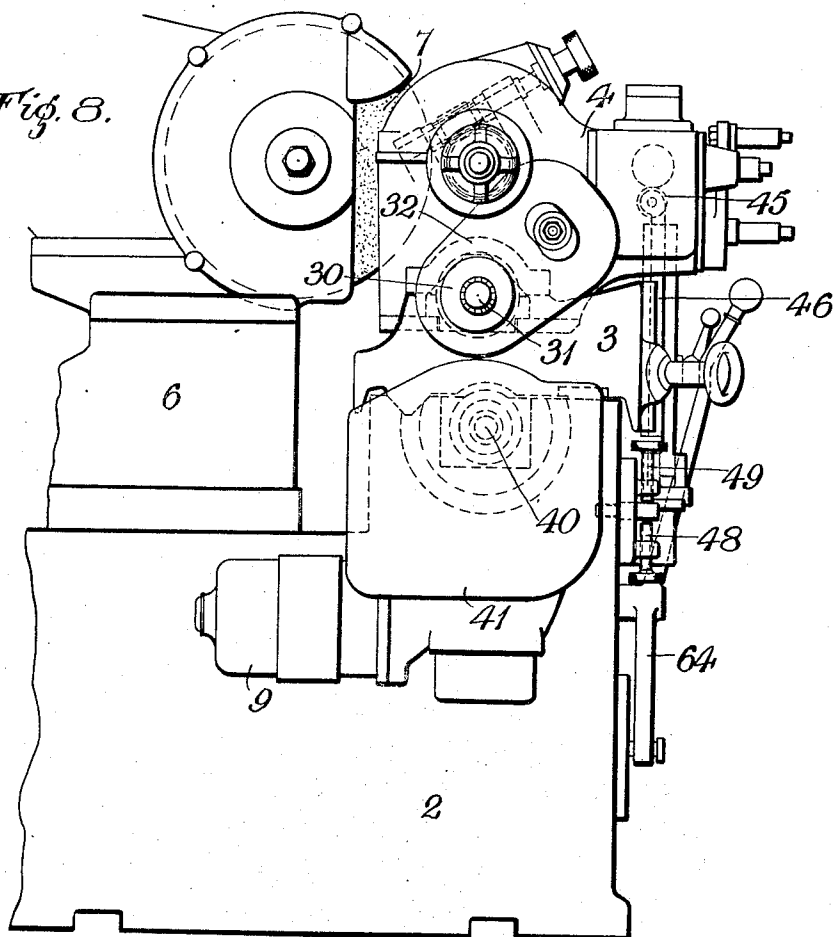
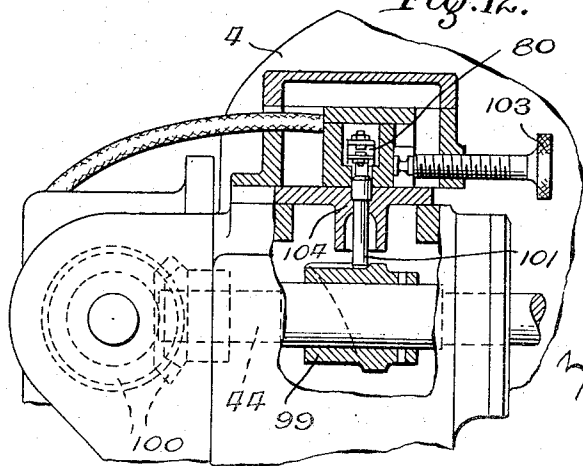


Fig. 12.



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9 Sheets-Sheet 8

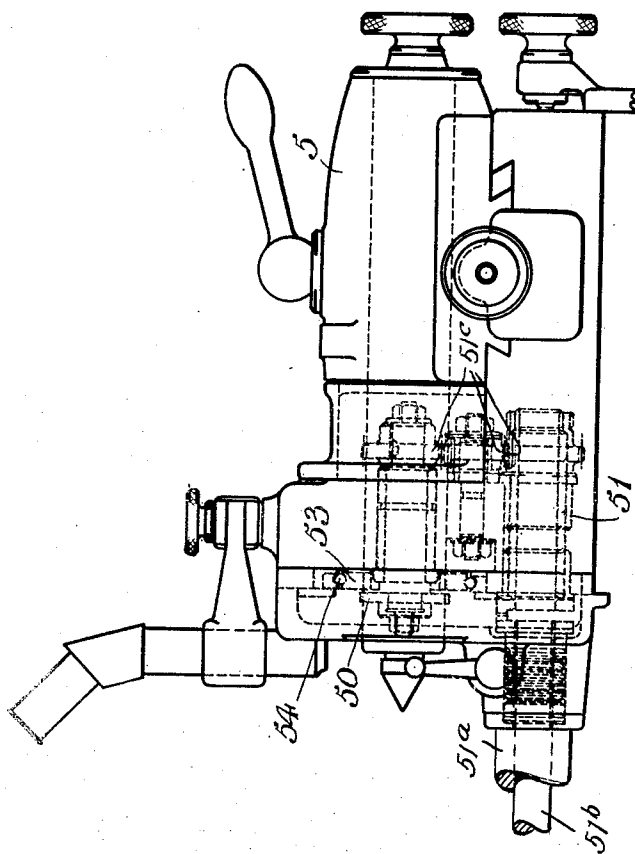


Fig. 9.

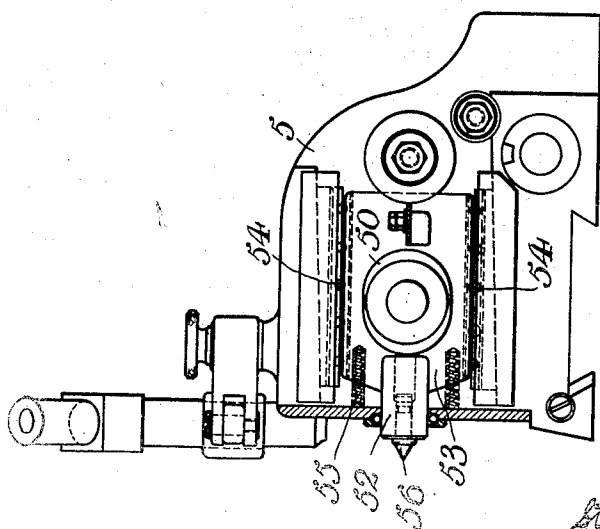


Fig. 10.

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9 Sheets-Sheet 9

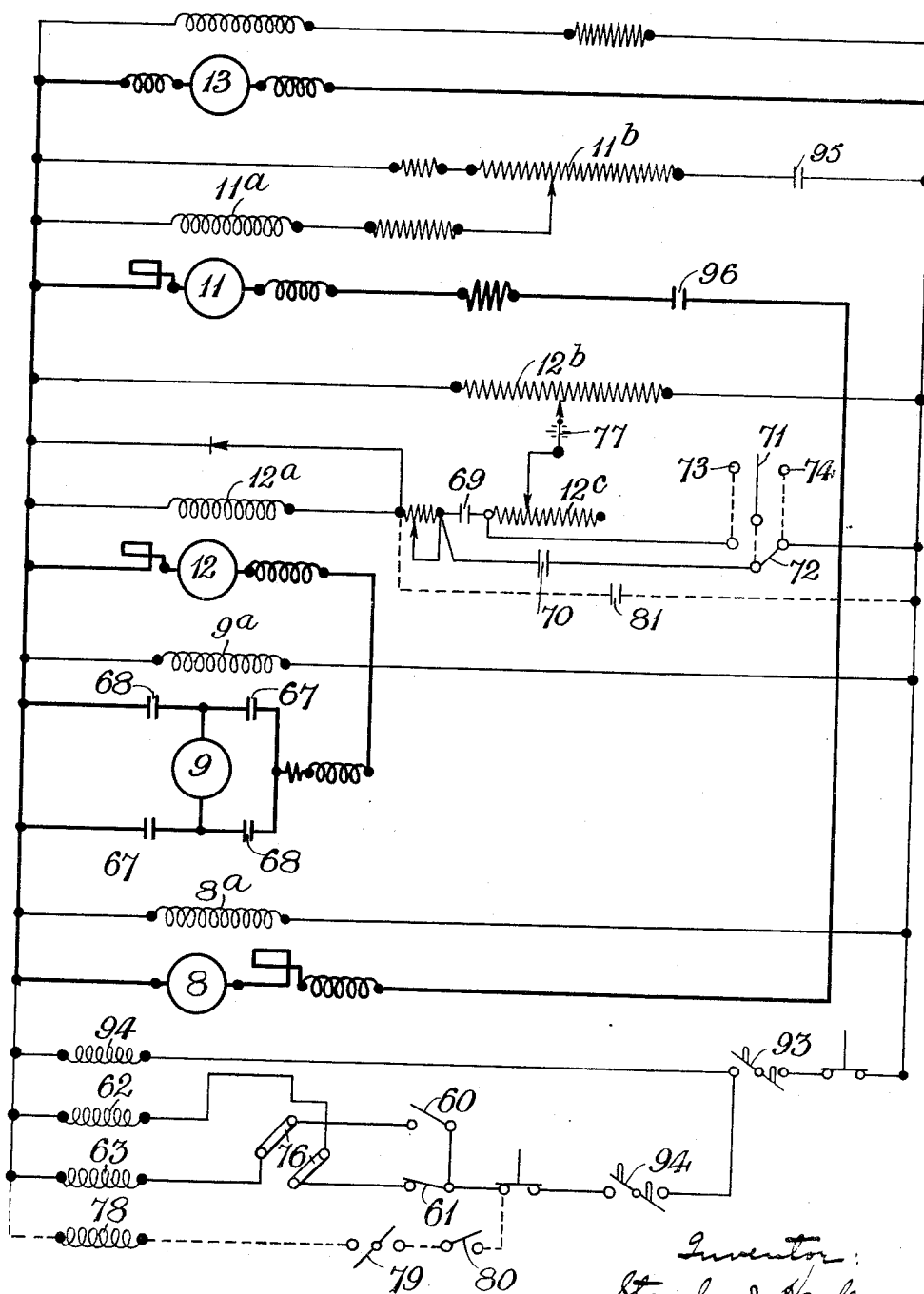


Fig: 11.

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UNITED STATES PATENT OFFICE

2,060,438

GRINDING MACHINE

Stanley Jaffa Harley, Stivichall, Coventry,
EnglandApplication March 22, 1935, Serial No. 12,475
In Great Britain March 21, 1934

5 Claims. (Cl. 51—94)

This invention relates to an improved grinding machine in which a formed grinding wheel is employed for producing screw threads from the solid material, or for finishing existing screw threads, and has for its object to provide a machine for this purpose, by means of which screw threaded work can be rapidly produced or finished with a high degree of accuracy.

The improved machine is electrically driven, the equipment comprising a main driving motor, a pair of generators and an exciter, driven thereby, a motor for the grinding wheel driven by one of said generators, and a motor for the work-head driven by the other generator.

The electrical equipment also includes a system of speed control for the grinding wheel and for the feed and rotational movements of the work-head.

Constructionally, the improved machine is characterized by a number of features including means for grinding taper work and for relieving purposes when grinding taps. Provision is also made whereby the peripheral speed of the work and of the feed movement thereof can be temporarily accelerated each time the flute of a tap passes the grinding wheel. Other features hereinafter described include means for effecting rapid withdrawal of the grinding wheel head when grinding shouldered work and for adjusting the said head to accommodate the helix angle of the thread to be ground. Means are also incorporated in the machine whereby the formed periphery of the grinding wheel can be accurately retrued without disturbing the setting of the machine. A lateral setting device for the work-head is also provided whereby the dead centre can be advanced or retarded so that existing threads on the work can be readily set relatively to the grinding wheel with the aid of a microscope incorporated in the machine.

In the accompanying drawings,

Figures 1 and 2 are front elevational and end views respectively of one form of the improved grinding machine.

Figures 3 and 4 are two views showing the arrangement of the main motor, generators and exciter.

Figure 5 shows the means employed for adjusting the position of the grinding wheel head in relation to the work.

Figure 6 shows the manner in which the wheel head is mounted to provide adjustment for the helix angle of the thread.

Figures 7 and 8 are side and end views of the

machine when adapted for producing or finishing screw threads on fluted or taper work.

Figures 9 and 10 are side and transverse sectional views of the tailstock showing the wheel truing device.

Figure 11 is a schematic diagram of the electrical equipment.

Figure 12 shows means for accelerating the work for gap-jumping or the like purposes.

The main constructional features of the improved machine comprise a fixed bed, 2, a horizontal slide 3 mounted on the bed and adapted for movement longitudinally thereof, a work-head 4 and a tailstock 5 mounted on said slide, and a grinding wheel head 6 mounted upon the said bed and capable of adjustment towards and away from the centre line of the work-head and tail stock.

The electrical equipment comprises a main driving motor 10, a pair of generators 11, 12 and an exciter 13, all driven by the main motor, a motor 8 for driving the grinding wheel energized by one of said generators, and motor 9 for driving the slide 3 and work-head 4 energized by the other generator. The grinding wheel motor 8 is carried on the wheel head 6 and drives the wheel by means of a belt 16.

The main motor, generators and exciter, Figures 3 and 4, are all arranged at the rear of the machine and enclosed in a louvered guard 14.

The grinding wheel head 6 complete with its motor 8 is enclosed in a louvered guard 14^a and is mounted on rollers running in oil baths in the bed of the machine and is guided by a V-section rib and groove engagement with the bed. Adjustment of the wheel for depth of cut, Figure 5, is obtained by a precision screw 20 and nut 21 controlled by means of a large hand wheel 22 located in front of the machine. Two rates of wheel adjustment are provided one being direct from the hand wheel 22 and the other through epicyclic reduction gear 23, the change from one ratio to the other being controlled by the knob 24 which puts the member 24^a either into direct driven relationship with the hand wheel or, as shown, into gear with the sun wheel 24^b of the epicyclic gear, the planet pinions 24^c rolling around the pinion 24^d on the spindle of the screw 20, which is thereby rotated at a proportionately lower ratio.

A quick return movement of the wheel head away from the work can be effected by means of a hand lever 25 which is fixed to one end of an externally screw threaded sleeve 25^a mounted loosely on the spindle 20^a of the screw 20 and

working in a fixed nut 25^b on the machine frame 2. By turning the lever in a clockwise direction the other end of the sleeve is caused to abut against a shoulder 25^c on the spindle and to move the latter bodily toward the left hand in Figure 5.

For screw-threading shouldered work the quick return movement of the wheel head is carried out automatically, a projection 27^b (see Figures 1 and 7) adjustably mounted in the slide 3 carrying the work-head being arranged so that as the latter reaches a predetermined point in its traverse movement said projection 27^b depresses a plunger 27 to release a trip-lever 27^a. Normally said trip-lever 27^a engages with a shoulder 25^d (see Figures 5 and 7) on the hand-lever 25 whereby said hand-lever 25 is held against displacement along the axis of the spindle 20^a, such displacement being due to the feed-forward of said hand-lever 25 on rotation. Depressing the plunger 27 by the projection 27^b disengages the trip-lever 27^a from the shoulder 25^d, sleeve 25^a and hand-lever 25 are then free to rotate in a clockwise direction under the influence of a spring 25^e attached to the collar 25^f carried by the sleeve 25^a. Such rotation moves the wheel-head away from the work as previously described, the spindle 20^a and its adjustable mechanism moving with it.

To accommodate the helix angle of the thread to be ground or finished, the wheel head is arranged, as shown in Figure 6, so that it can be adjusted angularly in a plane parallel with the rotational axis of the wheel for which purpose the wheel head is made in two parts, a lower part 6 sliding on the machine bed 2 formed on its upper side with a spherical seating 6^a and an upper part 6^b carrying the wheel spindle 7^a and having a spherical under part 6^c adjustably mounted in said seating. The grinding wheel 7 itself may be of the multiple rib type shown or of the single rib type.

Where the machine is intended solely for use in producing or finishing screw threads on plain cylindrical work the work-head 4 and tail-stock 5 are both mounted directly on the slide 3, as shown in Figures 1 and 2. For taper and fluted work such as taps, however, the work-head 4 and tail-stock 5, Figure 7, are mounted on a bar 30 which is free to rock about a longitudinal axis on trunnions mounted in bearings 32 at the ends of the slide 3. The slide, like the grinding wheel head, is mounted on rollers 33, Figure 2, rotating in oil baths 34 in the bed 2 of the machine and is guided by a rib and groove engagement 35 with the bed.

The slide 3 and work-head 4 are both driven by the motor 9, the former by a lead screw 40 from a gear box 41 at the left-hand end of the machine, and the latter through gearing housed within the work-head 4 and driven from the gear box 41. The direction of rotation of the lead screw 40 and of the work-head 5 for right and left hand threaded work is changed by means of tumbler gear within the gear box operated by a lever 42 having forward, neutral and reverse positions.

For flute relieving purposes the bar 30 carrying the work-head and tail-stock is adapted to be rocked about the axis of the trunnions to move the work toward and away from the wheel for backing the thread by means of a cam 43 carried by a longitudinal shaft 44 mounted in bearings in the work-head.

The cam bears upon a roller 45 carried by a vertical bar 46 mounted in guides on the slide 3 and resting at its lower end on a sine bar 47 which

is adapted to be moved into various inclined positions or into horizontal position according as may be selected in accordance with the work to be performed and locked in such adjusted position by the screws 48 and 49 and is adapted to take the thrust produced by the rocking of the work-head 4 and tail-stock 5. For flute relieving purposes when operating on a work-piece of the same cross-sectional size from end to end of that portion which is being ground the sine bar 47 will be adjusted to, and locked in, horizontal position. The arrangement is such that at the proper times during the rotation of the work the cam as it turns causes the work head to be moved toward the grinding wheel to give the required amount of relief at the flutes.

For gap-jumping purposes when forming or finishing screw threads on fluted work, such as taps, a cam 99 (see Fig. 12) carried by a longitudinal shaft 44 mounted in the work-head 4 and adapted to be driven from the motor 9 through the gear-box 41 and bevel-gearing 100 is provided. This cam is timed to operate a tappet 101 while a flute is passing the grinding wheel so as to close a switch 80 which short circuits a resistance in the field of the appropriate generator thereby momentarily increasing the speed of the work-head motor and in consequence the rotational speed of the work. The tappet 101 is housed in a member 104 which is longitudinally movable by an adjusting screw 103 so as to adjust the position of said tappet on the face of the cam 99, whereby the time during which the switch 80 is closed may be altered to suit the different sizes of tap flutes.

For screw threading taper work the work-head, which, as already stated is in this case mounted on the rocking bar 30, is gradually tilted towards the wheel as the work traverses across the face of the wheel. For this purpose the cam 43 on the longitudinal shaft is rendered inoperative and the inclination of the sine bar 47 is adjusted by the screws 48, 49 according to the angle of taper required, so that as the slide traverses the bed of the machine the foot of the vertical bar 46 slides along the inclined sine bar 47 and in doing so tilts the work-head gradually toward the wheel.

Where it is desired to relieve a tapering work-piece it will be understood that the proper form of cam 43 will be selected, and will be driven at the proper speed with relation to the longitudinal movement of the slide 3 to result in relieving the work-piece at the proper points, and the sine bar 47 will be adjusted to, and locked in, the inclined position necessary to the exact degree of taper involved. Of course also it will be understood that by using a grinding wheel with a differently formed operative face the machine may be used for form grinding generally.

The acting peripheral face of the grinding wheel is preferably formed in the manner described in my co-pending application Serial No. 651,597, the wheel truing and forming device being in this case permanently associated with the tail-stock so that there is no need to remove or disturb the work when truing up the wheel.

The said device, Figures 9 and 10, comprises a cam 50 driven from a spindle 51 through gearing 51c the outer end of said spindle 51 being adapted for driving connection with the work-head 4 by means of the splined shaft 51b in the housing 51a. The cam bears against a diamond holder 52 carried by a slide 53 which reciprocates between adjustable ball bearing guides 54 against the ac-

tion of springs 55. The cam operates to move the diamond 56 towards and away from the axis of the grinding wheel at the same time that the slide 3 carrying the work-head 4 and tail-stock 5 is traversed by the lead screw 40 across the face of the wheel, the two movements being correlated and relatively adjustable to give the desired form to the acting peripheral face of the wheel.

Referring now to the schematic diagram, Figure 11, of the electrical equipment it will be seen that the shunt fields 8^a, 9^a and 11^a, 12^a of the motors 8, 9 and generators 11, 12 are each separately excited, the supply of current thereto from the exciter 13 being regulated by variable resistances 11^b, and 12^b, 12^c of the potentiometer type so that whilst the voltage output of the generators can be varied at will the torque of the motors respectively driven therefrom remains constant throughout the whole of the speed range.

By suitable regulation of the resistance 11^b the speed of the grinding wheel motor 8 and hence the peripheral speed of the wheel itself can be readily varied in fine gradations between a speed as low as 730 feet per minute for economical wheel truing and forming purposes and a speed as high as 6500 feet per minute thereby enabling the most suitable grinding speed to be obtained for any class of work. The wheel motor 8 is started up by closing the push-button switch 93 which completes the circuit of the exciting coil 94 of a contactor controlling switches 95, 96 in the shunt field and armature circuits of the generator 11.

The movements of the work-head in feeding the work across the face of the grinding wheel are controlled by means of a pair of limit switches 60, 61 which open and close the circuits of the exciting coils 62, 63 of contactors governing the direction of rotation of the generator 12 supplying current to the work-head motor 9. The said switches are operated by a trip lever 64 pivoted in the bed of the machine and arranged between a pair of adjustable stops 65, 66 on the slide 3. The arrangement is such that when the work-head reaches the end of its feed movement the lever 64 is moved by the stop 66 to close limit switch 60 and open limit switch 61. The effect produced is to complete the circuit of the contactor exciting coil 63 and to break the circuit of the contactor exciting coil 64, respectively, and hence to close the switches 67 and open switches 68 in the armature circuit of the motor 9 thereby reversing the direction of rotation of the latter.

At the same time the closing of contactor energized by coil 62 also opens switch 69 and closes switch 70 in the field circuit of the generator 12 thus short circuiting the greater part of the controlling resistances 12^b, 12^c and increasing the speed of the motor so that the work-head is given a quick return movement. At the end of the return movement the trip lever 64 is moved in the opposite direction by the second stop 65 to open limit switch 60 and close limit switch 61 the effect of which is to break the circuit of the exciting coil 63 controlling switches 68, and 70 and to close the circuit of the exciting coil 62 thereby closing switches 67 and 69.

The work-head will now move forward on its feed movement at a speed which is set by adjustment of the regulating resistances 12^b, 12^c in the field circuit of the generator 12.

When the work speed is required to be the same in both directions a change-over switch 71 can

be introduced in the field circuit of the generator 12 in which case the connecting link 72 previously necessary will be removed.

The armature of the change over switch 71 is connected to that part of the field circuit of generator 12 containing switch 69 and is adapted to make contact with one or the other of terminals 73, 74 connected respectively with one end of resistance 12^c and with the armature circuit of the exciter 13 respectively. In this case when the work-head is moving in one direction switches 67, 68 are closed and switches 69 and 70 are open and the speed of the motor is controlled by the resistances 12^b, 12^c. When the work-head is moving in the other direction switches 67, 68 are open and switches 69, 70 are closed and the armature of the change over switch 71 makes contact with terminal 73 so that the speed of the motor is again controlled by resistances 12^b, 12^c.

For producing or finishing left-hand threads the operation of the limit switches 60, 61 has the reverse effect, that is to say, by means of a second changeover switch 76, which may be conveniently operated by the tumbler gear lever 42 aforesaid, the said limit switches and exciting coils 62, 63 are cross-connected so that when the work-head reaches the end of its feed movement in the left-hand direction the resultant operation of the trip lever 64 on the said switches 60, 61 is to reverse the direction of rotation of the motor and accelerate its speed to give a fast return of the work.

For flute jumping purposes the link 77 is removed and connections made as shown in dotted lines in Figure 11. A separate contactor is provided, the circuit of the exciting coil 78 of which when closed by the hand switch 79 is controlled by a cam-operated switch 80 (see Fig. 12). The cam 99 is arranged to close this switch during the time a flute is passing the grinding wheel the consequent excitation of the contactor coil 78 closing switch 81 thereby cutting out the variable resistance 12^c in the generator field and completing the latter across the circuit of the armature of the exciter 13, as shown in dotted lines, so that the speed of the motor is accelerated. When the flute has passed the wheel the cam allows the switch 80 to open thus breaking the circuit of the exciting coil 78 of the contactor controlling switch 81.

The switch panel is arranged at the front of the machine and conveniently carried by the door 90 of a housing in the bed of the machine for the resistances and contactors. The said panel comprises starting and stopping switches 91 of the press button type for the main motor and similar switches 93 and 94 for the motors for the wheel and work-head respectively, as well as speed control hand wheels 97, 98 for the variable resistances 11^b, 12^b in the field circuits of the generators. A safety switch may also be provided and arranged so that when the door of the housing is opened the machine is rendered inoperative.

The stop push button for the grinding wheel motor may be interlocked with the corresponding button of the work-head motor so that if the wheel is stopped the work is also stopped and cannot be restarted until the wheel is again set in motion.

I claim:—

1. A grinding machine comprising a fixed bed, a driven grinding wheel, means for moving said wheel transversely of said bed, a slide mounted in said bed for reciprocation longitudinally thereof across the operative face of said grinding wheel, 75

a bar extending longitudinally of said bed and rockably mounted on said slide, work-holding means mounted on said bar to present the work-piece to the operative face of said grinding wheel, a drive gearing, and means driven by said gearing for reciprocating said slide, in combination with a cam mounted in said work-holding means, a longitudinally extending sine bar mounted on said bed, means for adjusting said sine bar to a horizontal and to various inclined positions and for locking it in a selected position of adjustment, guides carried by said slide, a rod working in said guides and traveling with said slide, said rod engaging said cam with one end and slidably engaging said sine bar with its other end and moving endwise in its guides in accordance with the degree of inclination of said sine bar as said slide moves longitudinally whereby said bar will be caused to rock correspondingly about its axis, and means driven by said gearing in definite relation to said slide reciprocating means for rotating said cam to by its engagement with said rod cause an independent cyclic oscillatory movement of said bar and the work-piece.

2. A grinding machine comprising a fixed bed, a driven grinding wheel, a slide mounted in said bed for reciprocation longitudinally thereof across the operative face of said grinding wheel, a bar extending longitudinally of said bed and rockably mounted on said slide, work-holding means mounted on said bar to present the work piece to the operative face of said grinding wheel, and means for reciprocating said slide, in combination with a cam mounted in said work-holding means, a longitudinally extending sine bar mounted on said bed, means for selectively adjusting said sine bar to a horizontal and to various inclined positions, guides carried by said slide, a rod working in said guides and traveling with said slide, said rod engaging said cam with one end and slidably engaging said sine bar with its other end and moving endwise in its guides in accordance with the inclination of said sine bar as said slide moves longitudinally whereby said bar is caused to rock correspondingly about its axis, and means for rotating said cam to by its engagement with said rod cause an independent oscillatory movement of said bar and work-piece.

3. A grinding machine comprising a fixed bed, a driven grinding wheel, a slide mounted in said bed for reciprocation longitudinally thereof across the operative face of said grinding wheel, a bar extending longitudinally of said bed and rockably mounted on said slide, work-holding means mounted on said bar to present the work-piece to the operative face of said grinding wheel, and means for reciprocating said slide, in combination with a cam mounted in said work-holding

means, a longitudinally extending sine bar mounted on said bed, means for selectively adjusting said sine bar to a horizontal and to various inclined positions, guides carried by said slide, a rod working in said guides and traveling with said slide, said rod engaging said cam with one end and slidably engaging said sine bar with its other end and moving endwise in its guides in accordance with the degree of inclination of said sine bar as said slide moves longitudinally whereby said bar will be caused to rock correspondingly about its axis, means adapted to rotate said cam to by its engagement with said rod cause supplementary oscillatory movement of said bar and the work-piece, and means for rendering the last mentioned means inoperative.

4. A grinding machine comprising a fixed bed, a driven grinding wheel, a slide mounted in said bed for reciprocation longitudinally thereof across the operative face of said grinding wheel, a bar extending longitudinally of said bed and rockably mounted on said slide, work-holding means mounted on said bar to present the work-piece to the operative face of said grinding wheel, and means for reciprocating said slide, in combination with an abutment carried by said work-holding means, a longitudinally extending sine bar, means for selectively adjusting said sine bar to various inclined positions, guides carried by said slide, and a rod working in said guides and traveling with said slide, said rod engaging said abutment with one end and slidably engaging said sine bar with its other end and moving endwise in its guides in accordance with the degree of inclination of said sine bar as said slide moves longitudinally whereby said bar will be caused to be rocked correspondingly about its axis.

5. A grinding machine comprising a fixed bed, a driven grinding wheel, a slide mounted in said bed for reciprocation longitudinally thereof across the operative face of said grinding wheel, a bar extending longitudinally of said bed and rockably mounted on said slide, work-holding means mounted on said bar to present the work-piece to the operative face of said grinding wheel, and means for reciprocating said slide, in combination with a cam mounting in said work-holding means, abutment means engaged by said cam throughout the range of movement of said slide, said abutment means being rigid with said bed, and means for rotating said cam for causing a cyclic oscillatory movement of said bar and work-piece throughout the longitudinal movement of said slide.

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