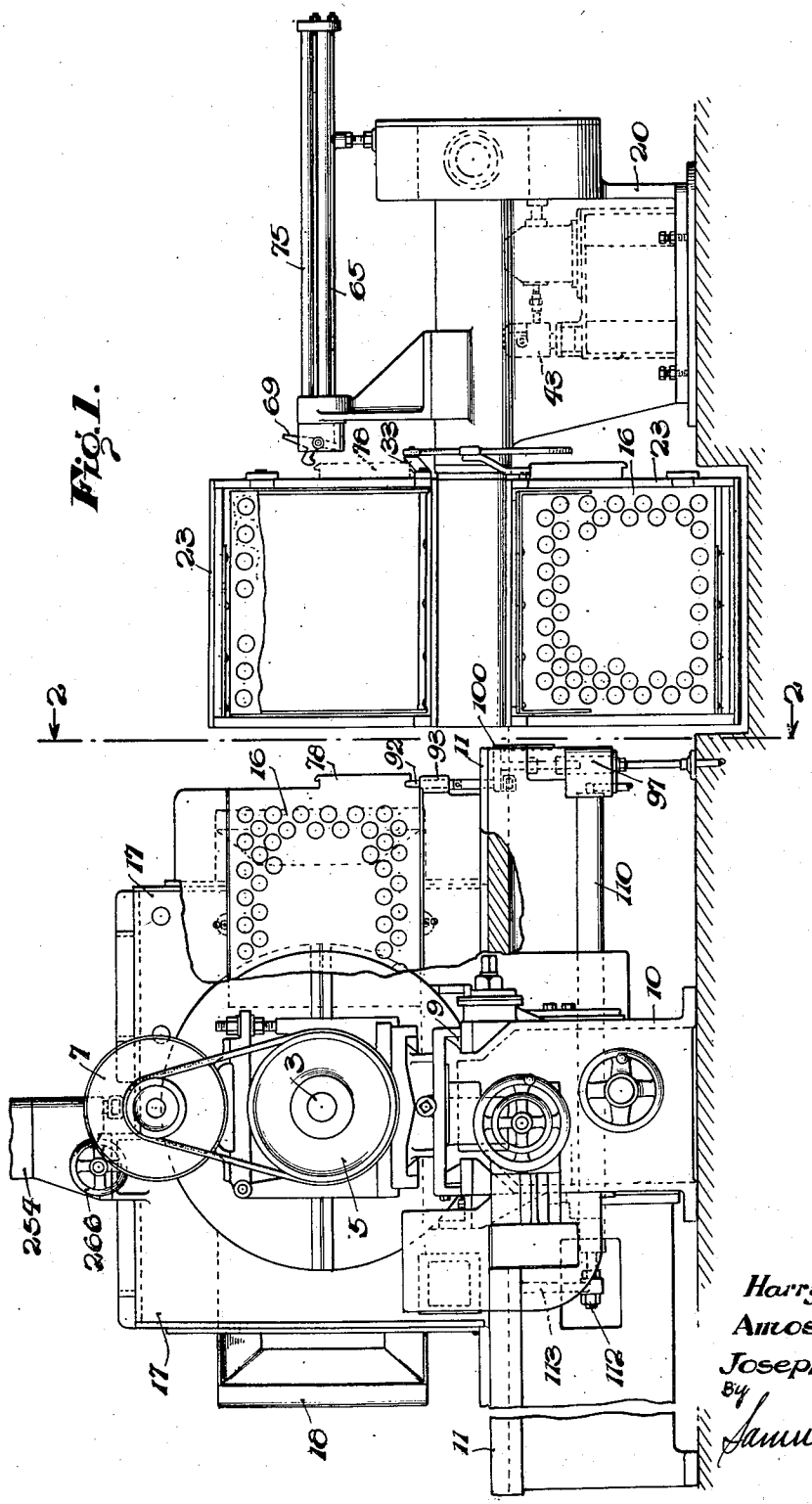
June 24, 1941. H. P. TROENDLY ET AL 2,246,869

GRINDING MACHINE

Filed Feb. 23, 1939 12 Sheets-Sheet 1

Fig. 1.



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GRINDING MACHINE

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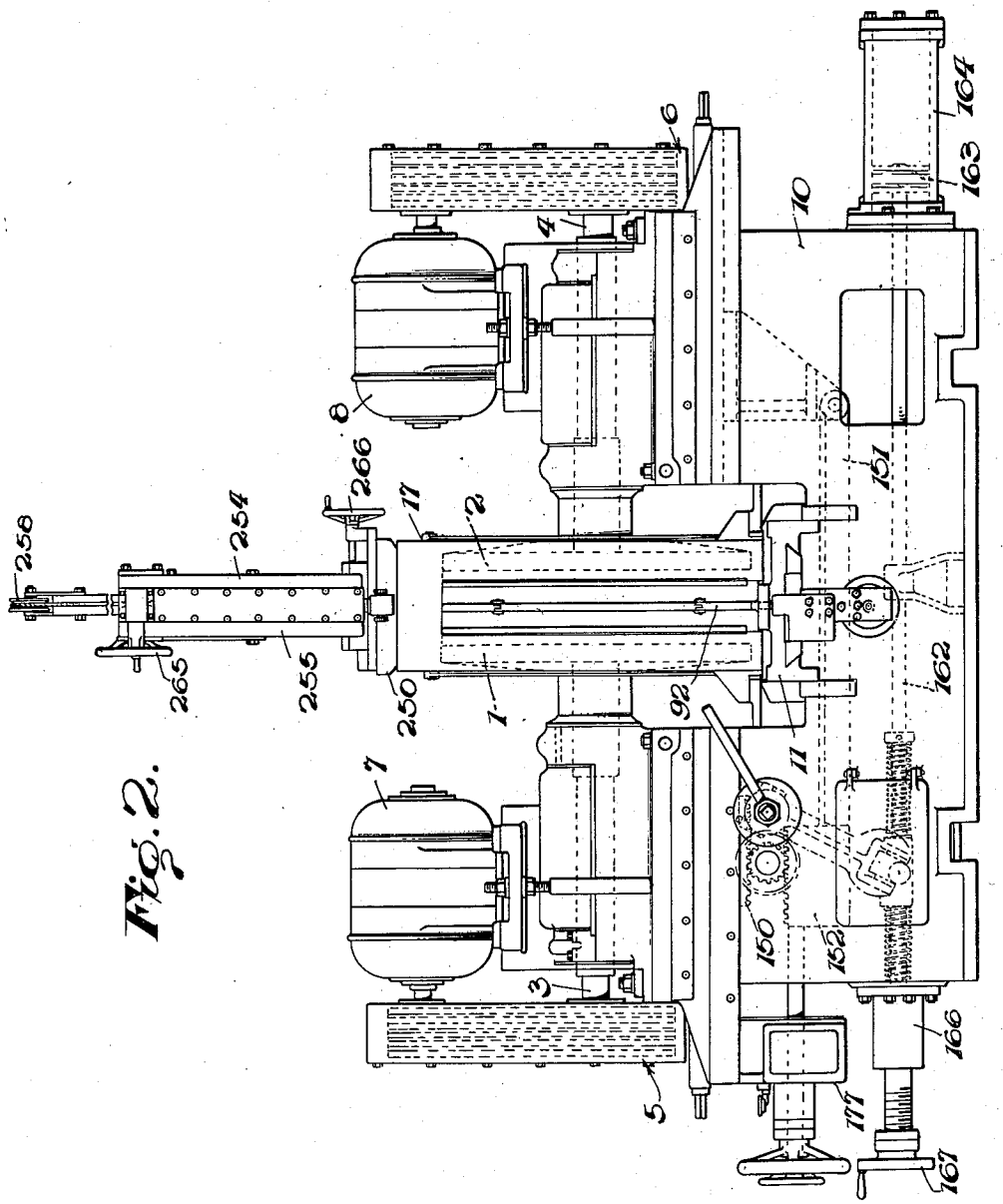


Fig. 2.

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GRINDING MACHINE

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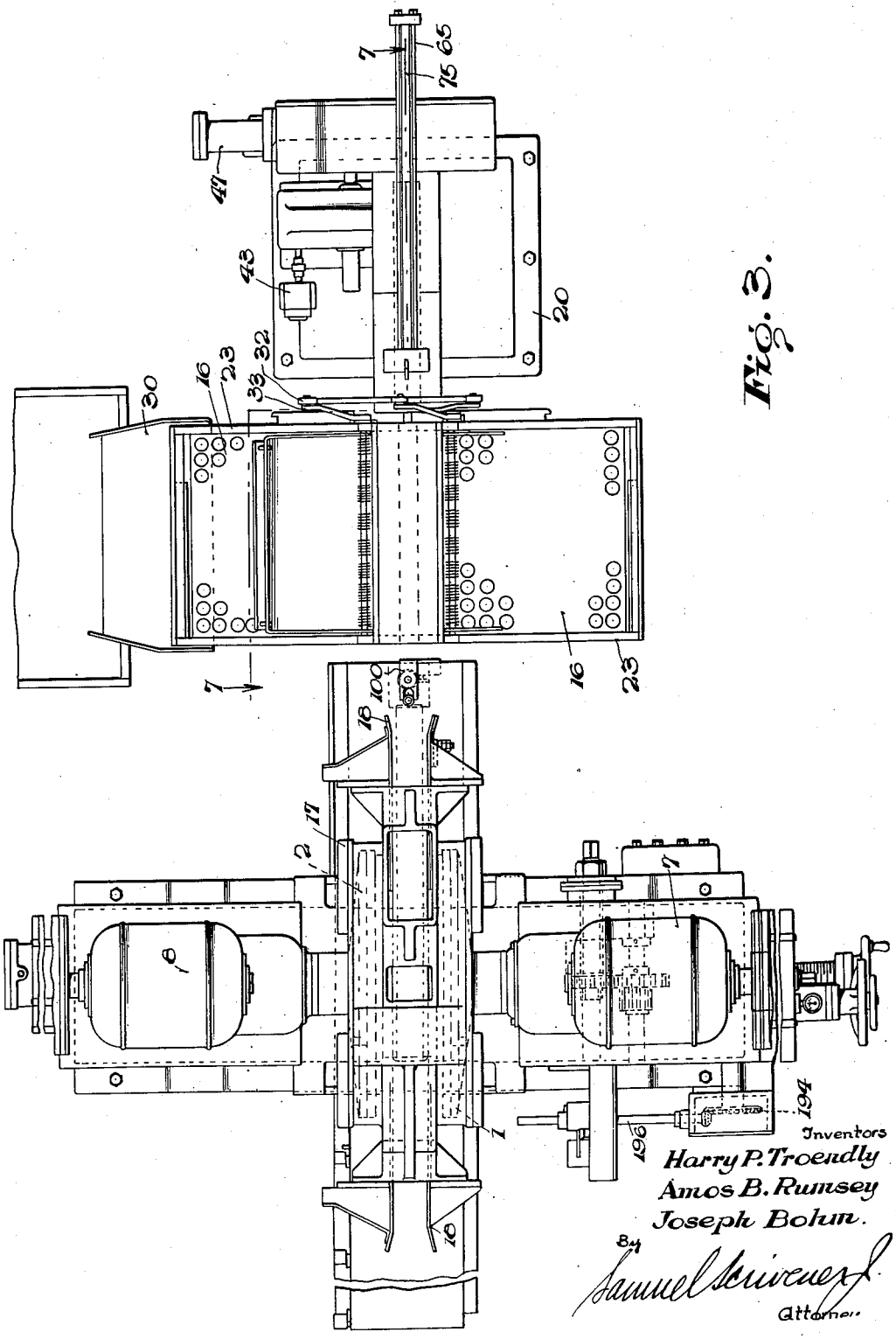


Fig. 3.

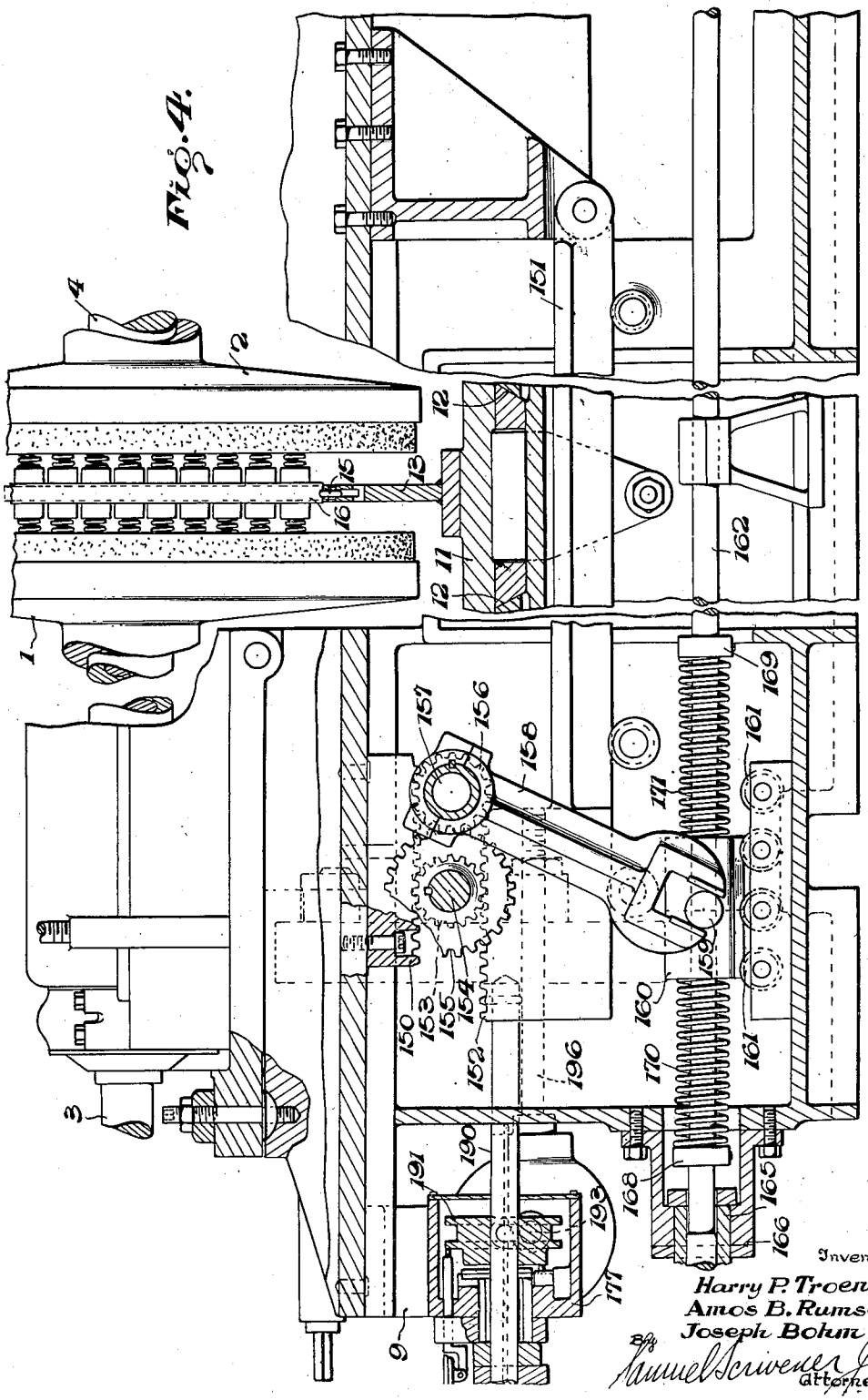
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Fig. 4.



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GRINDING MACHINE

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Fig. 5.

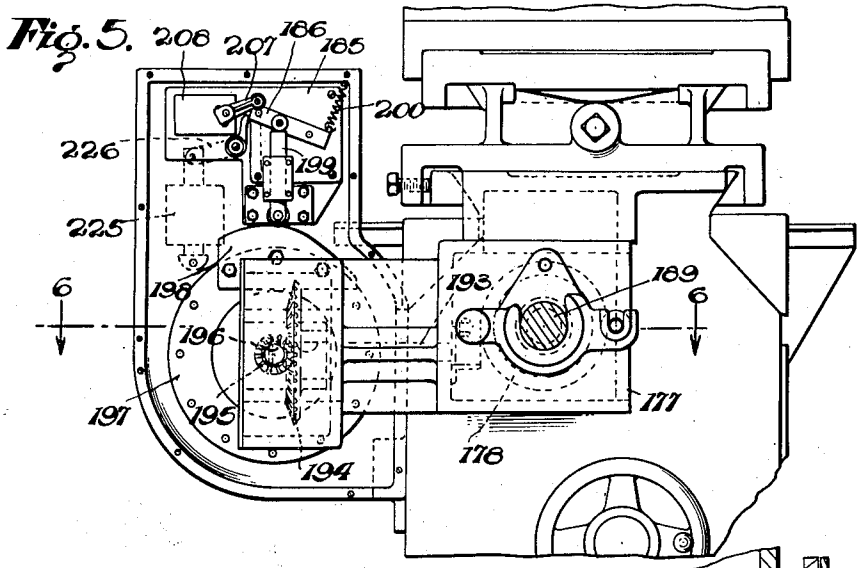
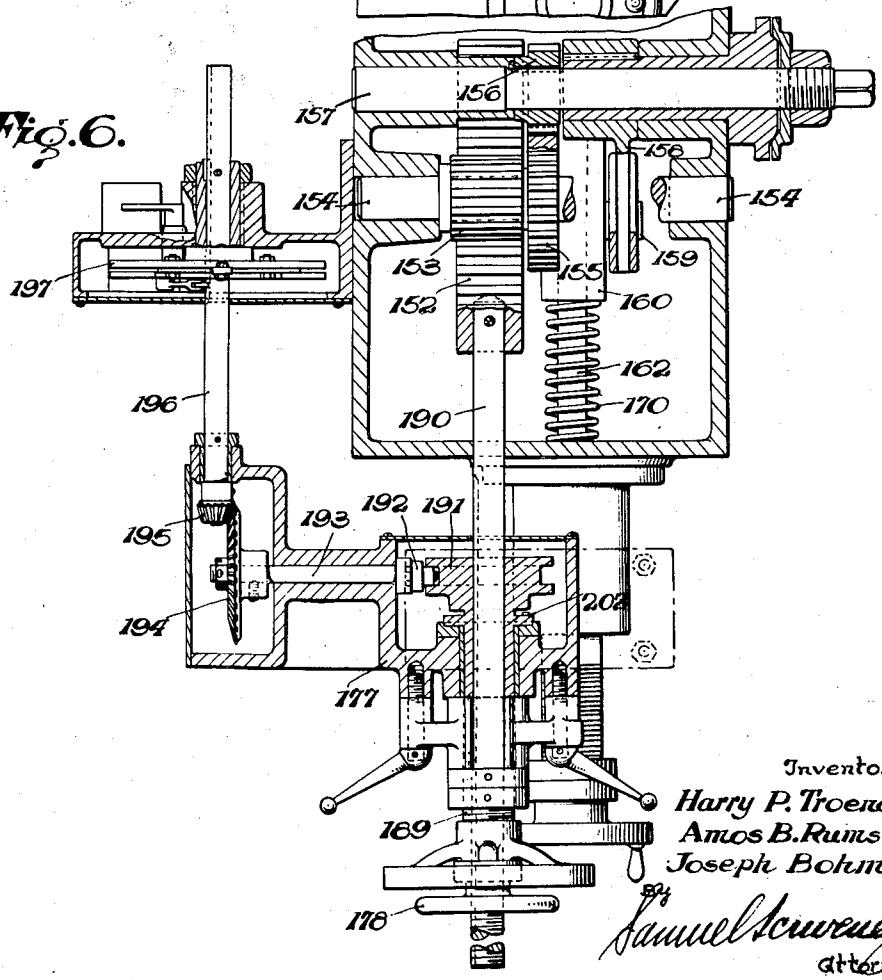


Fig. 6.



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GRINDING MACHINE

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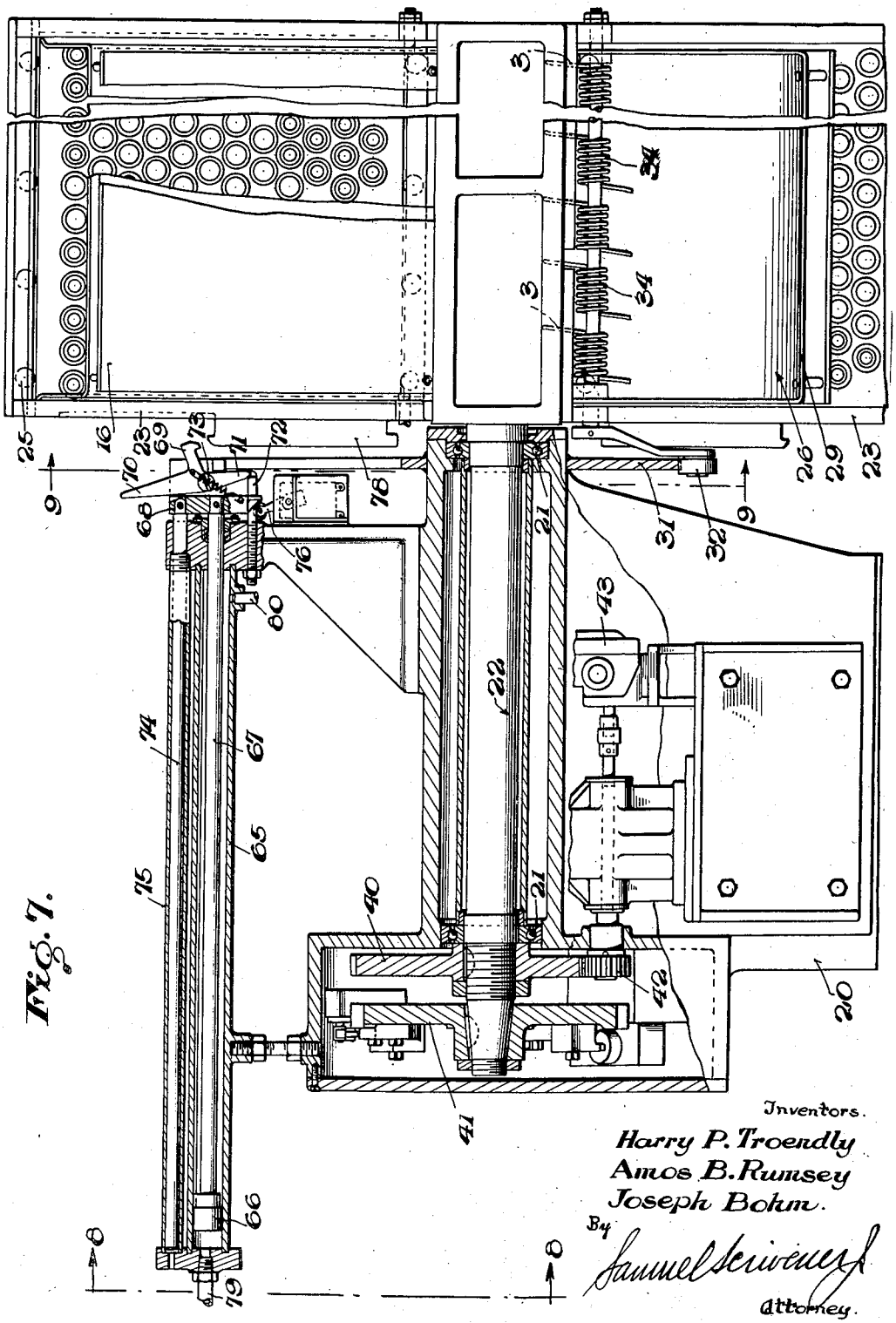


Fig. 7.

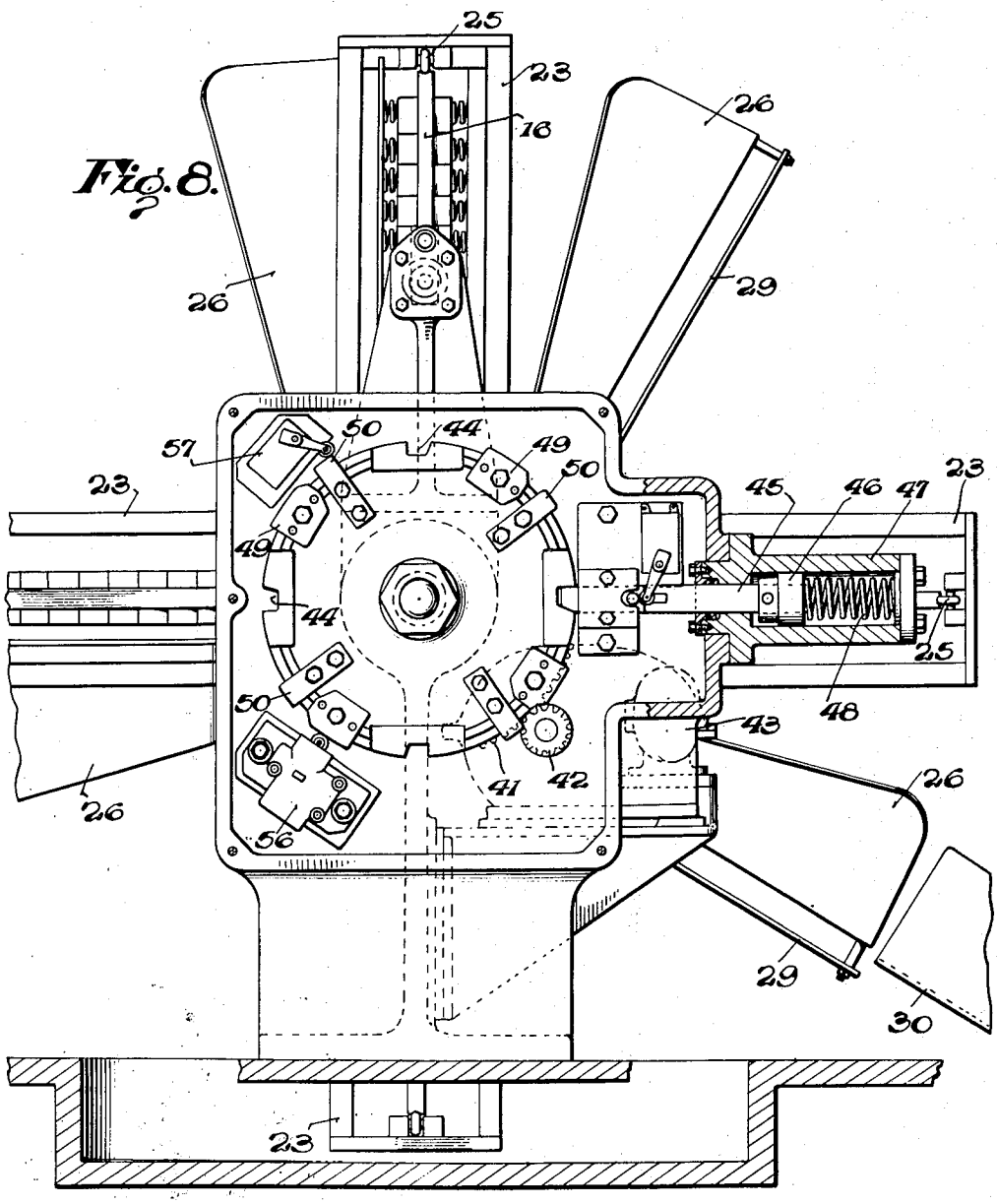
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GRINDING MACHINE

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Fig. 8.



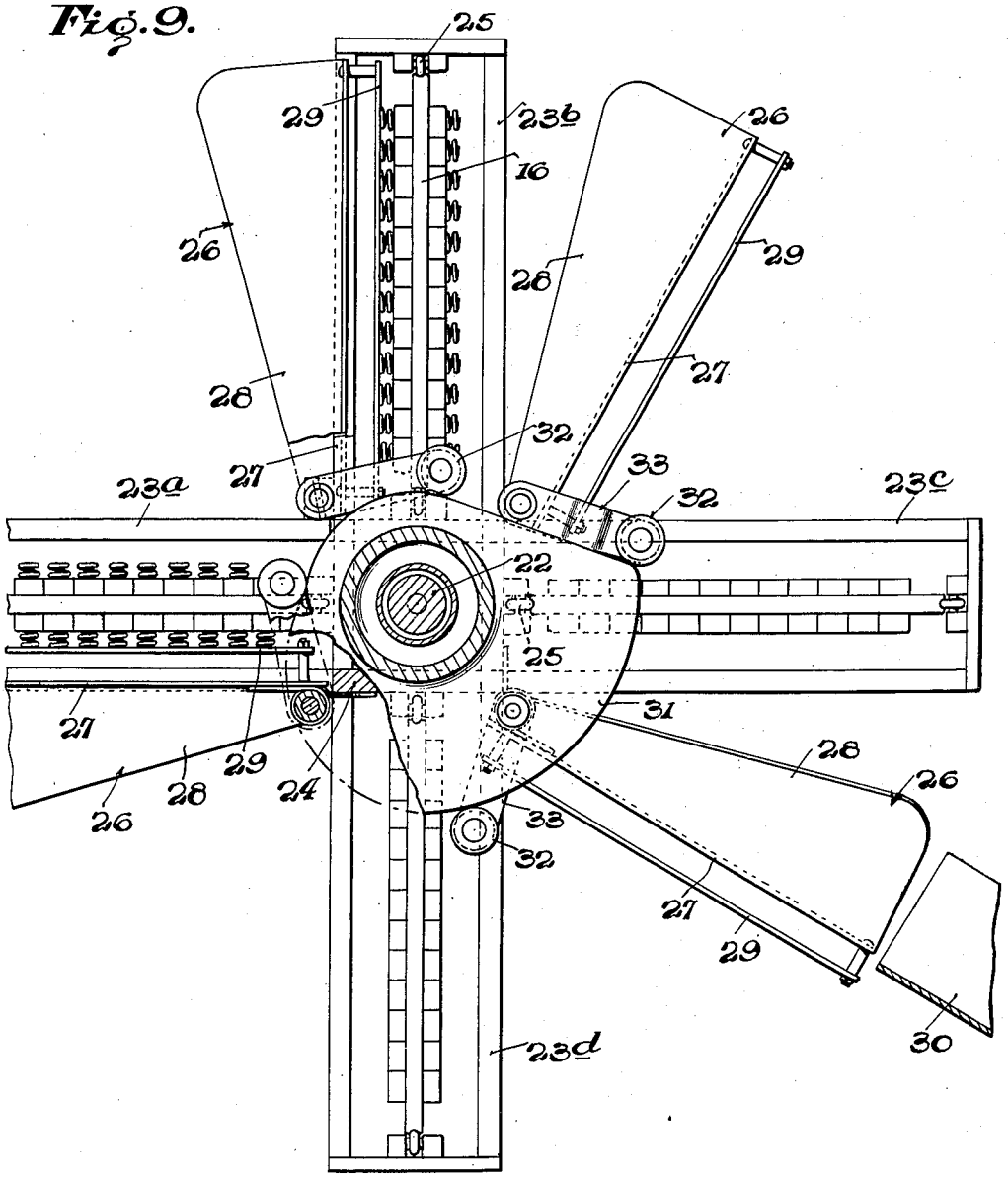
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GRINDING MACHINE

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Fig. 9.



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GRINDING MACHINE

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Fig. 10.

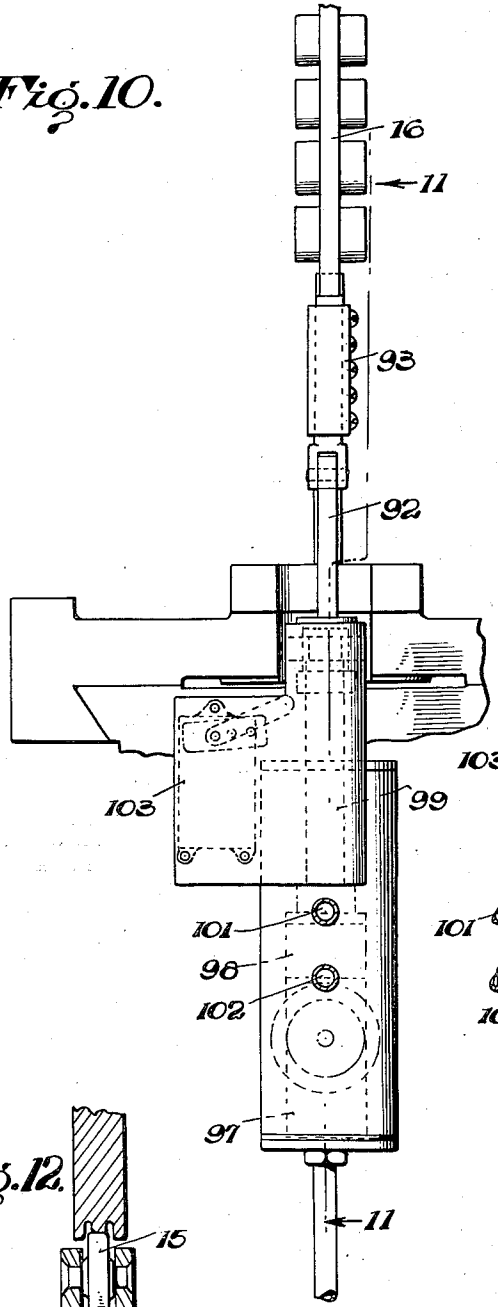


Fig. 11.

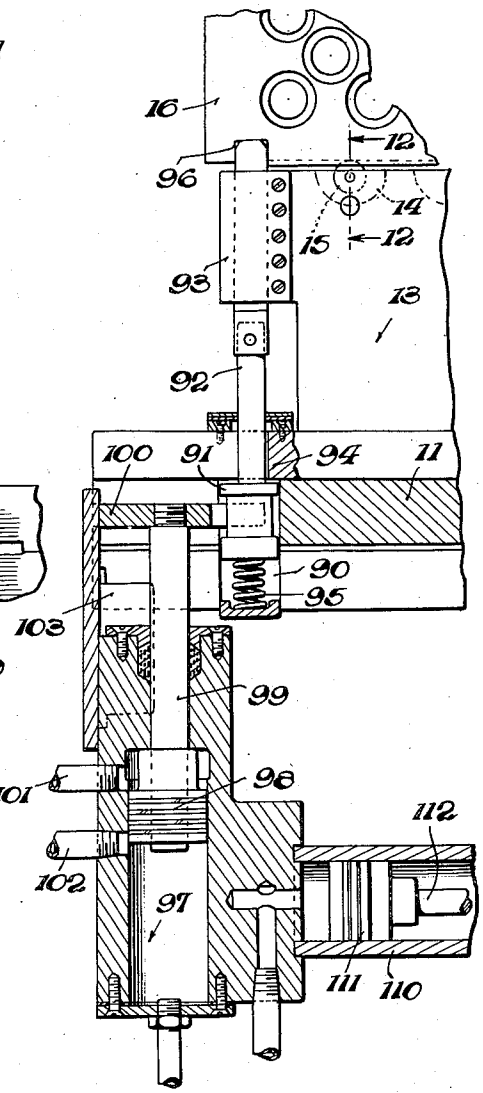
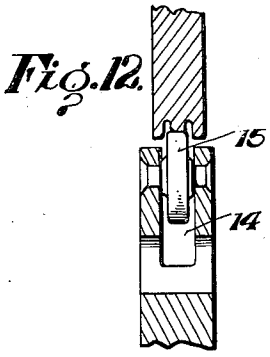


Fig. 12.



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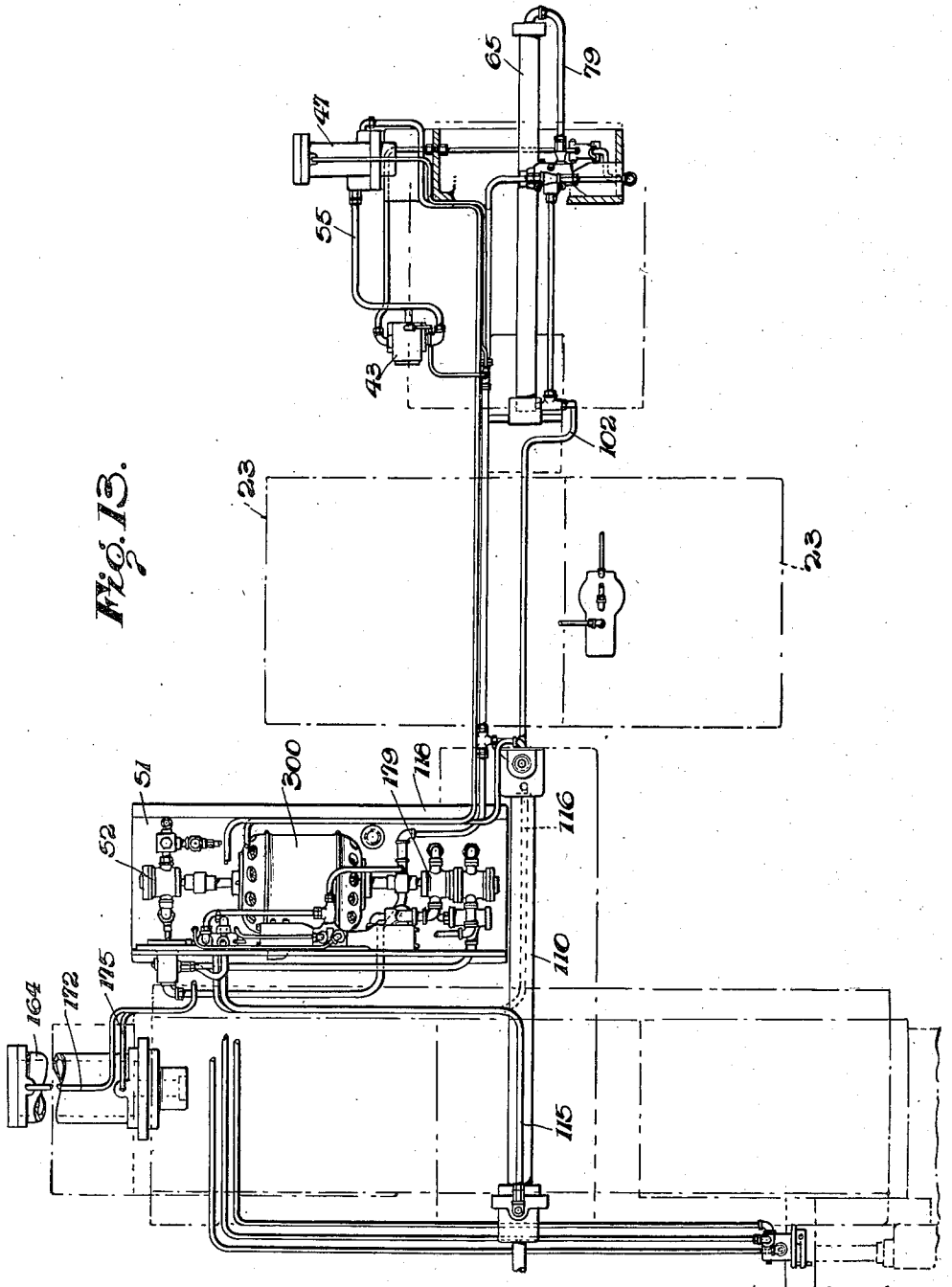
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GRINDING MACHINE

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Fig. 13.



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June 24, 1941. H. P. TROENDLY ET AL 2,246,869

GRINDING MACHINE

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Fig. 14.

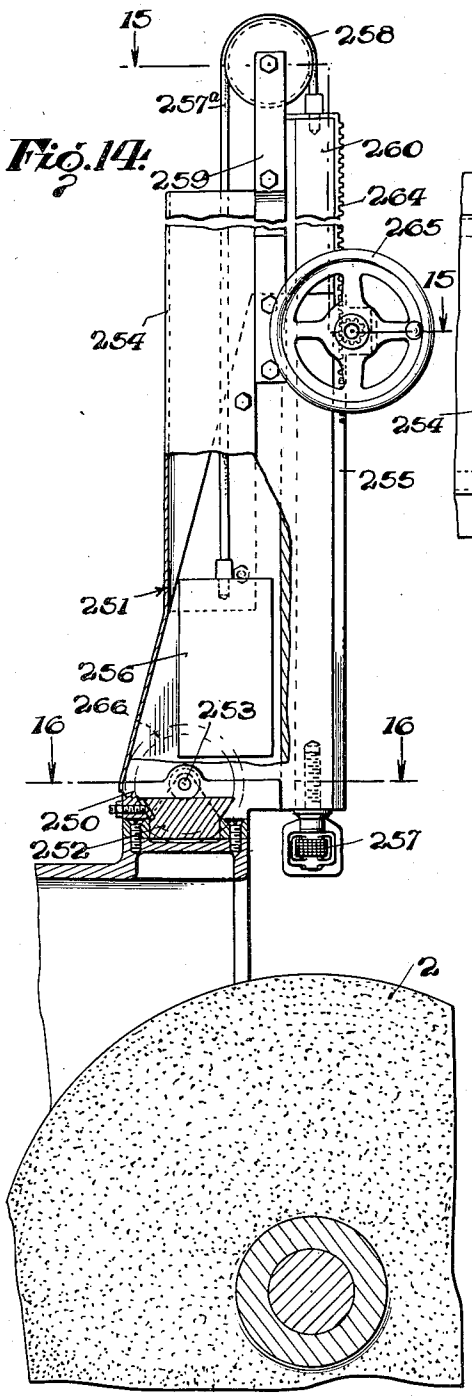


Fig. 15.

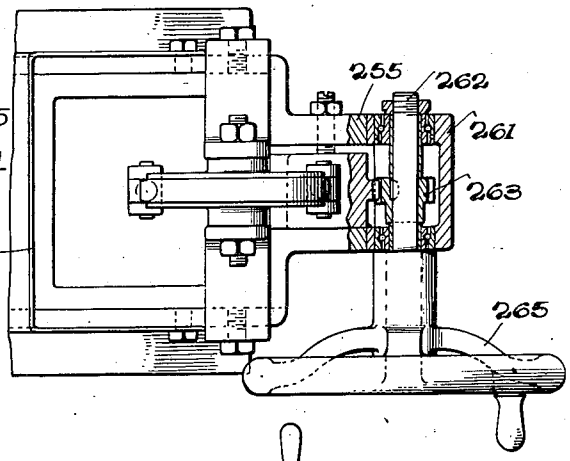
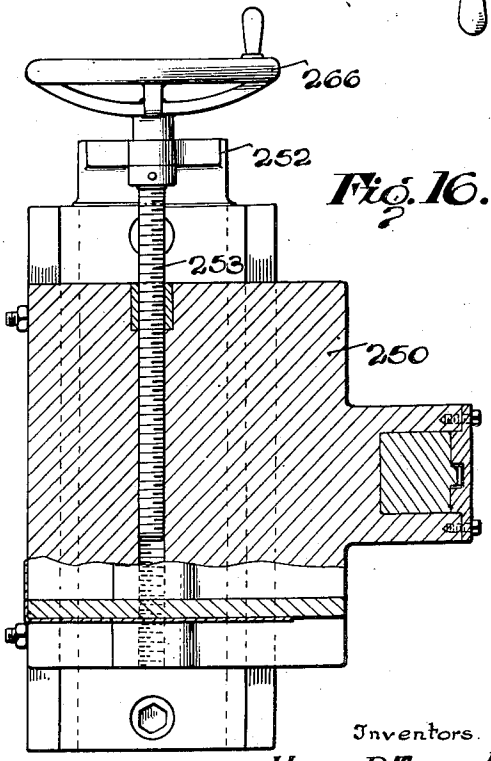


Fig. 16.



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GRINDING MACHINE

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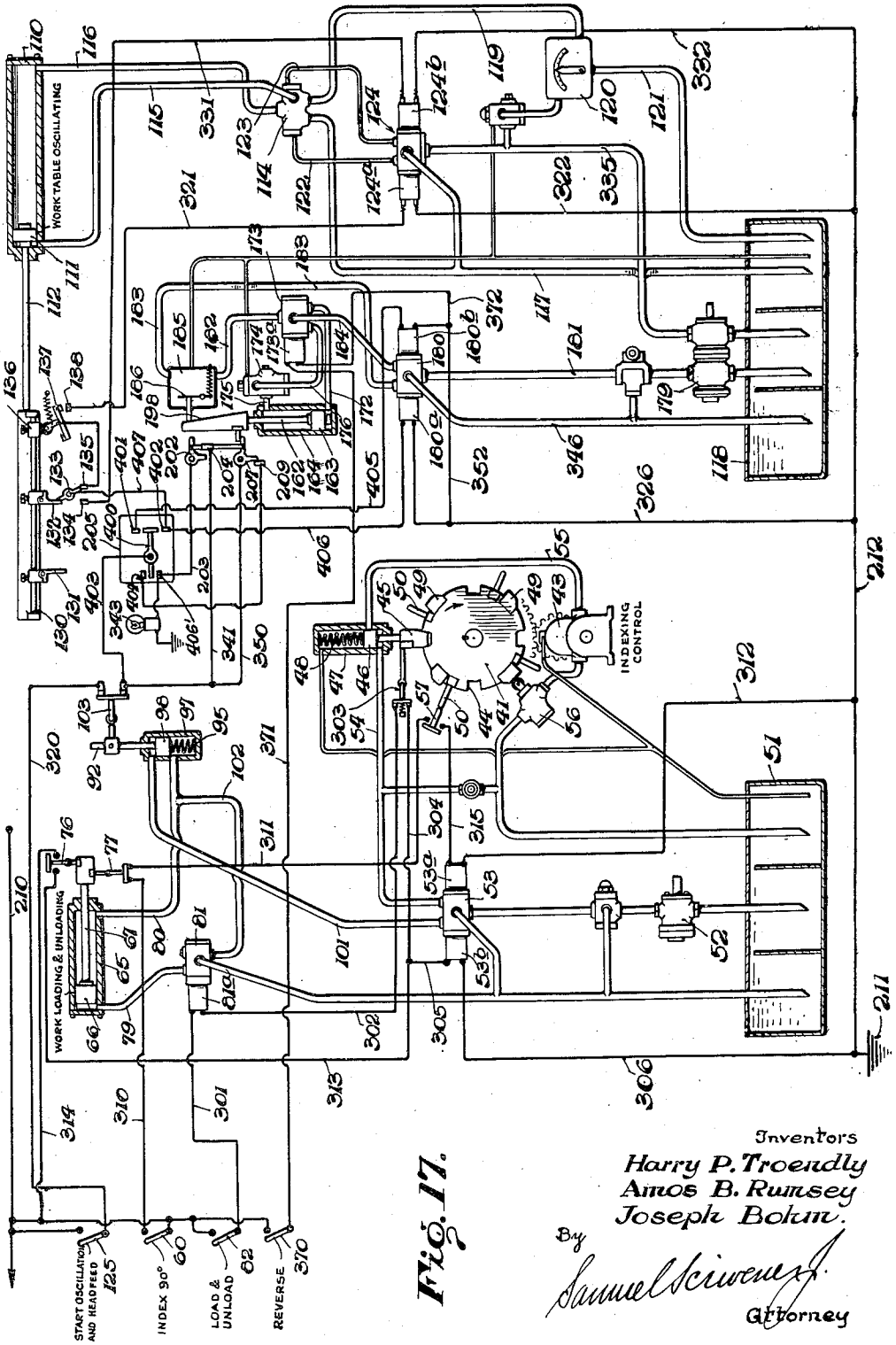


Fig. 17.

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Patented June 24, 1941 2,246,869

UNITED STATES PATENT OFFICE

2,246,869

GRINDING MACHINE

Harry P. Troendly, Chicago, Ill., and Amos B. Rumsey and Joseph Bohm, Beloit, Wis.; said Rumsey and said Bohm assignors to Gardner Machine Company, South Beloit, Ill., a corporation of Illinois, and said Troendly assignor to Associated Spring Corporation, Bristol, Conn., a corporation of Delaware

Application February 23, 1939, Serial No. 258,024

40 Claims. (Cl. 51—114)

This invention relates, generally, to grinding machines and, more particularly, to that class of grinding machines in which the work is given a reciprocating motion between opposed rotating grinding wheels. The invention provides a machine which is particularly intended for the grinding of the ends of coil springs, but machines embodying the features of this invention may be employed and adapted for all desirable grinding operations without departing in any way from the scope of the invention.

It is the object of the invention to provide a grinding machine of the type set forth hereinbefore and which will embody either all or certain of the following features of general or specific novelty:

(1) The provision of separate paddle members into which the springs are loaded and which are adapted to be locked to a work-carrying table for reciprocation between the grinding wheels.

(2) Work loading, indexing and unloading mechanism, characterized by frame members which carry the work-carrying paddles and which are rotatable about a horizontal axis to move the paddles from a loading position, in which unground springs are loaded therein, to a position from which the paddles are moved onto the reciprocable, work-carrying table and are removed therefrom after the grinding operation is completed, after which the paddle of ground springs is moved to a position where the springs are dumped therefrom. This general means includes indexing mechanism which causes the movement of the frames to proper positions and, further, effects the locking of the frames in such positions during the grinding operation.

(3) Means operable to lock the work-carrying paddles to the work table, and which means are moved, at the completion of the grinding operation, to unlocked position to thereby permit removal of the paddle from the table.

(4) Means for moving the grinding heads toward each other, which means will be operable to give the heads an initial quick movement, followed by a graduated infeed to a finish grinding position, after which the heads will be retained in such position for a sparking-out period and will then be quickly withdrawn from the work.

(5) Means operable to reciprocate the work-carrying table during the grinding operation and to automatically bring this to a stop in unloading position when the grinding heads have completed their inward movement and the sparking-out period has been completed.

(6) A single hydraulic and electric control system for the entire machine which will cause the operation of the parts in their proper sequence and will prevent the operation of any part or mechanism until all other related parts are in proper position or condition of operation.

An important object of the invention is the provision of a grinding machine in which the articles to be ground, such as springs, are given such a movement with respect to the grinding wheels that all of such articles are caused to travel across the entire face of the wheels and are all therefore in contact with the abrasive grinding wheels for equal periods of time, whereby all of the articles being ground are subjected to the grinding action of all of the various grinding areas of the wheels for equal periods of time, thus effecting a more uniform grinding action and also causing a more uniform wearing of the grinding surfaces.

A more particular object of the invention is the provision of novel means operated by the movement of the grinding heads toward and from each other for controlling the rate of movement of the heads.

A further particular object is the provision of cushioning means between the grinding heads, whereby a more gradual and controlled movement of these parts is effected.

A further particular object is the provision of work loading, indexing and unloading mechanism which is operable to move the work-carrying paddles about a horizontal axis in carrying them from charging position to loading position and then to unloading position.

A further particular object is the provision of novel means for mounting the work-carrying paddles on the work table, which mounting means are so constructed as to preclude any possibility of clogging thereof by material ground from the work.

Other objects and features of novelty of the invention will be apparent from the following description and the annexed drawings, it being understood, however, that such description and drawings are only illustrative of the invention, and that the invention is not limited in any way thereby or otherwise than by the appended claims.

Referring to the drawings, in which similar reference numerals refer to like parts:

Figure 1 is a side elevation, partially broken away, to illustrate the complete machine;

Fig. 2 is a front view of the machine proper

without the indexing fixture, as shown on line 2—2 of Fig. 1;

Fig. 3 is a plan view of the complete machine;

Fig. 4 is an enlarged fragmentary view, partially in section, similar to Fig. 2;

Fig. 5 is an enlarged fragmentary view of the left-hand end of the machine illustrating the mechanism controlling the movement of the heads;

Fig. 6 is a plan section taken on the line 6—6 of Fig. 5;

Fig. 7 is an enlarged vertical section of the indexing mechanism taken on the line 7—7 of Fig. 3;

Fig. 8 is an enlarged front view of the indexing mechanism taken on the line 8—8 of Fig. 7;

Fig. 9 is a vertical section through the indexing mechanism taken on the line 9—9 of Fig. 7;

Fig. 10 is an enlarged fragmentary view of the means for locking the paddles on the reciprocating table;

Fig. 11 is a vertical section of the locking mechanism taken on the line 11—11 of Fig. 10;

Fig. 12 is a fragmentary section taken on the line 12—12 of Fig. 11 and illustrating the rollers supporting the paddles on the reciprocating table, and the structure whereby the rollers are kept free of grit;

Fig. 13 is a plan view illustrating the location and interconnection of the various hydraulic devices;

Fig. 14 is an end elevation of the wheel dressing device;

Fig. 15 is a horizontal section taken on the line 15—15 of Fig. 14;

Fig. 16 is a horizontal section taken on the line 16—16 of Fig. 14; and

Fig. 17 is a diagrammatic sketch illustrating the complete electric and hydraulic control circuits.

General Structure

The grinding machine provided by the present invention is intended and adapted to effect the simultaneous grinding of the two ends of coil springs and therefore comprises two grinding wheels 1, 2 having vertical opposed cutting faces and which are respectively mounted on horizontal shafts 3, 4 for rotation thereby. Pulleys 5, 6 are keyed to the outer ends of the shafts 3, 4, respectively, and are connected by belting to driving motors 7, 8. As illustrated in Figs. 1, 2 and 3, each grinding wheel and its shaft, pulleys, driving motor and supports and bearings form a unitary structure which is supported on V-type ways 9 which extend at right angles to the grinding face and parallel to the driving shaft of the grinding wheel. Each grinding assembly may, accordingly, be moved along its V-type support toward or away from the other wheel by means which will be described fully hereinafter.

The grinding assemblies described are slidably mounted on a base 10 which also slidably supports an elongated horizontal work table 11 which extends beneath the grinding wheels at right angles to the axes thereof. This table is mounted for reciprocation at right angles to the axes of the grinding wheels on V-type ways 12 and means, to be described hereinafter, are provided for causing the reciprocation of the table and its proper operation with respect to other parts of the machine. The work table 11 carries on its upper face an elongated, horizontally disposed track or support 13, the upper, longitudinal edge of which is provided, along its length, with spaced, semi-circular depressions 14, which are clearly illustrated in Figs. 11 and 12, and within each of which is rotatably journaled a roller 15, the periphery of which extends above the upper edge of the track 13, thus providing a series of rollers along the upper edge of the track and along which and upon which the lower edge of a spring-carrying paddle 16 may be moved and supported. Means, to be described hereinafter, are provided for locking the paddle to the work-carrying table in order that the paddle and the springs carried thereby will be moved with the table when the same is reciprocated, to thereby effect the grinding of the springs carried by the paddle.

The spring-carrying paddles 16 comprise rectangular plates having a large number of openings extending therethrough within which spring coils may be positioned, the thickness of the plate being such that the ends of the coils extend beyond the opposite faces of the plate.

In order to protect the grinding wheels and work table, and also in order to enclose and restrict the dust and small particles of metal generated by the grinding operation, the wheels are enclosed by a protective housing 17 which surrounds the wheels on their outer and upper faces and peripheries. This casing extends in general parallelism to the work table and is provided at the extremities thereof with entrance guides 18 which align the springs in the work-carrying paddle 16 with the grinding faces of the abrasive wheels and which act to maintain the paddle carried by the work table in proper position and alignment.

Wheel dressing mechanism, illustrated in Figs. 14, 15 and 16 of the drawings, is provided for truing and dressing the grinding wheels and will be described more fully hereinafter.

In order to effect the charging of the spring-carrying paddles, the movement of these to a position from which the paddles may be loaded onto the work table, and, after the completion of the grinding operation, the subsequent movement of the paddle to a position where the ground springs may be dumped, an indexing mechanism which is shown generally in Figs. 1 and 3 and is illustrated more particularly in Figs. 7, 8 and 9 is provided. Associated with this indexing means is an hydraulically operated mechanism for moving the charged paddle onto the reciprocable work table 11 and, after the completion of the grinding operation, moving the paddle from the work table into the indexing mechanism which, as heretofore described, then moves it to a dumping position.

All of the various parts of the machine are operated and controlled by a unitary hydraulic and electric control system, which is so operable that none of the various parts and mechanisms may be operated until all other parts and mechanisms are in proper position or operative condition. This general control system will be described more fully hereinafter.

In order to more clearly describe the various parts and operative mechanisms which combine and cooperate to make up the machine illustrated, and in order to more clearly disclose the various features of the invention such various parts and mechanisms will be separately described.

Indexing mechanism

Means are provided by the invention for moving the spring-carrying paddles to charging, loading and dumping positions, this means being removed from the mechanism which actually

effects the grinding operation but being accessory thereto and forming a part thereof inasmuch as the hydraulic and electric control for the indexing mechanism is interlocked and operable with the control means for the grinding mechanism. This indexing means is generally illustrated in Figs. 1 and 3, and is more particularly disclosed in Figs. 7, 8 and 9, while the control means therefor and the interconnection of such control means with the control for other parts of the grinding machine is illustrated in Fig. 17.

Referring to the aforesaid figures of the drawings, it will be seen that the indexing mechanism comprises a supporting base **20**, which is spaced from the base **10** of the grinding machine, and which is provided with bearings **21** which rotatably support a horizontal shaft **22** which is aligned with and is approximately at the level of the upper surface of the track or support on the work table **11**. Mounted on the end of this shaft adjacent the work table **11** are four frames **23** which are spaced at 90° intervals about the shaft and are rigidly attached thereto and extend radially therefrom. Each of these frames is formed of structural members carried by a central support **24** which surrounds and is mounted on the shaft **22** and the structural members of each frame form merely a skeleton, open structure which is of small thickness relatively to its radial and longitudinal dimensions. Each frame is adapted to removably receive a spring-carrying paddle which, when disposed within the frame, extends longitudinally of the shaft **22**. The radially separated walls of each frame are therefore each provided with a centrally-located row of spaced rollers **25** which may be mounted in recesses in the manner described in connection with the rollers carried by the work table and illustrated in Fig. 12. These spaced rows of rollers are adapted to receive and support the upper and lower edges of a paddle **16** within which springs may be loaded, as illustrated in Fig. 9. Each frame is so constructed that a paddle may be moved into it longitudinally of the shaft **22** and, when so positioned within the frame, will be held in position therein by the rows of rollers **25**.

Inasmuch as the four frames extend at 90° intervals from the shaft **22**, the two horizontal positions into which the frame may be moved are employed as charging and dumping stations, while the vertical, upward position is utilized as a loading position, in which the frame is so positioned that the paddle carried thereby may be moved along the rollers **25** directly onto the rollers **15** of support **13** on the work table **11**. Thus, in Fig. 9, the frame **23***a* is shown in loading position, having a paddle therein which is in horizontal position in order that springs may be loaded therein. The frame **23***b*, which is in the vertical, upward position, has a fully charged paddle of springs therein which is in position to be moved onto the work table. The frame **23***c*, which has just been rotated from the vertical upward position in which it received a paddle of finished springs from the grinding machine, is now in a horizontal position in which the springs have been dumped from the paddle carried thereby. The frame **23***d* is at an inactive station and will next be rotated to the charging station in order to receive new unground springs in the paddle carried thereby. It is contemplated that a paddle, when once placed in a frame, will normally remain with that frame until its removal is required.

Means are provided by the invention for facilitating the charging and dumping of the paddles. Such means are clearly disclosed in Figs. 8 and 9 and comprise chutes **26**, one of which is provided for each of the four frames **23**, and each of which comprises a bottom **27** which extends radially of the shaft **22** and two side walls **28** which extend at right angles to the bottom member. Each of these chutes is pivoted to the central support **24** adjacent one of the frames **23** with its side wall members extending in such a direction as to provide a receptacle or chute for receiving and guiding springs dumped from the work-carrying paddle of the frame member which is disposed in a counter-clockwise direction therefrom. Each chute is provided with a separate bottom member **29** which is coextensive with the bottom **27** and is spaced therefrom by suitable supporting means.

The chutes described are adapted, in one of their positions, to underlie a frame **23***c* which is at the dumping station and to provide a chute for guiding the springs dumped therefrom into a receptacle **30**. In another position, the separate bottom wall **29** of each chute is adapted to underlie a frame **23***a*, which is at the charging position, in order to provide a support for the springs which are being charged into the paddle carried by such frame, to thereby hold such springs in the paddle.

Means are provided by the invention for moving the chutes to the various positions required in performing the functions described. Such means, which are disclosed in Fig. 9, comprise a cam member **31** which is rigidly supported adjacent the shaft **22** but does not move therewith. The periphery of this cam is engaged by rollers **32** which are carried at the outer extremities of arms **33**, the other ends of which are rigidly attached to the chutes **26** adjacent the pivotal connections thereof to the central support **24**. Associated with the pivotal connection between each frame and the central support are resilient means, such as springs **34** which constantly urge the chutes in such a direction as to maintain the rollers **32** in constant engagement with the surface of the cam **31**. The shape of the cam surface **31** is such, as illustrated in Fig. 9, that as a frame reaches the dumping position the chute disposed in a clockwise direction therefrom is moved, by the engagement of its arm **33** and roller **32** with the cam **31**, into such a position that it is inclined below the frame **23***c* and is so positioned that its lower, open end is adjacent the receptacle **30**, whereby the ground springs in the frame **23***c* fall into the chute and are led to the receptacle.

As the indexing fixture revolves, the chute, being carried therewith, is moved, by the springs acting on its pivotal connection to the central support **24**, to a position in which the separate bottom member **29** thereof closely underlies the frame **23***a* which is in the loading position, the shape of the cam **31** being such as to permit this positioning of the chute. In this position the separate bottom member **29** supports the springs being loaded into the paddle carried by the frame **23**.

Means are provided by the invention for rotating the shaft **22** through the 90° increments required, as hereinbefore described, stopping the shaft at the proper points, locking it at such points during the grinding operation and releasing it for a further movement when the grinding operation is completed. Such means are dis-

closed in Figs. 7, 8 and 17 and comprise two disks 40, 41, both of which are keyed to the shaft 22 at the extremity thereof removed from the frames 23. The innermost disk 40 is the driving disk and the periphery thereof is provided with teeth which are engaged by a gear 42 which is carried by the shaft of a fluid motor 43 the control means for which determines the rotary movement of the shaft 22. The disk 41 is the control disk and has formed in its periphery four slots or apertures 44 which are spaced apart at 90° intervals and which are adapted to receive the end of a locking plunger or index pin 45, the other end of which is attached to a piston 46 which is slidably received in a cylinder 47 and is constantly urged by a spring 48, disposed within the cylinder, toward the disk 41.

The periphery of the control disk 41 is also provided with four, equally spaced sets of control members, each set including a valve control abutment 49 and a switch control abutment 50, these being so positioned that the abutment 49 leads the abutment 50 as the disk rotates in a clockwise direction as viewed from the end of the shaft.

By reference to Fig. 17 of the drawings, it will be seen that the motor 43 is in a hydraulic circuit having its origin at the reservoir 51 and leading through pump 52, double solenoid valve 53, conduit 54 to the cylinder 47, conduit 55 to motor 43, valve 56 and thence back to reservoir 51. The solenoid valve 53*a* is operable, when energized, to permit fluid to pass from the reservoir to conduit 54, and is energized by depressing switch 60, completing a circuit through solenoid 53*a* and limit switch 77 which provides a safety interlock with the work loading and unloading means. The conduit 54 is connected to the cylinder 47 below the innermost locking position of the piston 46, while the conduit 55 is connected to the cylinder in such a way that when the piston 46 therein is in its normal, spring-pressed, locking position this conduit is blanked and cut off from communication with the cylinder or with conduit 54. The valve 56 is normally maintained in a position permitting free passage of the fluid output of the motor 43 therethrough, but upon engagement of the stem of the valve by one of the valve abutment members 49 carried by the control disk, the passage through the valve is restricted, thereby reducing the speed of rotation of the motor and, consequently, the shaft 22. A normally closed switch 57 is arranged adjacent the periphery of the disk 41 and is connected between the source of power and solenoid valve 53*a*, and acts with the interlock switch 77 to normally complete the circuit including solenoid 53*a*. Switch 57 is instantaneously moved to open position, deenergizing solenoid 53*a* when engaged by one of the abutments 50 as the shaft 22 reaches a position in which the frames carried thereby are opposite their respective stations.

In the operation of the indexing mechanism from a stationary, locked condition, the control switch 60 is operated to close the circuit through solenoid 53*a*, thereby operating the valve 53 to cause fluid to be supplied by pump 52 through the valve and conduit 54 to the inner side of piston 46, thereby moving the piston against the force of spring 48, releasing the index pin 45 from locking engagement with disk 41 and putting the conduit 55 in communication with conduit 54 through cylinder 47. Fluid will therefore flow to motor 43, operating the same and causing the shaft 22 and disks 40 and 41 to rotate. This rotation will continue until one of the valve abutment members 49 engages the stem of valve 56, whereupon the valve 56 will be operated to restrict the output of motor 43, thus retarding the speed of the motor and of the indexing mechanism. When one of the apertures 44 in the disk 41 is directly opposite the locking pin 45, one of the switch abutment members 50 will engage the switch 57, operating it to open position and thereby deenergizing the solenoid 53*a* and moving the valve 53 to position to completely unload the motor and stop the rotation thereof. This action will also relieve the pressure from the lower side of piston 46, thereby permitting the spring 48 to move the pin 45 into locking engagement with the adjacent aperture 44.

It will be seen that the shaft 22 and disks 40, 41 may be rotated through only 90°, due to the spacing of the valve and the switch actuators 49, 50. The movement of the shaft 22 through 90° will, of course, effect the movement of the frames 23 through equal intervals, thus moving each frame to the next succeeding station, while the movement of the chutes 26 with respect to the cam 31 will cause the chutes to assume the predetermined positions heretofore described.

The operating means for the indexing mechanism is interlocked with the operating means for other mechanisms and parts of the entire machine, whereby the indexing mechanism may be operated only when other parts and mechanisms of the machine are in proper position and operating condition. This interlocking means will be described hereinafter in connection with the description of the general hydraulic and electric control for the machine.

Work loading and unloading means

Means are provided by the invention for moving a loaded paddle from the indexing mechanism onto the work table of the grinder, and for removing the paddle from the grinder into the frame of the indexing mechanism when the grinding operation is completed.

Such means are particularly illustrated in Figs. 7 and 17, and comprise an elongated cylinder 65 which is mounted above the shaft 22 of the indexing mechanism and is so positioned that it is aligned with the paddle carried by the frame which is in the vertical, upwardly-extending position, i. e., the position of the frame 23*b* in Fig. 9. A piston 66 having a piston rod 67 is slidably disposed within the cylinder 65, and the outer end of this rod, which is adjacent the paddle and frame assembly, is provided with an enlarged head 68 to which there is pivotally connected a right-angled latch device having a horizontal, forwardly-extending latch portion 69, a vertical, upwardly-extending arm 70 and a vertical, downwardly-extending arm 71 which, when the piston is in its retracted position engages an abutment 72 which rotates the latch lever in a counterclockwise direction and moves the latch portion 69 upwardly into an inoperative position. A cross-center spring 73 is connected between the latch portion 69 and the head 68 and extends across the pivotal support of the lever. The upper portion of the head 68 has connected thereto the forward end of an elongated rod 74 which is received in a guide 75 and has the purpose of preventing any turning of the piston rod and head about their axes. The lower portion of the head 68, when the piston is in its most retracted position, engages two switch elements 76 and 77

and operates these for a purpose which will be set forth hereinafter. As illustrated in Figs. 3, 7 and 8, the latch portion 69 is constantly aligned with the latch portion 78 which is formed on the end of the paddle received in the frame which is in the vertically upward position. A conduit 79 is connected to the head end of the cylinder 65 and a second conduit 80 is connected to the rod end of the cylinder. As illustrated in Fig. 17, the flow of fluid through these two conduits is controlled by the four-way solenoid valve 81 and the master control valve 53.

The work loading and unloading cylinder is normally unloaded, and the piston 66 in the cylinder is normally in retracted or unloading position, the fluid under pressure being by-passed through valves 53 and 81. In this retracted position the abutment 72 engages the arm 71 of the latch lever, causing the spring 73 to hold the latch portion thereof in raised, inoperative position. When a paddle of unground springs has been rotated to loading position and it is desired to move the paddle onto the work table, the solenoid 81*a* of four-way valve 81 and solenoid 53*b* of valve 53 are energized through interlock limit switch 303 by operation of switch 82, causing fluid under pressure from the pump to be directed to the rod end of locking cylinder 97, moving the lock pin downwardly. As the pin 92 moves downwardly, fluid is by-passed through the lower port in cylinder 97 and through conduit 102 and valve 81 to the head end of the loading cylinder 65. The piston rod is accordingly moved toward the paddle, the arm 71 of the latch lever engaging the portion 78 of the paddle, thereby moving the latch 69 into operative position, thereby causing the latch to engage the latch portion of the paddle and move the paddle from the frame onto the work table of the grinding machine, the paddle moving on the series of rollers 15 and 25. When the piston has moved the paddle to its proper position on the work table the upwardly-extending portion 70 of the latch lever engages an abutment, causing the lever to move about its pivot in such a way as to release the latch 69 from the paddle. The switch 82, which has been held in closed or energized position during the entire loading movement of the piston is now released or moved to deenergizing position, thus causing the solenoid valve 81 to return to a position in which fluid under pressure is removed from the head end of the cylinder 65 through conduit 79 and is supplied to the rod end of the cylinder through conduit 80, thus moving the piston rod, the head 68 and the latch means to retracted position.

When the grinding operation is completed and it is desired to remove the paddle from the grinding machine to the indexing fixture the switch 82 is again operated to cause the piston 66, rod 67 and head 68 to move outwardly until the latch 69 engages the paddle, at which time the switch 82 is moved to deenergizing position, thus causing the piston to move to retracted position, carrying the paddle out of the grinding machine into the frame 23*b* of the indexing mechanism. When the piston reaches its fully retracted position, at which time the paddle will be in its proper position in the frame 23*b*, the downwardly-extending lever arm 71 will engage the abutment 72, thus releasing the latch from the paddle and permitting the paddle and frame to be turned by the indexing mechanism to dumping position, in the manner described hereinbefore.

The operating means for the work loading and unloading mechanism is interlocked with the operating means for other mechanisms of the entire machine, whereby the loading and unloading mechanism may be operated only when other parts and mechanisms of the machine are in proper position and operating condition. This interlocking means will be described hereinafter in connection with the description of the general hydraulic and electric control for the machine.

Work locking means

Means are provided by the invention for locking the spring-carrying paddle to the work table after it has been moved thereon by the work loading and unloading means heretofore described. Such locking means are disclosed in Figs. 1, 10, 11 and 17 of the drawings. Referring particularly to Figs. 10 and 11, it will be seen that there is provided at the loading end of the work table 11, i. e., the end which is adjacent the indexing fixture, a U-shaped bracket 90 within which is received for vertical movement the enlarged end 91 of a vertically-arranged locking pin 92, which extends above the upper surface of the work table and which, intermediate its ends, is slidably received in a vertical guide 93 formed on the end of the track 13 of the work table. The locking pin is normally urged upwardly against a stop 94 by a spring 95 located in the bracket 90 and in this upward or operative position the upper end of the pin is adapted to enter a notch or aperture 96 in the lower face of a paddle 16 which is operatively positioned on the work table.

Means are provided for moving the locking pin to its lowered or inoperative position in order to release a paddle which is on the work table or in order to permit a paddle to be moved onto or off of the work table. Such means comprise a vertically-disposed cylinder 97 which is carried by the base or frame 10 of the machine and within which is arranged for vertical movement a piston 98 having an upwardly extending rod 99. To the upper end of the rod 99 is connected a horizontal plate member 100, one side of which is bifurcated to receive the reduced central part of the enlarged end 91 of the locking pin, such end part 91 being formed at its upper and lower ends with enlarged rings, between which there is a reduced portion which is engaged, as aforesaid, by the bifurcated portion of the plate 100.

The upper surface of the piston 98 is provided with an abutment which prevents the piston from moving entirely to the upper end wall of the cylinder 97, and the space thus provided in the cylinder above the upper limit of movement of the piston is connected by a conduit 101 to the four-way double solenoid valve 53 where its connection to the reservoir 51 and other parts is controlled. Between its ends, and above the lowermost position to which the piston may be moved, the cylinder 97 is connected to the four-way solenoid valve 81 by a second conduit 102.

A switch 103 is arranged in the path of the plate 100 and is adapted to be operated to closed or energizing position when engaged by the plate on the upward movement of the piston 98, and to be moved to open or deenergized position on the return or downward movement of the piston, all for a purpose and function which will be described hereinafter.

In the normal condition of operation of the work locking means, fluid under pressure is cut off from conduits 101 and 102, and the spring 95

maintains the spool 91 and locking pin 92, in their uppermost positions. If it is desired to move a loaded paddle onto or off of the work table, the locking pin must first be lowered, and this is effected by operation of solenoid 53b of four-way valve 53 and solenoid 81a of four-way valve 81, through interlock switch 303, causing fluid under pressure to be supplied by the pump 52 through conduit 101 to the upper end of the cylinder, thus forcing the piston 98 and piston rod 99 downwardly and, through the connection between the bifurcated plate 100 and the enlarged end 91 of the locking pin, also moving the locking pin downwardly so that its upper end is below the upper surface of the work table. The spring-carrying paddle may now be moved onto the work table and into such a position that the aperture 96 in the lower face thereof is directly above the locking pin 92. The movement of the work table away from its loading position causes the spool member 91 to move out of engagement with the bifurcated member 100, thereby causing the spring 95 to move the pin 92 into locking engagement with the slot 96 in the paddle 16.

The operation of the work locking means is interlocked with the operation of other parts and mechanisms of the entire machine, whereby the work locking mechanism may be operated only when other parts and mechanisms of the machine are in proper position and operating condition.

This interlocking means will be described hereinafter in connection with the description of the general hydraulic and electric control for the entire machine.

Work table reciprocating means

Means are provided by the invention for reciprocating the work table in order to cause a loaded paddle thereon to be moved past the grinding wheels in order to effect the grinding of the springs carried by the paddle. Such means are illustrated in Figs. 1, 11 and 17 of the drawings and comprise a horizontally disposed cylinder 110 which is arranged below the work table and with its longitudinal length parallel to the direction of motion of the table. A piston 111 having a rod 112 attached thereto is slidably disposed within the cylinder and the outer end of the piston rod is connected by a rigid connecting means 113 to the lower face of the work table. It is a primary feature of the present invention that all of the springs carried by the work table are moved thereby over the entire faces of the grinding wheels and, accordingly, the cylinder 110 and the piston rod 112 are made of sufficient length to provide the long stroke so required.

The forward and rearward ends of the cylinder 110 are connected, respectively, to a three-way pilot valve 114 by conduits 115, 116, such valve being also connected, by a conduit 117, to a reservoir 118 and, by a conduit 119, to a fluid control device 120, the same being also connected to the reservoir 118 by a conduit 121. Pilot fluid conduits 122 and 123 also connect the valve 114 to a double-solenoid, four-way control valve 124, one solenoid of which is controlled by a switch 125. It will be apparent that alternate introduction and release of fluid under pressure to and from the opposite ends of the cylinder 110 will cause the piston 111 and rod 112 to reciprocate, thereby moving the work table back and forth, whereby the work is moved across the grinding heads. The control of the operating fluid to cause it to flow to the opposite ends of the cylinder 110 is effected by operation, in proper sequence of the solenoids 124a and 124b which control the valve 124.

Means are provided by the invention for alternately operating the solenoids 124a and 124b in order to cause fluid under pressure to be supplied to and released from the opposite ends of cylinder 110, and such means comprise a rod 130 which is attached to or movable with the piston 112. This rod carries two spaced abutment members 131, 132, one of which is pivotally connected to the rod in such a manner that it will swing in only one direction, while the other is so mounted that it will swing only in the opposite direction. A pivoted switch device 133, which is connected to a source of power in a manner to be described hereinafter, has a portion arranged in the path of movement of these two abutments and has a contact portion which is adapted to be moved into engagement with either of two spaced contacts 134, 135. The rod 130 also carries a third abutment 136, and arranged in the path of movement of this abutment is a pivoted switch member 137 which is normally held by a spring in engagement with a contact 138 but is moved, when engaged by abutment 136 out of engagement therewith. Contact 134 is connected to one terminal of solenoid 124b through lead 331, while contact 135 is connected to one terminal of solenoid 124a through the two switch contacts 137, 138 and lead 321, whereby current will be supplied to one or the other of the solenoids when the connected switch contact is engaged by movable contact 133.

The reciprocating movement of the rod 130 and abutments 131 and 132 causes the operation of the switch 133 to control the alternate supply of fluid to the opposite ends of the cylinder 110, it being noted that each of the abutments 131, 132 will operate the switch 133 in one direction of movement of the rod 130. The circuits controlled by the switches 133 and 137, the control of the hydraulic circuits which operate the piston 111 and the interlocking of these electrical and hydraulic circuits with the control means for other parts and mechanisms of the machine will be described fully hereinafter in connection with the description of the general hydraulic and electric control for the entire machine.

Grinding head feeding means

It will be apparent that, in order to grind the spring coils to proper length or condition of squareness, the opposed grinding wheels must be moved toward each other at controlled speeds, to positions which will effect the proper grinding, and must then be moved apart. In order to effect the proper movement of the grinding heads, means are provided by the invention which are effective to (1) move the heads toward each other at an initial rapid rate which takes up quickly the space between the normal, retracted positions of the heads and the unground work; (2) move the heads further toward each other at a controlled rate in order to effect proper and sufficient grinding of the ends of the spring coils; (3) hold the heads at their finished grinding positions for a short period in order to provide a sparking-out period; and (4) retract the heads rapidly to their normal, inoperative positions at the completion of the grinding operation. In addition, means are provided for permitting a so-called "jog" cycle, which is used by the operator to "touch up" the work, and which causes a

rapid movement of the heads toward each other to a predetermined point, a dwell at this point, and thereafter a rapid retraction of the heads. Such head feeding means are illustrated in Figs. 2 to 6 and 17 of the drawings and reference will be had thereto.

As stated hereinbefore, the grinding heads, each of which includes a grinding wheel and driving means therefor, are mounted on supports which are, in turn, mounted on aligned V-type ways extending at right angles to the opposed, parallel faces of the grinding wheels and on which the heads may be moved toward and away from each other. As illustrated in Fig. 2, the movable grinding assembly including the grinding wheel 1 has formed on the lower portion thereof a downwardly-facing rack bar 150, while the assembly including the grinding wheel 2 has rigidly attached to the lower portion thereof an elongated bar 151 which extends below the grinding wheels and terminates below the rack 150 in an upwardly-facing rack bar 152. A pinion 153 is disposed between the two racks and has teeth which mesh with both of them. The pinion 153 is keyed to a shaft 154 which is rotatably mounted in the frame portion of the machine, as illustrated in Fig. 6, and on this shaft there is also keyed a second pinion gear 155, the teeth of which mesh with the teeth of a gear 156 which is keyed to a shaft 157. The ratio of the gears 155 and 156 is made such that the grinding heads, which are moved by gear 155 are caused to move a short distance while the operating piston, which is connected to gear 156, moves a much greater distance, thus providing a better control of the infeed of the heads. The shaft 157 is journaled in the machine frame and has keyed thereto one end of a crank arm 158 which extends downwardly from the shaft 157 and, at its lower end, is bifurcated to receive a pin 159 which extends laterally from a block 160 which is supported by rollers 161 in such a manner that it may move at right angles to the shaft 157.

The block 160 is adapted and intended to be moved in either direction at right angles to the shaft 157 on the rollers 161 and, to effect such movement, the block is provided with a passage which extends therethrough in the direction of the intended movement and through which freely passes a piston rod 162, the one extremity of which is connected to a piston 163 which is disposed in a cylinder 164. The opposite end of the piston rod extends through and is threaded into a sleeve 165 which slides in a bracket 166 which is bolted to the machine. Sleeve 165 has an enlarged head at one end and locknuts at the external end which may be adjusted so that the gap between them and the face of sleeve 165 is slightly greater than the ratio of movement of the piston 163 to the infeed travel of the heads. The sleeve 165 may be adjusted on the piston rod by means of a handwheel 167. Only a portion of the stroke of operating piston 163 is used, and the adjustable nuts prevent undue over-travel in moving the heads together, the head of sleeve 165 acting as a stop in the opposite direction. The adjustment of the sleeve on the piston rod regulates the possible opening movement of the heads but does not affect the gap between the nuts and the face of the sleeve, which remains constant when once set. In order to provide an operative connection between the piston rod and the block 160, spaced abutments 168, 169 are formed on or attached to the piston rod on opposite sides of the block and compression springs 170, 171 are respectively disposed between these abutments and the block, whereby movement of the rod in either direction will cause a corresponding movement of the block.

As illustrated in Fig. 17, the head end of the cylinder 164 is connected, by conduit 172, to a four-way solenoid valve 173, while the rod end of the cylinder is connected to valve 173 through conduits 175 and 176 and a valve 174. It will be apparent that movement of piston rod 162, caused by the admission of fluid under pressure to the cylinder 164 at one or the other side of the piston 163, will cause a corresponding movement of the block 160 on the rollers 161, which movement will be transmitted through the pin 159 to the crank 158, causing a turning movement thereof and effecting a corresponding rotation of the shaft 157. Such rotation of the shaft 157 will be transmitted through gearing 156 and 155 to shaft 154, thereby rotating the pinion gear 153. The rotation of the pinion gear 153, which meshes with the two racks 150, 152 will cause these racks to move in opposite directions, and such movement will be transmitted to the two grinding heads which are, respectively, connected to the racks. The grinding heads are thus caused to move toward or away from each other by equal amounts and in accordance with the pressure applied to the piston 163. The resilient connection between the piston rod 162 and the block 160 will provide a cushioning effect between the prime mover, i. e. the cylinder 164 and piston 163, and the gearing which causes the opposite movement of the heads. This cushioning effect will prevent the transmission of quick movements or shocks to the gearing and the grinding heads and will, therefore, cause an even and gradual movement of the grinding heads under all conditions.

Means are provided for controlling the rate of feed of fluid under pressure to the opposite ends of the cylinder 164 in order to effect the proper operation of the grinding heads in the manner hereinbefore set forth. Such means are illustrated in Fig. 17 and comprise a four-way, double solenoid valve 180 which is supplied, through conduit 181, with fluid under pressure by a pump 179, the inlet side of which is connected to reservoir 118. The solenoids 180*a* and 180*b* of valve 180 are adapted, respectively, to control the supply of fluid pressure to two outlet conduits 183 and 184. Conduit 184 is connected directly to valve 173, while conduit 183 is also connected to valve 173 through a control device 185 which is adapted to restrict or enlarge the flow of fluid through conduit 183 by the movement of a control arm 186. The solenoid 180*a*, when energized, is operable to move the valve 180 to a position in which fluid under pressure flows from pump 179 through conduit 181, valve 180, conduit 183, control device 185, pipe 182, valve 173 and conduit 172 to the head end of cylinder 164, thereby moving the piston 163 and causing the grinding heads to be moved toward each other and toward the work. Solenoid 180*b*, when energized, causes valve 180 to move to a position in which fluid under pressure flows from reservoir 118 and pump 179, through conduit 181, valve 180, conduit 184, valve 173 and conduits 176 and 175 to the rod end of the cylinder 164, thereby causing the piston 164 to move outwardly to move the grinding heads apart, it being noted that valve 173 is

normally positioned to permit the described flow of fluid. The condition of the fluid control means 185, as determined by the position of the arm 186, constantly controls the rate of flow of fluid through conduits 183, 182 and 172 and thus determines the rate of infeed movements of the piston 163 and, consequently, the rate of movement of the grinding heads toward each other.

Means are provided for controlling the position of the operating arm 186 of the fluid control device 185 in accordance with the position of the piston 163 and, therefore, in accordance with the position of the grinding heads, thus controlling the rate of inward movement of the heads in accordance with the positions thereof with respect to each other and with respect to the work. Such means are illustrated diagrammatically in Fig. 17 of the drawings and, more particularly, in Figs. 4, 5 and 6 thereof.

Referring particularly to these figures, it will be seen that the rack 152 has connected thereto and extending exteriorly of the machine base, a rod 190, the outer end of which is threaded to receive a handwheel 178 which may be operated to adjust the position of the rack 152 and the connected gearing. Surrounding the outer portion of the shaft 190, and being concentric therewith, is a sleeve 189, to the inner end of which is rigidly connected a grooved collar 191. This collar is disposed within a housing, denoted generally at 177, which is carried on the lower portion of one of the grinding heads, whereby it moves therewith and with respect to shaft 190 and collar 191. A shaft 193 is journaled in the housing 177 and has connected to one end thereof a crank arm 192 which, at its free end is provided with a pin which is received within the groove in the collar 191. A beveled gear 194 is connected to the other end of shaft 193 and meshes with a beveled gear 195 which is carried at one end of a shaft 196 which is journaled in the housing 177. A disk 197 is slidably keyed to shaft 196 and a removable cam surface 198 is attached to the periphery of this disk, and engages one end of a slidable follower 199, the other end of which is in engagement with an abutment carried by the pivoted control arm 186. A spring 200 urges the control arm into engagement with the end of the follower 199 and in such a direction as to restrict the flow of fluid between conduits 182 and 183. The parts are so arranged and operable that movement of the grinding heads toward each other causes movement of the cam surface 198 in such a way that the follower 199 is lowered and the control arm 186 is accordingly caused to move in such a way as to restrict the flow of fluid to the head end of the head feeding cylinder, while movement of the grinding heads away from each other causes fluid to be by-passed through a check valve in valve 185 which permits full flow regardless of the position of cam 198, thereby permitting fluid to flow without restriction to the rod end of the head feeding cylinder.

Means are provided by the invention for controlling the flow of operating fluid to the ends of cylinder 164 in such a manner that the movement of the grinding heads will be controlled in the desired manner. As stated hereinbefore, the four-way valve 180 is provided for this purpose and the invention provides means for controlling the operation of the solenoids 180*a* and 180*b* which operate this valve. Such means comprise, broadly, a circuit for operating the solenoid 180*a* to cause operating fluid to be admitted to the head end of cylinder 164 to move the grinding heads together, and a second circuit which is operable upon completion of the inward travel of the heads to cause the solenoid 180*a* to be de-energized and, after a suitable period of time controlled by a time-delay relay, to cause the solenoid 180*b* to be energized to supply operating fluid to the rod end of the cylinder 164 to move the grinding heads apart.

The control circuit for solenoid 180*a*, which causes operating fluid to be supplied to the head end of cylinder 164 is disclosed in Figs. 5, 6 and 17. Disposed above the control arm 186 and in position to be engaged and operated thereby when the arm reaches the limit of its upward or head-separating movement, is the operating arm 207 of a switch 208 which also includes the contact 209. The operating arm 207 is connected to the source of power through lead 350 and interlock 103, while the contact 209 is connected to a time-delay relay device in such a way that when this contact is engaged by the contact 207 and current is supplied thereto the relay is operated to supply current to solenoid 180*a*. Contact 207 is normally in engagement with contact 209 and is moved out of engagement therewith only when the control arm 186 is moved to the limit of its possible movement in a counter-clockwise direction by movement of cam 198 as the grinding heads are moved together. The contacts 207 and 209 are again moved into engagement when the heads are moved apart, by means of the rotation of control arm 186 by cam 198.

By reference to Fig. 6 it will be seen that a microswitch 202 is positioned between the collar 191 and parts of the housing 177. The contact elements of this switch are normally separated but are adapted to be brought into engagement when the collar 191 engages the housing 177 at the end of the movement of the heads toward each other. One contact of this switch is connected to the source of power while the other is connected to the aforesaid time-delay relay device in such a way as to operate the same to cause energization of solenoid 180*b* after a suitable dwell, thereby causing the grinding heads to be moved apart.

It will be seen that the operation of head feeding control means consists in energization of the solenoid 180*a* to cause operating fluid to be supplied to the head end of cylinder 164, moving the heads toward each other. As this movement continues, the rod 190 and the housing 177 will be moved in opposite directions, being respectively mounted on the two grinding heads, and the crank 192, shaft 193, gear 194, shaft 196 and disk 197 will therefore be rotated, causing the cam 198 to move the follower 199. The spring 200 will accordingly cause control arm 186 to rotate, adjusting the valve which is controlled thereby to restrict the flow of fluid through control device 185 and therefore to the head end of cylinder 164. The movement of the grinding heads toward each other will therefore be retarded and the grinding wheels will advance against the work at a controlled rate.

When the heads have reached the predetermined limit of their inward movement, a solid stop will be engaged and the microswitch 202 will be operated, energizing the time-delay relay which, after a suitable period of time, operates to connect the solenoid 180*b* to the source of

power, energizing the same and moving the heads apart. The movement of the heads away from each other causes fluid pressure from the head end of the cylinder to be released through the check valve in valve 185, thereby permitting separation of the heads at a rapid traverse rate. During the delay period caused by the operation of the relay the piston 163 will continue its movement, although the inward movement of the heads is stopped. The relative movement between the rod 162 and other parts of the head feeding mechanism is taken up by the springs 170, 171. Also, during the delay period, the grinding wheels continue to rotate and the work table continues to oscillate, thus providing a sparking-out period during which the grinding of the spring is completed.

The arrangement and operation of the circuits which control the operation of the head feeding means will be described fully hereinafter. Further, the operation of the head feeding means is interlocked with and dependent upon the condition of operation and position of other parts of the machine and such interlocking means will be described fully hereinafter in connection with the description of the hydraulic and electric control for the entire machine.

Wheel dressing mechanism

The machine provided by the invention includes means for dressing the grinding wheels in order to true and sharpen them after a series of grinding operations have been performed. Such means are disclosed particularly in Figs. 14, 15 and 16 of the drawings and comprise an elongated vertical casing disposed above the grinding wheels 1, 2 and including a base 250, from which the casing 251 extends vertically upward. The base 250 is suported on V-type ways 252 which extend axially of the grinding wheels and above and across the faces thereof. An adjusting rod 253 is screw threaded to the fixed V-type support 252 and also to the base 250 and is provided with an operating wheel 266 whereby the rod may be operated to move the base and the casing with respect to the V-type support in order to adjust the dressing apparatus with respect to and axially of the grinding wheels.

The upwardly extending portion 251 of the dressing mechanism comprises a vertical casing 254, which is preferably rectangular in cross section, and a second vertical casing 255 which is smaller in cross section than the casing 254 and which is parallel to and in abutment with the casing 254. A counterweight 256 is hung in the casing 254 and is supported therein by a rope or chain 257*a* which is trained over a pulley 258 which is supported above the two casings on supporting bars 259, the opposite end of the rope or chain being connected to a vertical rack bar 260 which is slidably mounted in the casing 255 and to the lower end of which is attached a dressing tool 257. Extending outwardly from the side of casing 255 is a supporting framework 261 in which there is journaled a shaft 262 to which is keyed a gear 263 which meshes with the teeth 264 on the rack bar 260. An operating wheel 265 is connected to shaft 262 exteriorly of the casings and provides means for rotating the shaft.

In the operation of the wheel dressing means, the dressing tool 257 is lowered between the grinding wheels 1, 2 by moving the rack bar 260 downwardly against the force of the counterweight 256. Movement of the rack bar to cause either downward or upward movement of the dressing tool is effected by operation of the wheel 265 to cause rotation of the gear 263, which meshes with the teeth on the rack bar, thereby causing proper and desired movement of the rack bar and of the dressing tool. In order to move the dressing tool axially of the grinding wheels and selectively into engagement with either of them, the operating wheel 266 may be operated to rotate the adjusting rod 253, thereby causing the base 250 of the dressing means to move along the V-type ways 252 which are fixed with respect to the grinding wheels.

General hydraulic and electric control circuits

The invention provides a general control means for the entire machine which has been described, this control means being effective to cause the operation of the various parts and mechanisms of the machine under the general control of the operator and in predetermined sequence. Further, the control system provides an interlock between various parts and mechanisms of the machine, whereby the operation of such parts and mechanisms is permitted only when other parts and mechanisms are in proper operative position or condition. These general hydraulic and electric control circuits are disclosed generally in Fig. 13 and diagrammatically in Fig. 17 of the drawings and reference will be made to these figures in the following description.

The reservoirs 51 and 118 disclosed in Fig. 17 may be combined, if desired, and the pumps 52 and 179 may be operated by a single motor 300, disclosed in Fig. 13.

Referring first to the indexing mechanism, the general mode of operation of this part of the machine has heretofore been fully described. This mechanism is interlocked with and made dependent upon the position and condition of operation of other parts of the machine, in order that such mechanism and parts may be operated only when the other elements of the entire machine are in proper condition to permit such operation.

Means are provided for preventing any operation of the work loading and unloading means except when the indexing mechanism is locked against any movement. In order to effect this interlock the circuit controlled by the load and unload switch 82 comprises the lead 301, the solenoid 81*a* of the valve 81 which controls the flow of fluid to load and unload cylinder 65, lead 302, switch device 303 which is moved to closed position by locking movement of the indexing fixture locking pin 45, leads 304 and 305, solenoid 53*b* of the control valve 53 and lead 306 which is connected to ground. This circuit cannot be completed unless the indexing fixture locking piston is in locking position and, accordingly, the load and unload control valves 53 and 81 cannot be operated unless the indexing fixture is in locking position.

The completion of the described circuit through switch 303 will energize solenoid 53*b* of the control valve 53 and will operate the same to cause fluid under pressure to flow to the rod end of locking pin control cylinder 97, causing the piston 98 to retract the locking pin 92 out of locking position, thereby permitting the work loading piston 66 to move a paddle onto or off of the work table. Thus, a further interlock between the indexing fixture and the locking means is provided, whereby the locking pin may not be

retracted unless the indexing fixture is locked, the switch 303 again providing the interlock.

In order to prevent the movement of the locking pin 92 to locking position by the spring 95 while the work loading and unloading means is operating in any way, the conduit means supplying fluid to the load and unload cylinder are made to pass through the locking cylinder 97. Thus, upon simultaneous operation of solenoids 81*a* and 53*b*, fluid under pressure is supplied to the load and unload cylinder through valve 53, conduit 101 the rod end of cylinder 97 thereby moving the locking pin 92 to unlocking position, conduit 102 and valve 81. Fluid will flow from valve 81 to the head end of cylinder 65 or will be returned to the reservoir 51 depending upon whether the valve 81 is energized or not, it being remembered that the loading or unloading operations of piston 66 are identical, in each case the piston moving first outwardly and then inwardly to complete either the loading or unloading cycle. The control of the locking pin during operation of the load and unload piston is made independent of the operation of the manual control switch 82 by a switch 76 which is constantly urged to closed position and is moved to open position by the movement of the load and unload piston to retracted position. The switch 76 is included in the control circuit of the locking pin control valve solenoid 53*b* which includes lead 314 which is connected to the source of power, switch 76, lead 313, lead 305, solenoid 53*b* and lead 306 to ground. This switch will be operative at all times during operation of the load and unload cylinder to connect the solenoid 53*b* to power, thus maintaining the locking pin in retracted or unlocking position.

Means are provided for preventing the operation of the indexing fixture during operation of the loading and unloading means, and such means comprise the switch 77 which is normally open but is moved to closed position by the movement of the load and unload piston 66 to retracted or inoperative position. The switch 77 is included in the indexing control circuit, which comprises master switch 60, lead 310, switch 77, lead 311, switch 57, indexing control solenoid 53*a* and lead 312 to ground, and prevents the completion of this circuit and the energization of the indexing control mechanism except when the load and unload piston is in inoperative, fully retracted position.

As hereinbefore described, the movement of the indexing fixture to any one of the locking positions causes one of the switch control abutments 50 carried by the disk 41 to operate the switch 57 to open position. This switch forms part of the circuit described hereinbefore and which provides the interlock between the indexing control means and the loading and unloading means. The solenoid 53*a* is therefore deenergized upon movement of disk 41 to one of its locking positions, to thereby shut off the supply of fluid to the motor 43 which drives the indexing fixture, causing the same to stop. It will be seen that switch 57 is normally closed, as by spring means and is merely snapped to open position for an instant when engaged by one of the abutments 50.

The fluid supplied through valve 53 to the indexing driving motor 43 is caused to pass through the indexing locking cylinder 47 and fluid supplied to the driving motor through conduit 54 raises the locking pin piston 46, thereby uncovering the conduit 55 and supplying fluid therethrough to the driving motor. At the same time the fluid will maintain the piston 46 and the attached indexing fixture locking pin in retracted or unlocking position.

As stated hereinbefore, the grinding head feeding means and the work table oscillating means are controlled by a master switch 125 which controls a work table oscillating means control circuit comprising the source of power, lead 320 interlock switch 103, lead 403, relay contacts 400, 402, control switch contacts 133, 134, 135 and connections from these to the solenoids 124*a* and 124*b* of the work table oscillating control valve 124. The switch 125 also controls the head feed operator control circuit which has been described hereinbefore. It will be seen that both of these circuits include the interlock switch 103 which is normally open and is moved to closed position only by the movement of the work locking means 92 to locking position. It will accordingly be seen that means have been provided for preventing operation of the head feed and work table oscillating means while the work locking pin is in any position other than locking position.

Means are provided for causing the alternate operation of the work table in opposite directions, such means being automatically operated by movement of the table itself. Such means comprise the movable switch contact 133 which may be moved into engagement with either of two fixed contacts 134, 135 by the spaced, pivoted abutments 131, 132 which are carried by a rod fixed to the side of work table 11. The movable contact 133 is connected to the source of power through contacts 400 and 402 of the time-delay relay 205. Fixed contact 134 is connected to one terminal of solenoid 124*b* of valve 124 by lead 331, the other terminal of the solenoid being connected to ground through leads 332 and 212. Fixed contact 135 is connected to one terminal of solenoid 124*a* of valve 124 through the normally closed switch 137, 138 and lead 321, the second terminal of the solenoid being connected to ground through lead 322. It will be seen that after the master switch 125 is operated to supply fluid to the rod end of cylinder 110, to thereby start the oscillation of the work table, the movement of the piston will continue until abutment 131 engages movable contact 133, shifting the same from engagement with fixed contact 135, thereby deenergizing solenoid 124*a*, into engagement with fixed contact 134, thereby energizing solenoid 124*b*. The deenergization of solenoid 124*a* will shift valve 124 to a position to cause pilot fluid to pass through conduit 122, shifting valve 114 to cause fluid to flow out of the rod end of cylinder 110 through conduits 115 and 117. The energization of solenoid 124*b* will shift valve 124 to cause pilot fluid to pass through conduit 123 shifting valve 114 to a position in which fluid under pressure will pass to the head end of cylinder 110 from pump 179, through conduit 335, regulating device 120, conduit 119, valve 114 and conduit 116, thereby moving the piston 111 and the work table to the position illustrated in Fig. 17. As the end of this movement is approached the abutment 132 will engage movable contact 133 and shift the same from engagement with fixed contact 134 into engagement with fixed contact 135, thus causing the operation of the solenoids 124*a* and 124*b* to again reverse the direction of motion of the piston 111 and the attached work table.

The invention includes means for controlling the operation of the head feed means in the manner and sequence described hereinbefore. The

piston 163, which operates the grinding heads, is normally held in retracted position in which the heads are moved apart. In this condition the switch contacts 207 and 209 are closed, and movable contact 207 is connected to the source of power through interlock 103 which permits connection of the contact 207 to power only when the work-locking piston 98 is in raised or locking position. The contact 209 is connected to one operating element 404 of a time-delay relay device 205.

The time-delay relay includes a movable contact 400 which may be moved into engagement with either of two fixed contacts 401 and 402, and which is connected to the source of power through lead 403 and the interlock 103. The fixed contact 401 is connected to one terminal of the solenoid 180b of four-way valve device 180 by lead 405 while the fixed contact 402 is connected to one terminal of solenoid 180a by lead 406, and is also connected to the movable contact 133 of the table reversing mechanism through lead 407.

The microswitch 202, which is positioned between the collar 191 and parts of the housing 177 and is so arranged that it is engaged by the collar and operated when the grinding heads have reached their limit of movement toward each other, comprises a fixed contact 204 which is connected to the source of power through lead 341 and interlock 103, and a movable contact 202 which is connected by lead 203 to the operating element 406' of the time-delay relay device 205. Operating element 406' is also connected to one terminal of a signal lamp 343, the other terminal of which is grounded.

In the operation of the described control means the head-feeding cycle is initiated by the operation of the control switch 125 to cause the energization of solenoid 180a of four-way valve 180, it being noted that this circuit will be completed only when the locking pin 92 is in work-locking position, thereby closing the interlock switch 103. It will be seen that in the starting position, the piston 163 is in retracted or head-separating position and thus causes the contacts 207, 209 to be closed and the contacts 202, 204 to be opened. The operation of switch 125 therefore causes current to be supplied through lead 320, interlock 103, lead 350 and switch contacts 207 and 209 to the operating element 404 of the time-delay relay 205, thereby causing the movable contact 400 of the relay to engage fixed contact 402. A circuit is thereby completed from the source of power and interlock 103, through the lead 403, contacts 400 and 402 of the relay 205 and lead 406 to the solenoid 180a, thereby energizing the same and causing the piston 163 to move outwardly to move the grinding heads toward each other. At the same time power will also be supplied from relay contact 402 through lead 407 to movable switch contact 133 of the table oscillating control circuit.

When the heads have reached the limit of their inward movement a solid stop is engaged and their inward traverse is stopped. At the same time, the microswitch contacts 202 and 204 are caused to engage, while at the same time the contacts 207 and 209 are moved apart. The operation of the microswitch starts the operation of the time-delay feature of relay 205. During the period between the operation of the microswitch and the operation of the relay, the piston 163 will continue its inward movement, the springs 170 taking up relative movement between the piston and the grinding heads which are now held in fixed position by engagement with the solid stop. Also, during this period, the work table will continue to oscillate to effect a sparking-out operation.

Upon the operation of the time-delay relay to end the sparking-out period the movable relay contact 400 moves out of engagement with fixed contact 402 and into engagement with contact 401, thereby deenergizing solenoid 180a and removing fluid from the head end of the operating cylinder 164, at the same time engaging relay contact 401 and causing current to be supplied through lead 405 to solenoid 180b, energizing the same and causing fluid under pressure to be supplied to the rod end of cylinder 164, thereby retracting the heads at rapid traverse rate. The operation of the time-delay relay also deenergizes the movable contact 133 of the work table oscillating circuit. At the same time the signal lamp 343 is energized to indicate that the grinding cycle has been completed.

After the completion of any grinding operation, it may be found that further grinding of some or all of the springs is required and, in this case, it will not be necessary or desirable to retard the inward movement of the grinding heads by the operation of the fluid control device 185. Means are accordingly provided for inhibiting the action of this device when desired, and such means are illustrated in Fig. 5 and comprise a solenoid 225, the armature of which is connected to one arm of a lever 226, the other arm of which is so positioned that it may be moved to a position underlying the end of the operating arm 186 and preventing the movement thereof with the piston. The subsequent operation of the grinding heads, in the manner set forth hereinbefore, will be unrestricted and the grinding heads will move toward each other at a rapid rate until the stop and microswitch are engaged.

Means are provided for causing the oscillation of the work table, as described hereinbefore, to continue until the grinding heads have approached each other to a predetermined distance, after which such means are operative to stop the oscillation of the work table and cause the grinding heads to be retracted to their separated positions. The oscillation of the work table, caused by the shifting of movable switch 133 into alternate engagement with contacts 134, 135, will continue until the grinding head feed piston 163 has moved outwardly, moving the heads toward each other, sufficiently to cause the operation of the microswitch 202 and the separation of the switch contacts 207, 209, thereby causing the time-delay relay, after a suitable dwell, to open the circuit through contact 402, lead 407 and movable contact 133 of the work table oscillating control circuit. The disconnection of contact 133 from the source of power will prevent the usual reversing operation of the switch devices 133, 134, 135 as the work table operating piston moves to the left as viewed in Fig. 17. The table will therefore continue to move until the abutment 136 which is carried thereby engages the movable switch contact device 137, moving it out of engagement with fixed contact 138, thereby deenergizing solenoid 124b, dumping the valve 124 and cylinder 110 and stopping the motion of the work table.

Means are provided for causing the immediate movement of the grinding heads to retracted or separated positions at any time, if

an overload on the grinding motors occurs. Such means comprise an overload control switch 370 which is operated by excess current in the grinding motors, one contact of which is connected to the source of power while the second contact of which is connected to one terminal of the solenoid 173a which controls valve 173, the second terminal of the solenoid being connected to ground through leads 372, 352, 326 and 212. It will be apparent that in the event of overload closing the switch 370, the solenoid 173a will be immediately operated to shift valve 173 to a position in which fluid under pressure will be supplied to the rod end of cylinder 164, shifting the piston 163 and moving the grinding heads to separated positions.

It will be understood that the disclosure of Fig. 17 is diagrammatic and that the operation of various contacts by the movement of piston 163 is, in reality, effected by the movement of cam 198 or rod 190, as illustrated in Figs. 5 and 6, and the position of which elements depends at all times upon the position of piston 163.

General Operation

The sequence of operation of the machine consits in loading unground springs into a paddle which is mounted in an open frame carried on a rotatable horizontal shaft, rotating the shaft to move the frame and paddle from horizontal charging position to a vertical position, moving the paddle from the frame onto a horizontal work table, reciprocating the work table so that the paddle moves between opposed grinding wheels, moving the wheels toward each other at a controlled rate until the grinding operation is completed, withdrawing the grinding wheels to fully separated positions, withdrawing the paddle from the work table into the frame of the indexing fixture and rotating the frame to a horizontal position in which the ground springs are discharged from the paddle.

It may be assumed that a paddle containing unground springs has been moved onto the work table and that the springs are to be ground square and to a predetermined length. To start the grinding cycle the operator will first operate switch 125, thereby starting the work table oscillating mechanism and the grinding head feeding mechanism by energizing solenoid 124a of valve 124 and solenoid 180a of valve 180, shifting these valves so that fluid under pressure is delivered by the pump 179 to the table oscillating and head feed cylinders. The circuits energizing the solenoids 124a and 180a are completed through the interlock switch 103 which is controlled by the position of the locking pin 92, thus insuring that the work table and grinding heads will not be operated unless the lock pin is in locking position and the work-holding paddle is accordingly locked to the work table.

When solenoid 124a is energized pilot pressure is directed through conduit 122 to the left side of the four-way valve 114, shifting the same and directing fluid under pressure to the rod end of work table oscillating cylinder 110, moving the work table to the right, as viewed in Fig. 17, at a rate of speed determined by the setting of the feed control device 120. When solenoid 180a is energized, valve 180 will be shifted to direct fluid to the head end of the cylinder 164, causing the heads to move toward each other at a rate which is controlled by the cam 198 which operates the control device 185.

During the movement of the piston 163 to move the grinding heads together, the table oscillating piston 111 moves to the right as viewed in Fig. 17 and this movement continues until pivoted abutment 131 contacts the movable switch contact 133 and shifts the same from engagement with contact 135 to engagement with contact 134, thus deenergizing solenoid 124a and energizing solenoid 124b of valve 124, shifting valve 124 and directing pilot pressure through conduit 123 to the right side of valve 114, shifting valve 114 and directing pressure to the head end of cylinder 110. The work table is now reversed, moving to the left, as viewed in Fig. 17, until pivoted abutment 132 contacts switch 133 shifting the same out of engagement with contact 134 and into engagement with contact 135. Solenoid 124b of valve 124 is now deenergized and solenoid 124a is energized, causing fluid under pressure to be released from the head end of cylinder 110 and supplied to the rod end thereof in the manner described, moving the work table to the right as viewed in Fig. 17.

This oscillation of the work table will continue until the grinding heads move against a solid abutment stopping their movement toward each other and operating the microswitch 202 to energize the time delay relay 205 in such a way as to stop the inward movement of the grinding heads, prevent further operation of the work table oscillation control switch 133, 134, 135 and light the signal lamp 343. A sparking out period will take place during the operation of the time-delay relay and while the work table is moving sufficiently beyond its normal travel to cause the abutment 136 to operate the switch contacts 137, 138 to open position, thereby deenergizing the work table oscillation control means and stopping all movement of the table.

The operation of the time-delay relay by closing of microswitch 202 causes solenoid 180a to be deenergized, and solenoid 180b to be energized after a predetermined dwell. Pressure is accordingly removed from the head end of cylinder 164 and supplied to the rod end thereof, returning the grinding heads to their separated positions at a rapid traverse rate. The return movement of piston 163 will cause the operating lever 186 of fluid control device 185 to return to inoperative position. At the end of the return stroke of piston 163 the switch contacts 207, 209 will be closed, resetting the time-delay relay in order to permit repetition of the grinding cycle.

The next step is to unload the work, and this operation is initiated by the closing of master switch 82, energizing solenoid 53b of four-way valve 53 and solenoid 81a of four-way valve 81. The circuits of these solenoids include interlock switch 303 and may be completed only when the indexing fixture locking pin 45 is in locking position holding this switch in closed position, whereby the work may not be unloaded unless the indexing means is in proper position and is locked. The energization of the aforesaid solenoids causes fluid under pressure to be directed to the rod end of cylinder 97, moving the lock pin 92 to unlocking position and releasing the paddle from the work table. As the lock piston moves to unlocking position fluid under pressure is by-passed through the cylinder 97, conduit 102 and valve 81 to the head end of the load and unload cylinder 65, moving the piston 66 outwardly to engage the paddle on the work table. During the complete outward movement of the piston 66 the operator holds the switch 82 in closed position. When the piston has engaged the paddle, in the

manner hereinbefore described, the operator opens the switch 82, deenergizing the solenoid of valve 81, permitting the valve to return to position to direct fluid under pressure to the rod end of the load and unload cylinder and move the piston 66 to unloading position, thereby moving the paddle off of the work table and into the frame of the indexing mechanism. During the outward and return movements of the piston 66 the switch 76 will be held in closed position, thus maintaining the solenoid 53*b* in energized condition. The movement of piston 66 to its fully retracted, unloading position will open switch 76, deenergizing solenoid 53*b* and causing valve 53 to move to neutral position in which the pump 52 is unloaded and the unloading part of the cycle is completed.

It should be noted that the loading operation is exactly the same as the unloading operation in all respects, and the loading operation will not be further described.

The indexing mechanism must now be operated to move the paddle of ground springs to dumping position and to move a paddle of unground springs from charging position to loading position in which the paddle may be moved onto the work table. The operator initiates the indexing operation by closing master switch 60, thereby energizing solenoid 53*a* of four-way valve 53, this circuit being completed through interlock switch 77 whereby operation of the indexing mechanism is prevented unless the load and unload piston 66 is in fully retracted position. The operation of solenoid 53*a* shifts valve 53 to a position in which fluid is directed to the rod end of cylinder 47, moving piston 46 in such a way as to release the locking pin 45 from engagement with the indexing fixture. As the piston 46 moves fluid is by-passed through the cylinder 47 to conduit 55 and fluid motor 43, thereby causing operation of the motor to rotate the indexing mechanism. As one of the apertures 44 in the control disk approaches the locking pin 45, one of the abutments 49 on the control disk engages the stem of decelerating valve 56, throttling the exhaust of motor 43 and slowing the movement of the indexing fixture. When the aperture is directly opposite the locking pin, one of the abutments 50 on the control disk will engage the control switch 57, opening the same and deenergizing solenoid 53*a*, causing valve 53 to move to neutral position to unload the pump 52 and exhaust fluid from the cylinder 47. The spring 48 in the cylinder 47 will now move the piston 46 in such a way as to cause the locking pin 45 to enter the adjacent aperture 44, thereby locking the indexing fixture against further rotation. The spring 48 should be of sufficient strength to positively seat the tapered locking pin in the adjacent aperture and, if necessary, to rotate the indexing fixture slightly to correct any misalignment. To further permit this, the stem of valve 56 should never be fully depressed, thus allowing the indexing fixture to coast slightly, thereby permitting free movement of the locking pin. Upon completion of a 90° indexing movement, as described, the operator may again close master switch 60 in order to effect a second indexing movement of 90°.

If at any time an overload on either of the grinder motors exists, the operator may close master switch 370, thereby energizing the solenoid 173*a* of reversing valve 173, thereby shifting the valve to a position in which fluid is exhausted from the head end of cylinder 164 and supplied to the rod end thereof. The grinding heads will, accordingly, be immediately moved apart, relieving the overload on the motors.

While we have illustrated and described one embodiment of our invention, it will be understood by those skilled in the art that various changes and modifications may be made in the disclosed machine and many improvements thereto may be made, all without departing in any way from the spirit or scope of the invention, for the limits of which reference must be had to the appended claims.

We claim:

1. In a grinding machine, a base, a work table mounted on said base, means for reciprocating said table, and means for locking work pieces to said table comprising a vertically extending locking pin mounted on said table adjacent one end thereof for vertical movement with respect thereto, means constantly urging said pin to raised locking position, and means mounted on said base and being constructed and operable to engage said pin and move it to lowered position.

2. In a grinding machine, a base, a work table mounted on said base, means for reciprocating said table, and means for locking work pieces to said table comprising a vertically extending locking pin mounted on said table adjacent one end thereof for vertical movement with respect thereto, an enlarged base on the lower end of said pin, means engaging said enlarged base and constantly urging the pin to raised, locking position, and means mounted on said machine base and being constructed and arranged to engage said enlarged base and exert a force thereon to move said pin to its lowered inoperative position.

3. In a grinding machine, a base, a work table mounted on said base, means for reciprocating said table, and means for locking work pieces to said table comprising a vertically extending locking pin mounted on said table adjacent one end thereof for vertical movement with respect thereto, means constantly urging said pin to raised, locking position, a cylinder mounted on said machine base, a piston slidably mounted in said cylinder, means connected to said piston and operable to engage said pin, and means for moving said piston to cause said pin to be moved to lowered, inoperative position.

4. In a grinding machine, a base, a work table mounted on said base, a vertically arranged pin mounted adjacent one end of said table, a spring arranged between the lower end of said pin and said base and constantly urging said pin to raised, locking position, and means for moving said pin to lowered, unlocking position comprising a vertically arranged piston and cylinder assembly on said base, means connected to said piston and slidably engaging the enlarged base on said pin, and means for operating said piston to cause said pin to be moved to its lower, inoperative position.

5. In a grinding machine, a base, opposed annular grinding elements slidably mounted on said base, opposed, parallel rack bars each connected respectively to one of said elements, a pinion mounted between and meshing with the teeth on said rack bars, a crank operably connected at one end thereof to said pinion to cause rotation of the pinion, a cylinder, piston and piston rod assembly mounted on said base, a yielding connection between the piston rod and the second end of said crank whereby the crank may be operated by the cylinder and piston assembly to

thereby effect relative movements of said rack bars and grinding elements.

6. In a grinding machine, a base, opposed annular grinding elements slidably mounted on said base, opposed, parallel rack bars each connected respectively to one of said elements, a pinion mounted between and meshing with the teeth on said rack bars, a crank operably connected at one end thereof to said pinion to cause rotation of the pinion, a cylinder, piston and piston rod assembly mounted on said base, spaced abutments on said piston rod and disposed on opposite sides of the second end of said crank, springs disposed between said abutments and the second end of the crank and providing a yielding connection between the piston rod and the crank whereby the crank may be operated by the cylinder and piston assembly to thereby effect relative movement of said rack bars and grinding elements.

7. In a grinding machine, a base, opposed annular grinding elements mounted on said base for movement toward each other, fluid pressure operated means connected to said elements for effecting such movement, a valve controlling the supply of operating fluid to said means, a rotatable cam associated with said valve for operating the same, a member movable linearly with said elements, a crank connected to be operated by movement of said member, and means operably connecting the crank and said cam, whereby movement of said elements causes said cam to operate said valve.

8. In combination with a grinding machine having a horizontally reciprocable work table, a device for loading work pieces onto said table and unloading work pieces therefrom, comprising a rotatable shaft aligned with said table and separate therefrom, supporting devices extending radially from said shaft and being so constructed and arranged as to slidably receive frame devices having work pieces mounted therein, means for rotating said shaft to move said supporting devices to a plurality of stations, and means for locking said shaft in order to hold said devices at said stations.

9. In combination with a grinding machine having a horizontally reciprocable work table, a device for loading work pieces onto said table and unloading work pieces therefrom, comprising a rotatable shaft aligned with said table and separate therefrom, supporting devices extending radially from said shaft and being so constructed and arranged as to slidably receive frame devices having work pieces mounted therein, means for rotating said shaft to a plurality of positions one of which is aligned with the work table in order that a frame device may be moved from its supporting device onto the work table, and means for locking the shaft in each of said positions.

10. In combination with a grinding machine having a horizontally reciprocable work table, a device for loading work pieces onto said table and unloading work pieces therefrom, comprising a rotatable shaft aligned with said table and separate therefrom, supporting devices extending radially from said shaft and being spaced 90° apart on said shaft and being so constructed and arranged as to slidably receive work piece carriers in such a manner that such carriers may be moved into and out of said devices in a direction axially of said shaft, means for rotating said shaft to successive stations spaced 90° apart, means operated by rotation of the shaft for stopping the rotation thereof at each station, and means for locking the shaft at each station.

11. A machine for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to said shaft and each lying in a plane which is parallel to the axis thereof and extends radially therefrom, means for supporting work-carrying paddles in said frames in such a manner that the paddles may be moved into and out of said frames in directions axial of the shaft, means for rotating the shaft to align said frames with spaced stations, and means for locking the shaft at each of said stations.

12. A machine for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting work-carrying paddles in said frames in such a manner that the paddles may be moved into and out of said frames in directions axial of the shaft, means for rotating the shaft to align said frames with spaced stations, means operated by the rotation of the shaft for stopping the rotation thereof at each of said stations, and means for locking the shaft at each of said stations.

13. A machine for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting work-carrying paddles in said frames in such a manner that the paddles may be moved into and out of said frames in directions axial of the shaft, power-operated means for rotating said shaft, means for supplying operating power to said power operated means, means operated by rotation of the shaft to control the supply of operating power to said power operated means in order to control the rotation of the shaft.

14. A machine for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting work-carrying paddles in said frames in such a manner that the paddles may be moved into and out of said frames in directions axial of the shaft, means for rotating the shaft to align said frames with spaced stations, means controlled by the angular position of the shaft as it is rotated for stopping the rotation thereof at each of said stations, and means for locking the shaft at each of said stations.

15. A machine for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting work-carrying paddles in said frames in such a manner that the paddles may be moved into and out of said frames in directions axial of the shaft, fluid pressure operated means for rotating said shaft, a valve controlling the supply of fluid pressure to said operated means, and means for operating said valve in accordance with the angular position of the shaft as it is rotated, to thereby control the rotary movement of the shaft.

16. A machine for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting

work-carrying paddles in said frames in such a manner that the paddles may be moved into and out of said frames in directions axial of the shaft, fluid pressure operated means for rotating said shaft, a valve controlling the supply of fluid to said operated means, a second valve controlling the exhaust of fluid from said operated means, and means for operating said valves in accordance with the angular position of the shaft as it is rotated, to thereby control the rotary movement of the shaft.

17. A machine for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting work-carrying paddles in said frames in such a manner that the paddles may be moved into and out of said frames in directions axial of the shaft, fluid pressure operated means for rotating said shaft, a valve controlling the supply of fluid to said operated means, a second valve controlling the exhaust of fluid from said operated means, and means carried by said shaft and adapted to operate said valves as the shaft is rotated, to thereby control the rotary movement of the shaft.

18. A machine for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting work-carrying paddles in said frames in such a manner that the paddles may be moved into and out of said frames in directions axial of the shaft, fluid pressure operated means for rotating said shaft, an electrically operated valve controlling the supply of fluid pressure to said operated means, a switch controlling the operation of said valve, a second valve controlling the exhaust of fluid from said operated means, and means for operating said switch and said second valve in accordance with the angular position of the shaft as it is rotated, to thereby control the rotary movement of the shaft.

19. A machine for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting work-carrying paddles in said frames in such a manner that the paddles may be moved into and out of said frames in directions axial of the shaft, fluid pressure operated means for rotating said shaft, an electrically operated valve controlling the supply of fluid pressure to said operated means, a switch controlling the operation of said valve, a second valve controlling the exhaust of fluid from said operated means, and means carried by said shaft and adapted to operate said switch and said valve to thereby control the operation of said operated means.

20. A machine for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting work-carrying paddles in said frames in such a manner that the paddles may be moved into and out of said frames in directions axial of the shaft, fluid pressure operated means for rotating said shaft, an electrically operated valve controlling the supply of fluid pressure to said operated means, a switch controlling the operation of said valve, a second valve controlling the exhaust of fluid from said operated means, means carried by the shaft and operable on rotation thereof to operate said exhaust controlling valve to retard the operation of said driving means, and means carried by said shaft and operable on further rotation thereof to operate said inlet-controlling valve to shut off the supply of fluid to said driving means to stop the rotation of said shaft.

21. Apparatus for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting work-carrying paddles in said frames, means for rotating the shaft and frames, and a plurality of chutes connected to and movable with said shaft, each of said chutes being arranged adjacent one of said frames and being so disposed with respect thereto that it is positioned beneath the associated frame when such frame is in horizontal position.

22. Apparatus for handling work pieces and loading and unloading the same to and from a grinding machine, comprising a rotatable shaft, supporting frames connected to and extending radially from said shaft, means for supporting work-carrying paddles in said frames, means for rotating the shaft and frames, and a plurality of chutes connected to and movable with said shaft, each of said chutes being arranged adjacent one of said frames and being so disposed with respect thereto that it is positioned beneath the associated frame when such frame is in horizontal position, and means for moving each chute with respect to its associated frame, as the frame is rotated from one horizontal position to another horizontal position, from a position underlying the frame but spaced therefrom to a position underlying the frame and abutting the same.

23. In combination with a grinding machine having a horizontally reciprocable work table, a device for loading work pieces onto said table and unloading work pieces therefrom, comprising a rotatable shaft aligned with said table and separate therefrom, supporting devices extending radially from said shaft and being so constructed and arranged as to slidably receive frame devices having work pieces mounted therein, a cam surface surrounding said shaft and fixed with respect thereto, and means connected to each chute and engaging the cam and adapted to be operated by the cam to move the chute, as the frames and chutes are rotated by the shaft, from a chute position underlying the associated frame to a supporting position underlying the frame and closely adjacent thereto.

24. In combination, a grinding machine, a work table mounted in said machine, work holding means arranged exteriorly of the machine and adapted to support a work holder in position to be moved onto said table, reciprocable means mounted on said exterior work holding means, a latch mounted on said reciprocable means and adapted to engage the work holder upon operation of the reciprocable means, means for normally holding the latch member in an inoperative position and operable upon operation of the reciprocable means to move the latch means to operative position, and means for operating the reciprocable means.

25. In combination, a grinding machine, a work table mounted in said machine, work holding means arranged exteriorly of the machine and adapted to support a work holder in position to be moved onto said table, reciprocable means

mounted exteriorly of the machine, a latch mounted on said reciprocable means and adapted to engage the work holder upon operation of the reciprocable means, an abutment arranged to engage the latch and move the same to an inoperative position when the reciprocable means is moved to inoperative position, a spring operable to move the latch to operative position when the reciprocable means is moved from inoperative position toward the machine, and means for operating the reciprocable means.

26. In a grinding machine, a reciprocable work table, a cylinder mounted exteriorly of the machine, a piston reciprocable in the cylinder and adapted to engage work pieces and move the same onto and off of the work table, a reciprocable pin adapted to be moved to a position in which it engages work pieces on the work table and attaches the same thereto, a second cylinder mounted adjacent the work table, a piston in said second cylinder and connected to said pin, means for conducting fluid under pressure to the first-named cylinder, said conducting means being arranged to cause fluid to be supplied to the first-named cylinder through the second-named cylinder in such a manner as to cause the piston in the second-named cylinder to move the pin to an unlocking position in which it is removed from the work pieces.

27. In a grinding machine, a reciprocable work table, reciprocable means for moving work pieces onto and off of the work table and being movable to an inoperative position, a work piece handling device arranged exteriorly of the machine and being operable to move work pieces to a position adjacent the work table, fluid pressure operated means for causing operation of said handling device, a valve controlling the operation of said fluid pressure means, and means operable in response to movement of said reciprocable means to permit operation of said valve.

28. In a grinding machine, a reciprocable work table, reciprocable means for moving work pieces onto and off of the work table and being movable to an inoperative position, a work piece handling device arranged exteriorly of the machine and being operable to move work pieces to a position adjacent the work table, fluid pressure operated means for causing operation of said handling device, an electrically-controlled valve controlling the operation of said fluid pressure means, an electric circuit including said valve, a switch in said circuit and positioned adjacent the inoperative position of said reciprocable means and operable to closed position in response to movement of the reciprocable means to inoperative position to thereby complete the circuit through said valve.

29. In a grinding machine, a reciprocable work table, reciprocable means for moving work pieces onto and off of the work table and being movable to an inoperative position, a work piece handling device arranged exteriorly of the machine and being operable to move work pieces to a position adjacent the work table, means for locking said handling device from movement, fluid pressure operated means for moving said locking means to unlocking position, fluid pressure operated means for causing operation of said handling device, a valve controlling the operation of both of said fluid pressure means, and means operable in response to movement of said reciprocable means to permit operation of said valve.

30. In a grinding machine, a reciprocable work table, reciprocable means for moving work pieces onto and off of the work table and being movable to an inoperative position, a work piece handling device arranged exteriorly of the machine and being operable to move work pieces to a position adjacent the work table, means for locking said handling device from movement, fluid pressure operated means for moving said locking means to unlocking position, fluid pressure operated means for causing operation of said handling device, an electrically-controlled valve controlling the operation of said fluid pressure means, an electric circuit including said valve, a switch in said circuit and position adjacent the inoperative position of said reciprocable means and operable to closed position in response to movement of the reciprocable means to inoperative position to thereby complete the circuit through said valve.

31. In a grinding machine, a reciprocable work table, reciprocable means for moving a work holder onto and off of the work table and being movable to an inoperative position, a pin reciprocably mounted on said table and being movable from an inoperative position to a position in which it engages the work holder on the table and attaches the same thereto, fluid pressure operated means for moving said pin to inoperative position, a valve controlling the supply of fluid to said fluid pressure operated means, and means operable in response to movement of said reciprocable means for controlling the operation of said valve.

32. In a grinding machine, a reciprocable work table, reciprocable means for moving a work holder onto and off of the work table and being movable to an inoperative position, a pin reciprocably mounted on said table and being movable from an inoperative position to a position in which it engages the work holder on the table and attaches the same thereto, fluid pressure operated means for moving said pin to inoperative position, an electrically operated valve controlling the supply of fluid to said fluid pressure operated means, an electric circuit including said valve, a normally-closed switch in said circuit, said switch being positioned adjacent the inoperative position of said reciprocable means and being so constructed and arranged as to be operated to open position by movement of the reciprocable means to inoperative position.

33. In a grinding machine, a slidably mounted work table, means for reciprocating the work table, means for controlling the operation of said reciprocating means, work locking means movable from an inoperative position to a position in which work pieces are locked to the work table, and means operable in response to movement of said locking means for controlling the operation of said means for controlling the reciprocating means.

34. In a grinding machine, a slidably mounted work table, fluid pressure operated means for reciprocating the work table, an electrically operated valve controlling the operation of said fluid pressure operated means, an electric circuit including said valve, a work locking device movable from an inoperative position to a position in which it engages a work holder and attaches the same to the work table, a switch in said circuit and positioned adjacent the locking position of said locking device, and being constructed and arranged to be operated to closed position by movement of said locking means to locking position to thereby permit operation of said valve.

35. In a grinding machine, opposed annular grinding heads, power operated means for moving said heads toward each other, means operable by

movement of said heads toward each other for controlling the supply of power to said power operated means, and inhibiting means operable to prevent the operation of said controlling means and thereby permit unrestricted movement of the heads toward each other.

36. In a grinding machine, opposed annular grinding heads, fluid pressure operated means for moving said heads toward each other, valve means controlled by movement of the heads toward each other for progressively restricting the flow of fluid to said fluid pressure operated means to thereby control the rate of movement of the heads toward each other, and means operable to inhibit the operation of said valve means to thereby permit unrestricted movement of the heads toward each other.

37. In a grinding machine, opposed annular grinding heads, fluid pressure operated means for moving said heads toward each other, valve means controlled by movement of the heads toward each other for progressively restricting the flow of fluid to said fluid pressure operated means to thereby control the rate of movement of the heads toward each other, and means movable from an inoperative position to a position preventing operation of said valve means to thereby permit unrestricted movement of the heads toward each other.

38. In a grinding machine, opposed annular grinding heads, fluid pressure operated means for moving said heads toward each other, valve means controlled by movement of the heads toward each other for progressively restricting the flow of fluid to said fluid pressure operated means to thereby control the rate of movement of the heads toward each other, and a solenoid having an armature movable into the path of movement of said valve means to prevent operation thereof to thereby permit unrestricted movement of the heads toward each other.

39. A work loading and unloading means for a grinding machine having an elongated longitudinally reciprocable work table, comprising means arranged exteriorly of the machine for supporting a work holder in a position adjacent one limit of movement of the work table, reciprocable work moving means mounted adjacent said supporting means and operable in a direction toward and from said table, said work moving means being constructed and operable to engage a work holder on said supporting means and to move the same onto the table and being constructed and operable to engage a work holder on the table and to move the same onto the supporting means.

40. A work loading and unloading means according to claim 39, in which the reciprocable work moving means comprises a piston and cylinder device, a latch device mounted on the piston rod exteriorly of the cylinder and positioned to engage a work holder on the supporting means or on the table, and means for causing reciprocation of the piston in the cylinder.

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