No. 809,594.

PATENTED JAN. 9, 1906.

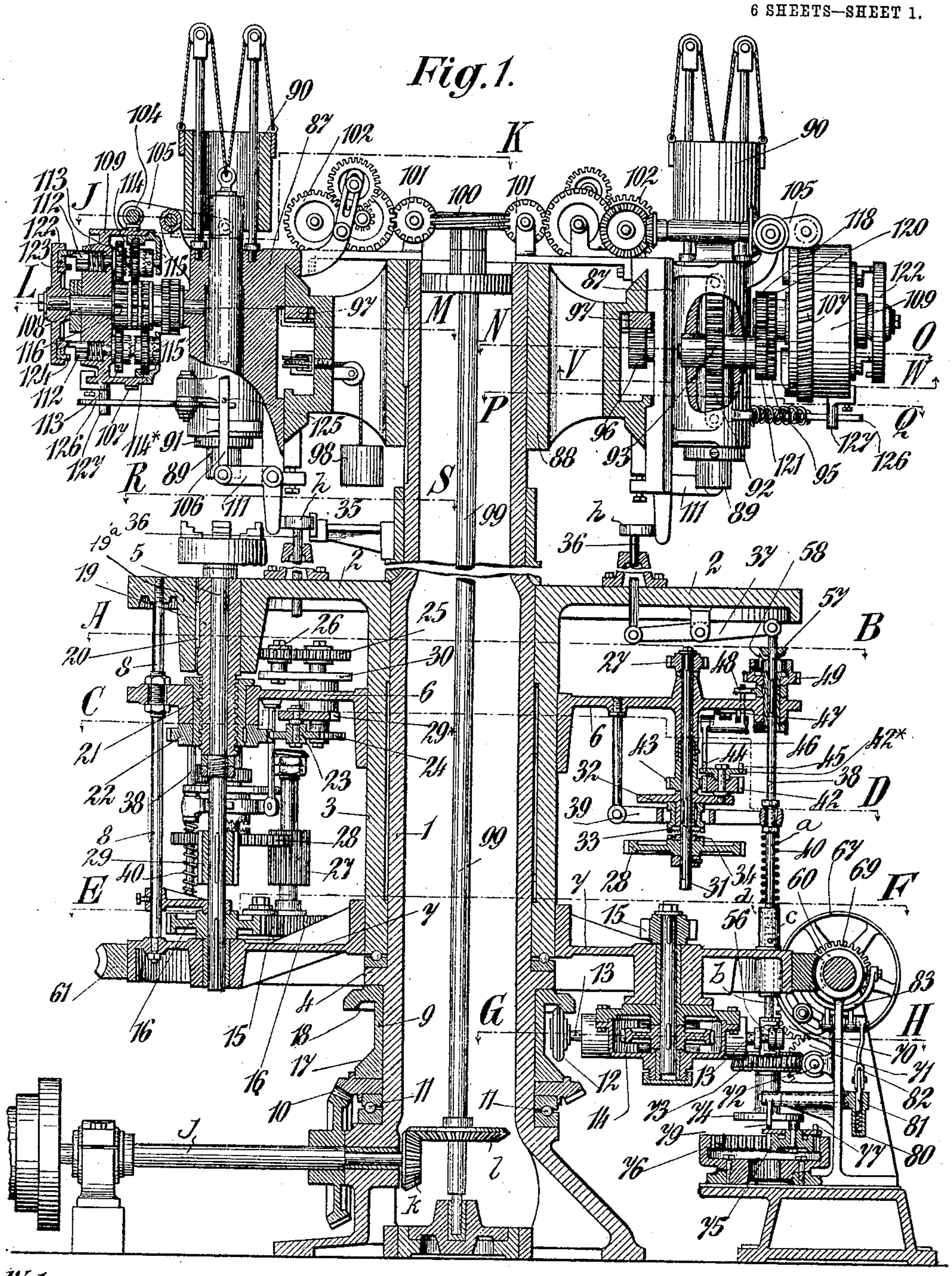
E. WIDMER-ABEGG.

SELF ACTING MULTISPINDLE MACHINE.

APPLICATION FILED OCT. 2, 1903.

6 SHEETS—SHEET 1.

Fig. 1.



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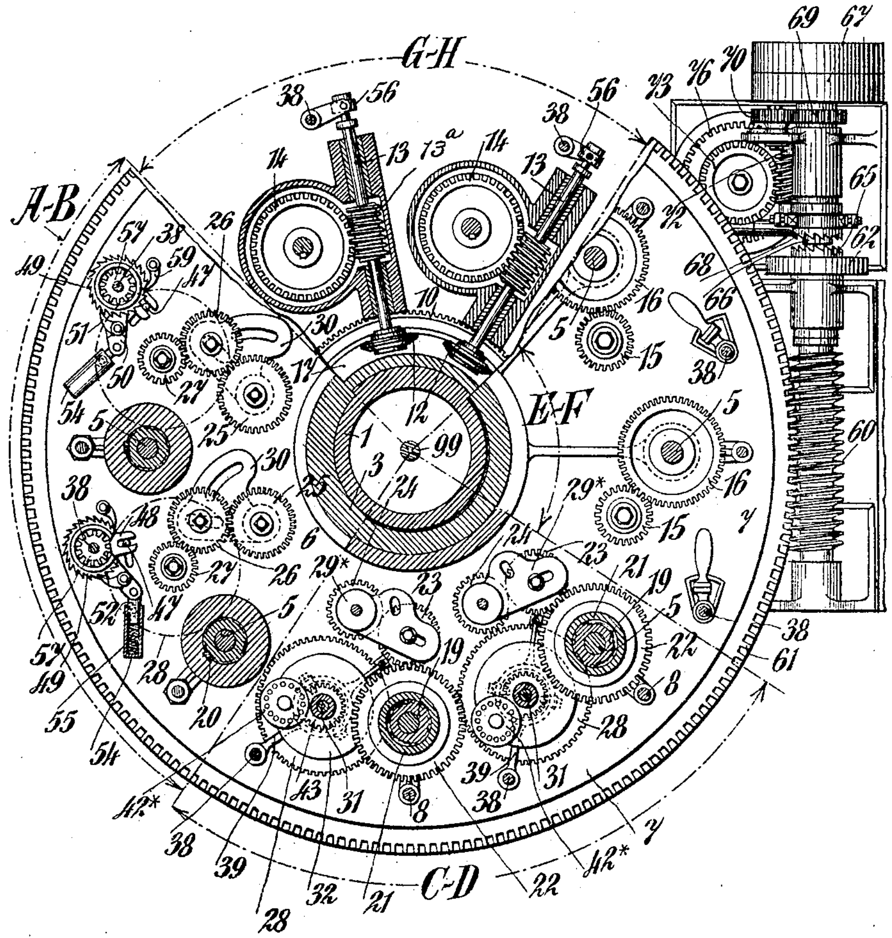
6 SHEETS—SHEET 2.

Fig. 2



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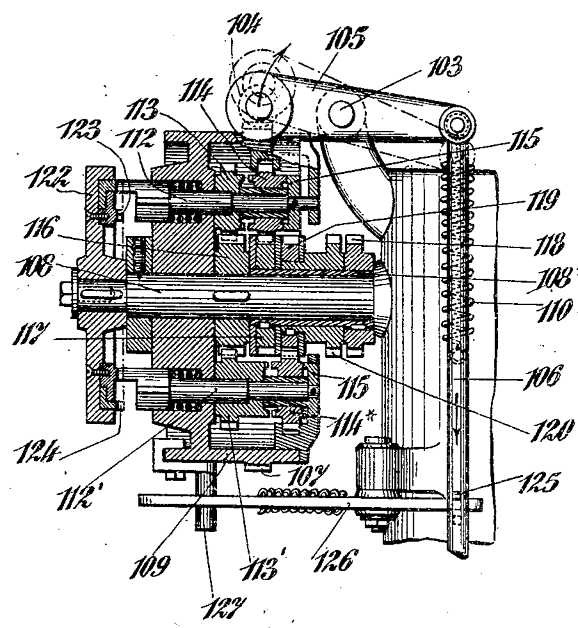
6 SHEETS—SHEET 3.

Fig. 3.



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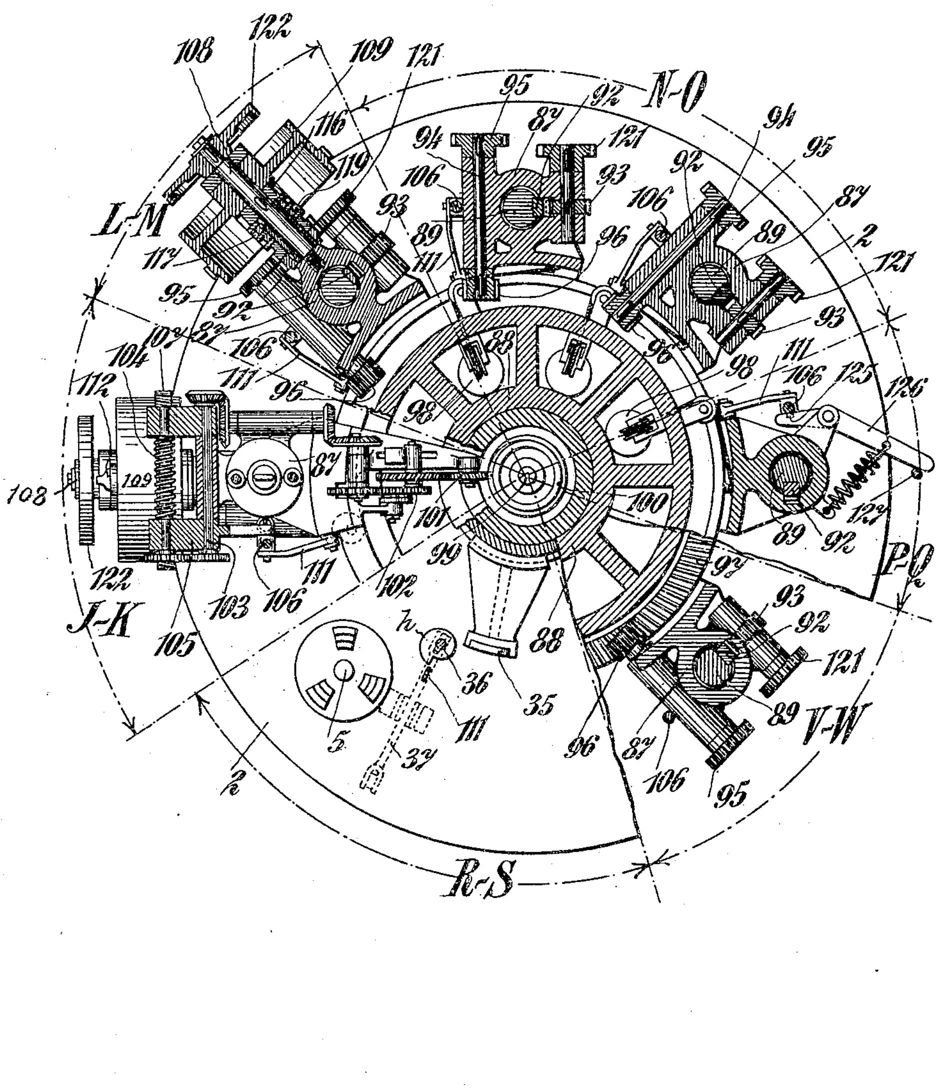
6 SHEETS—SHEET 4.

Fig. 4.



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6 SHEETS—SHEET 5.

Fig. 5.

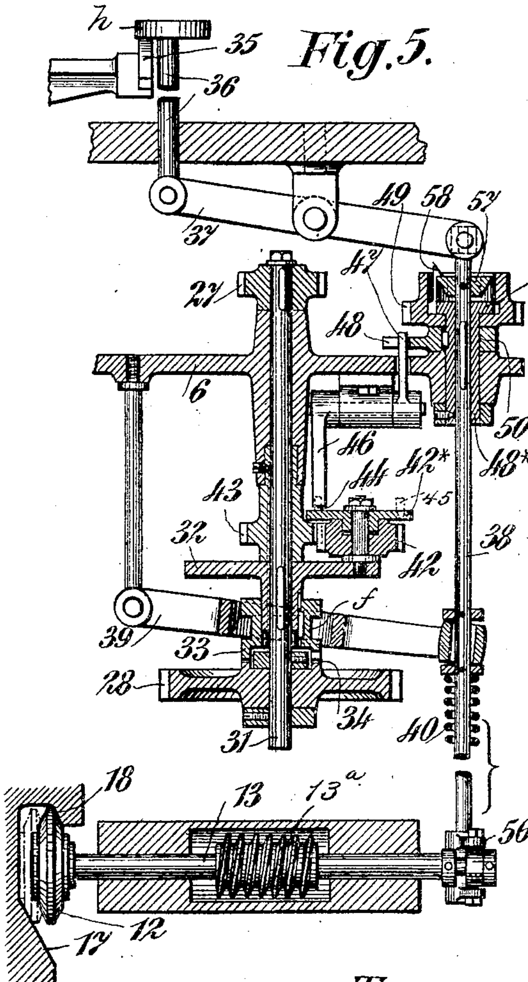


Fig. 6a.

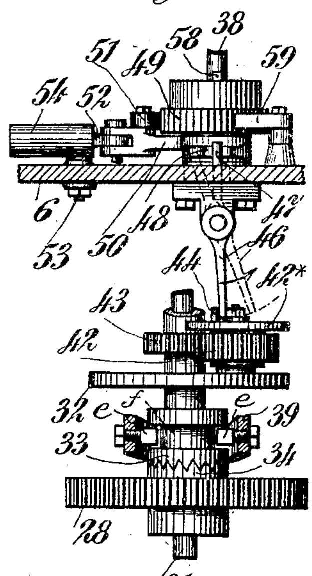


Fig. 6.

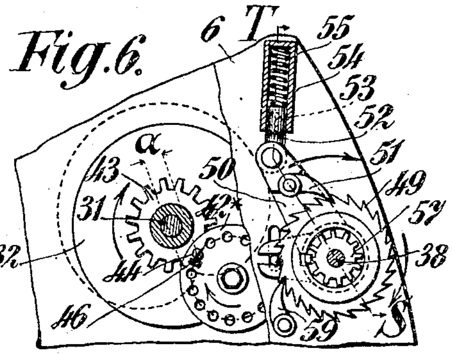
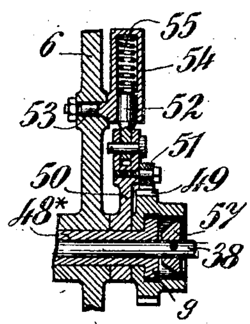


Fig. 7.



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6 SHEETS—SHEET 6.

Fig. 8.

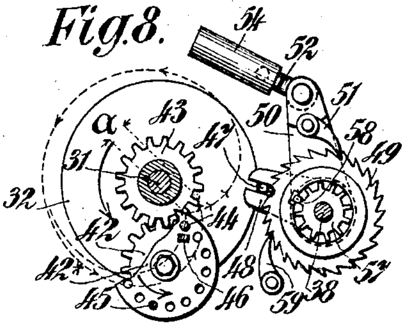


Fig. 9.

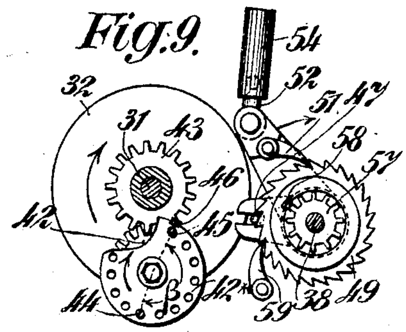


Fig. 10.

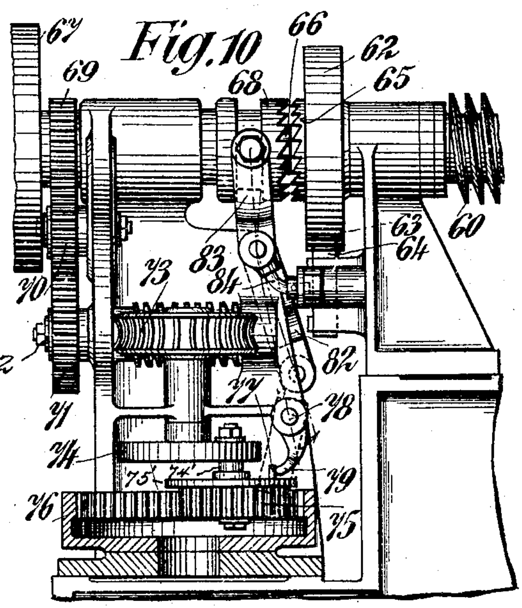
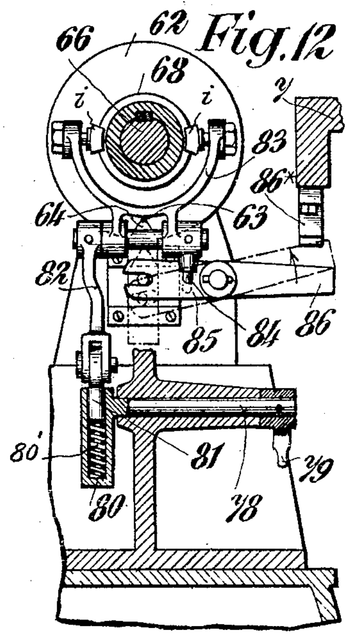


Fig. 12.



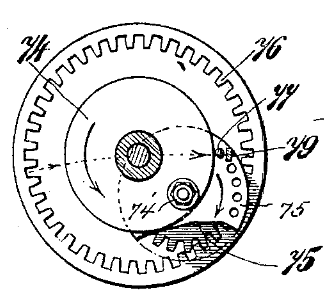


Fig. 11.

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UNITED STATES PATENT OFFICE.

ERNST WIDMER-ABEGG, OF HORGEN, SWITZERLAND, ASSIGNOR TO THE FIRM OF WANNER & CO., OF HORGEN, SWITZERLAND.

SELF-ACTING MULTISPINDLE-MACHINE.

No. 809,594. Specification of Letters Patent. Patented Jan. 9, 1906.

Application filed October 2, 1903. Serial No. 175,521.

To all whom it may concern:

Be it known that I, ERNST WIDMER-ABEGG, a citizen of the Republic of Switzerland, residing at Horgen, Switzerland, have invented new and useful Improvements in Self-Acting Multispindle-Machines, of which the following is a specification.

This invention relates to a self-acting multispindle-machine for boring, drilling, turning, planing, shaping, and the like of the class in which a number of tool-holders and tools arranged around a common central axis are so operated that each of the tools executes at the same time as the others a partial machining of the article under treatment and situated opposite to it, the arrangement being such that by shifting at intervals the articles under treatment relatively to the tools the said articles are conveyed from one tool to the other in succession. In existing machines of this class the relative arrangement between the articles under treatment and the tools situated for the time being opposite to said articles is such as to limit the machine to the treatment of comparatively small articles. This limitation is a consequence either of the circumstance that the tools are mounted on the rotary spindles while the articles under treatment are stationary during the machining or it is a consequence of the circumstance that the main tools situated in the prolongation of the articles under treatment are capable of displacement only in this direction and are not capable of being traversed across the surface being machined. Moreover, in those machines the feed movements of the tools are dependent on one another in that during the working of the machine the interruption of the motion of one tool necessitates also the interruption of the feed movements of the other tools. Now in a machine constructed in accordance with this invention the rotary spindles (hereinafter referred to as "rotary work-spindles") are arranged to carry the articles under treatment, and each tool, which in its operative position is situated in the prolongation of one of these rotary spindles, is clamped in a separate tool-slide and is fed independently of the other tools as regards direction, amount per unit of time, and duration either in the direction of the work-spindle or perpendicularly to the said direction or along a resultant of these two directions, and each tool is controlled independently in such a manner that when the tool has completed its alloted portion of the machining of the article under treatment and situated opposite to it its feed is automatically stopped and it is returned into its initial position. The rotary work-spindles are mounted in a rotary frame common to all of them—that is, rotated by separate mechanism (driven independently of the tool-driving mechanism) at any desired and variable intervals of time. The said separate mechanism is, however, capable of being thrown into and out of operation at any time without affecting any other movement. The connection or correspondence (which is necessary for the automatic action of the machine) between the feed movements of the tools and the rotation (produced by the said separate mechanism) of the rotary frame is provided by utilizing this rotation to bring the feed movement of each tool into operation immediately before the completion of the exchange movement—that is to say, of the bringing of the articles under treatment to the next tools in the series, which tools execute in their turn their allotted partial machining on the articles thus brought to them, and when this machining is finished return, as above stated, into their initial positions, wherein they remain until they are brought again into operation by the next exchange of articles to be operated upon.

The advantages possessed by a machine in accordance with this invention compared with existing multispindle-machines of the same class are as follows: In consequence of the independent automatic controlling of each tool and of its independent rotary motion the adjustment of the tools is very considerably facilitated and can be effected very quickly, because the tools do not depend in any way on one another and each tool can be set in operation simply and quickly. The separate tool-slides are easily removable, and any one of them can be replaced for special purposes by a tool-slide provided with any desired separate device. For that reason, as well as by reason of the great mobility of each single tool, it is possible in selecting the order of succession of the several partial machinings to take into consideration solely the article to be manufactured and not the arrangement of the tools. The preferably vertical arrangement of the machine allows of ready inspection of the several articles under treatment and of easy access to each tool.

The accompanying drawings illustrate, by way of example, a machine constructed in accordance with this invention.

Figure 1 is a vertical section, and Figs. 2 to 12 illustrate details.

The machine illustrated is provided with (for example) eight rotary work-spindles. It is built up around a pillar 1, the lower portion of which is broadened to receive the bearings for the driving mechanism and also for the purpose of affording greater stability to the machine. The work-spindles are carried in a rotary frame in the form of a table 2, cast with a long central drum 3, mounted to rotate on the pillar 1. The table 2 rests on a supporting-flange 4 of the pillar, balls being provided between the drum and the flange for the purpose of obtaining an easy rotation of the table. The eight rotary work-spindles 5 are mounted at equal intervals apart in a circle in the table and are further guided by means of two guide-plates 6 and 7, keyed on the drum 3 of the table and below the latter. These guide-plates are connected with each other and with the table by means of tie-bolts 8 at their peripheries, so that the three parts 2, 6, and 7 form together a structure capable of rotating as a whole on the pillar 1. Means hereinafter described are provided for rotating the spindles 5 in either direction and also for shifting them vertically. The vertical movement is provided for the purpose of cutting screw-threads, for instance. Upon the pillar above the spindle-table is a drum 88, carrying tool-carriages or slide-rests 87, in which are mounted tool-spindles 89, intended to receive the cutting-tools. These spindles are adapted to be moved up and down and sidewise by means hereinafter described. Each work-spindle is provided at its upper end with a chuck or device for holding the work. The work-spindles are driven by means of a friction-cylinder 9, which is arranged around the pillar below flange 4 and is driven from the exterior by means of variable-speed bevel-gearing 10. A ball-bearing 11 carries the friction-cylinder for the purpose of obtaining easy running. The friction-cylinder transmits its rotation to the friction-bowls 12, fixed on worm-shafts 13, capable of being moved longitudinally. From the shafts 13 rotary motion is transmitted to worm-wheels 14 and from these, through toothed wheels 15, to toothed wheels 16 on the lower ends of the work-spindles 5, which are thereby caused to rotate in a right-hand or in a left-hand direction, according as the friction-bowls 12 bear on the lower surface 17 or on the upper surface 18 of the cylinder 9. The worms 13ª are fixed on the shafts 13, and both are free to move longitudinally. The extent of motion is limited by the two friction-surfaces 17 and 18, Fig. 5. The longitudinal thrust of the worm-shaft 13, due to the action of the worm-wheel 14 on the worm 13ª, is taken up directly by the friction-bowl 12, which is thereby pressed against the driving friction-cylinder with a force that increases with the thrust of the worm-wheel, due to the resistance of the work to the tool, so that the greater this thrust the greater will be the force transmitted by the worm-drive. That portion of Fig. 2 which is a section on the line G H of Fig. 1 shows the worm and worm-wheels in plan.

For the purpose of imparting vertical motion to the work-spindle each of the latter is mounted at its upper end in a long sleeve 19, which is capable of being moved vertically in a boss 19ª in the table 2 and is prevented from rotating by means of a spring-key 20, Fig. 1. The lower end of the sleeve 19 is screw-threaded and works in a nut 21, which is mounted in the plate 6 in such a manner as to be capable of rotating, but not of vertical movement. Upon this nut is keyed a toothed wheel 22, by means of which the nut may be rotated. (See Fig. 1.) This toothed wheel is in engagement with a nest of toothed gearing composed of the toothed wheels 23, 24, 25, 26, 27, and 28, of which the toothed wheel 28 engages; also, with a long pinion 29, mounted on the work-spindle. The toothed wheels 23 and 26 have a bearing on pins fixed in slots in frames 29* and 30, which allow of a large amount of play for the purpose of changing wheels with different numbers of teeth when it is desired to produce screw-threads of different pitches. (These parts are shown more clearly in Fig. 2 in the horizontal sections on the lines A B and C D of Fig. 1.) The pair of toothed wheels 24 and 25 of each nest of gear-wheels are fixed on a common axle, and the toothed wheels 28 are arranged so as to be capable of rotating loosely on vertical axles 31, to the upper ends of which are secured the wheels 27, said axles being mounted in the guide-plate 6. On each of these axles 31 is keyed a horizontal disk 32, having a boss carrying the movable half 33 of a claw-clutch. The fixed half 34 of each clutch is constituted by the suitably-shaped boss of the toothed wheel 28. Each claw-clutch serves to throw the nut 21 in and out of gear with its respective nest of gear-wheels.

For the purpose of throwing the vertical feed of the work-spindles into gear there is provided at the place where the screw-threading tool is located a stop 35, fixed to the pillar 1, Figs. 1 and 4, Fig. 4 being in part a horizontal section on the line R S, Fig. 1. This stop is formed with an inclined plane or surface against which the disk or cam-shaped head of a rod 36 (capable of moving vertically in the table 2) is adapted to bear when the table rotates and be drawn upward thereby. To the lower end (situated below the table) of this rod 36 there is connected one arm of a lever 37, pivoted to the under side of the table. The other arm of this lever is connected to a rod 38, which is composed of an upper portion *a* and a lower portion *b*. The upper portion is mounted in the guide-plate 6 and can move vertically without this mode of motion being transmitted to the lower portion, which is mounted in the guide-plate 7. (Fig. 5 illustrates, on a larger scale, that portion of Fig. 1 which relates to these parts.) This is effected by rigidly securing a sleeve *c* to the lower portion *b* of the rod 38 and connecting the lower end of the upper portion *a* thereto by means of a feather *d*, Fig. 1. This rod 38 is engaged between two collars mounted thereon by the free end of a lever 39, which is mounted on the guide-plate 6 and which embraces with an annular portion the movable half 33 of the clutch and engages therewith by means of pins *e*, projecting into an annular groove *f* in the said clutch-half, Fig. 6ᵃ. When the rod 36 is raised by the inclined surface of the projection 35, the upper portion *a* of rod 38 moves down, compressing a spring 40, and through the medium of the lever 39 brings the two halves of the clutch into engagement with each other, whereby the wheel 28, which rotates loose on the shaft 31 and is in engagement with the long pinion 29, keyed on the work-holding spindle 5, is coupled to the disk 32, that is keyed on the shaft 31, and thus the rotary motion of the spindle 5 is transmitted, through the medium of the hereinbefore-referred-to nest of toothed gearing, to the nut 21, which raises or depresses the spindle, according to the direction of the rotation of the nut.

For the purpose of reversing the rotation of the work-spindle and of limiting its vertical movement there is mounted on the disk 32 a toothed planet-wheel 42, which engages with a stationary toothed wheel 43 on spindle 31. On a disk 42*, fixed to the planet-wheel 42, are two stops or pins 44 and 45, of which one may be shifted, Fig. 5. When the disk 32 rotates, it carries the planet-wheel 42 round with it and causes the said wheel 42 to roll on the stationary toothed wheel 43. The toothed wheel 42 is larger than the wheel 43 by a small amount, and the difference between their circumference is contained a certain whole number in the circumference of the toothed wheel 43. In consequence of the rolling of the wheel 42 on the wheel 43 the stops or pins 44 and 45, mounted in the disk, describe epicycloids having the form shown in Figs. 6, 8 in such a manner that at each completed development in the rolling movement the apex of the epicycloid will be shifted by the amount α—that is to say, by the difference between the circumferences of the wheels 42 and 43—in the direction of rotation around the wheel 43. Figs. 6, 8, and 9 show in plan and in various positions the disk 32, which is shown in section in Fig. 5, and the pins 44 and 45; also, further parts, hereinafter described, serving to limit the vertical movement of the spindle. Fig. 7 is a section on the line T S of Fig. 6. A small portion of this epicycloid is utilized to reverse the rotation of the spindles by causing the end of a small lever 46, (shown in side elevation in Fig. 6ᵃ,) pivoted on the under side of the guide-plate 6 and projecting into the epicycloidal path of the pins 44 and 45, to be shifted by one of those pins as soon as the said pin is situated in the said portion. Figs. 5, 6, and 6ᵃ show the pin 44 at the moment that it is beginning the reversal of the rotation of the spindle. In consequence of the difference between the circumferences of the gears 42 and 43 the pin 44 will resume its operative position after a number of revolutions around 43 equal to the circumference of the latter divided by X. When the disk 32 rotates in the direction indicated by the arrow shown in Fig. 6, (which produces, for example, the upward movement of the spindle,) the pin 44 at the moment when the desired vertical movement of the spindle is reached comes to bear behind the lever end of the lever 46, Fig. 6ᵃ, and moves this lever into the position shown in dotted lines in Fig. 6ᵃ. This movement of the lever 46 is transmitted to a second lever 47, which extends upward, and is mounted on the same pivot as the lever 46. This lever 47 engages in the forked arm 48 of a bell-crank lever 50, fixed on a sleeve 48*, spring-keyed on the shaft 38, Figs. 7 and 8. Upon this sleeve there is further mounted, so as to be capable of rotation thereon, a disk 49 with ratchet-teeth, which is held against the eye of the bell-crank by means of a shoulder *g* on the sleeve. The other arm 50 of the bell-crank, Figs. 6, 8, and 9, is provided with a pawl 51, which engages with the teeth of the ratchet-disk 49. This arm has also connected to it a plunger 52, which works against a spiral spring 55 in a cylinder 54, pivoting on the axle 53. When the bell-crank 48 50 is rotated by means of the lever 47, it will rotate the rod 38 and will also rotate the ratchet-wheel 49 by means of the pawl 51, and the spiral spring located in the pivoted cylinder 54 will be compressed by the plunger during one-half of the movement of the bell-crank. As soon as the pivot between the lever-arm 50 and plunger 52 passes beyond its dead-center the spiral spring will expand, aid, and complete the rotary motion of the bell-crank, which now rotates the ratchet-wheel quickly on through a farther extent. The rod 38 has fixed on its lower end a lever 56, Fig. 2, section G H, which engages between two collars arranged on the worm-shaft 13. Now when the rod 38 is rotated by means of the bell-crank the lever 56 moves the shaft 13 in the direction of its length, whereby the friction-bowl 12 is moved away from one friction-surface—for instance, the outer surface 18—and caused to bear against the other driving-surface—in this case the lower friction-surface 17—and thus reverse the rotary motion of the spindle 5. This reversal produces also the reversal of the rotary motion of the disk 32, with the result that the pin 44 is moved again away from the lever 46, while the pin 45 is moved toward the same lever, which is thereby returned into the position it occupied at first, thereby again producing a reversal of the rotary motion of the spindles. The periods of time in which these reversals of the rotary motions of the spindles take place are the greater the greater the angle β which is included between the pins 44 and 45, Fig. 9. For the purpose of varying these periods of time one pin is made removable, and the disk 42*, fixed to the toothed wheel 42, has a circular row of holes, into which this pin may be inserted. The in-and-out motion—that is to say, the vertical up-and-down motion of the spindles—is repeated until the clutch 33 34 is again thrown out of gear. Therefore the work is raised any desired number of times—for instance, up against a stationary screw-threading tool, which is then preferably fed against the work slightly at every fresh rise of the work.

For the purpose of throwing the clutch 33 34 out of operation after any desired number of up-and-down movements of the spindle—say at the moment when the spindle has reached its lowest position—a small removable cone 57, provided with a number of recesses, Fig. 2, section A B, is keyed on the upper end part of the rod 38, and a hooked spring 58 is provided, which is inserted in a groove in the ratchet-wheel 49, Figs. 1, 5, 6, 8, and 9. When the rod 38 is depressed by the stop 35 by means of the lever 37, and thereby the clutch 33 34 is thrown into gear, the cone presses back the spring 58, whose hook end snaps back again over the cone as soon as the latter has moved into its lowest position, and it thereby prevents the rod 38 from being pushed up again by the spring 40, which has been compressed by the depression of the rod 38. Usually—that is to say, during the periods of rest after each periodical rotation of the frame 3—the cam *h* on rod 36 is out of engagement with stop 35, which is then on one side of said cam, as shown in Fig. 4, so that on the release of spring 38 by the cone 57 the rod 38 is moved upwardly. The spring 58 is rotated, together with the ratchet-wheel 49, in the direction indicated by the arrow in Fig. 6, the return movement being prevented by a pawl 59, mounted on the guide-table 6, Figs. 6, 8, and 9. On the return movement of the bell-crank 50, which takes place at the moment at which the spindle has reached its lowest point, only the rod 38 is rotated, so that the cone 57 is rotated relatively to the spring 58. The pawl 51 rotates the ratchet-wheel 49 and spring 58 step by step until said spring is opposite a recess in the cone, whereupon the spring 40 is free to raise the rod 38 and the cone 57, whereby the clutch 33 34 is thrown out of gear and the vertical movement of the spindle is stopped. Therefore the operator is enabled by inserting cones in which the recesses are spaced at a greater or less distance apart to cause the throwing out of gear to take place after the first, second, third, &c., completed descent of the spindle.

For the purpose of periodically turning the spindle-table through the distance between two adjacent work-spindles a special indexing mechanism is provided comprising a worm-shaft having on it a worm 60. This apparatus is illustrated in vertical section in the lower right-hand portion of Fig. 1 and is also partly shown drawn to larger scale in Fig. 12. Fig. 10 is a side elevation of the apparatus, also drawn to a slightly larger scale than Fig. 1. The worm 60 gears with a worm-wheel rim 61, keyed on the periphery of the guide-plate 7, and thereby transmits the desired rotary movement to the table. On one end of the worm-shaft is keyed a disk 62, formed at its periphery with a wedge-shaped recess 63, Fig. 12, into which a spring-pressed bolt 64 is adapted to engage for the purpose of arresting the worm in a determined position, Figs. 10 and 12. This disk has a hub 65 constructed to form the fixed member of a claw-clutch. A shaft 66, situated in line with the worm-shaft and receiving continuous rotary motion from a belt-pulley 67, keyed on it, carries the movable member 68 of the aforesaid clutch, which is adapted to move freely along the shaft 66. For the purpose of throwing the clutch member 68 into engagement with the member 65 there is keyed on the shaft 66 a toothed wheel 69, which engages with a set of toothed gearing composed of the toothed wheels 70 and 71, of which the toothed wheel 70 can be changed. The toothed wheel 71 is keyed on a worm-shaft 72, Fig. 1, the worm of which gears with a worm-wheel 73 on a shaft carrying a disk 74. (Shown in plan in Fig. 11.) This disk carries on a pin or pivot a tooth-wheel 75, which engages with a stationary ring of internal teeth 76, on which it rolls when the disk 74 is rotated by the worm-shaft. The toothed wheel 75 is provided on its upper part with a disk 75′, having formed therein a number of holes arranged in a circle concentric with the axis of pin 74′ and equidistant from one another, Fig. 11. The ratio of diameters of the wheel 75 and of the internally-toothed ring 76 is such that a stop or pin 77 inserted in one of the aforesaid holes in disk 75′ will describe during the rolling of the wheel 75 an almost diametrical hypocycloid, as indicated in dotted lines in Fig. 11. A lever 79, Figs. 10, 11, and 12, mounted on a shaft 78, extends into this hypocycloidal path, and as soon as it is struck by the pin 77 it is moved toward the periphery of the disk 75′, mounted on the toothed wheel 75. This motion is transmitted in the form of rotary motion to a cylinder 80 on the shaft 78, in which cylinder is contained a spiral spring 80′, Fig. 12, against which bears a plunger 81, working in the cylinder and pivotally connected to a lever 82, on the axis of which is fixed a fork 83, that engages, by means of slide-blocks *i* attached thereto, in an annular groove in the movable half 68 of the claw-clutch 65 68. When now the lever 79 is turned by the pin 77 in the direction indicated by the arrow shown in Fig. 10, the lever 82 and the fork 83 are also turned, and the spring in the cylinder is compressed by the plunger 81, which is forced into the same. This compression continues until the axis of the cylinder has come into line with the center line of the lever 82—that is to say, until those two parts have reached their dead-center. If now the lever be further moved by the pin 78, so that the parts 82 and 81 are moved slightly beyond their dead-center, then the compressed spring in the cylinder comes into operation and turns the lever 82, with the fork 83, suddenly, so that the halves of the clutch are brought into engagement with each other and the worm-shaft 60 is thereby coupled to the partial worm on the driving-shaft 66. At the same time a finger 84, mounted on the axle of the lever 82, rotates with the lever and engages with its end in a hole in the arm 85 of a two-armed lever 85 86, so as to rotate this arm downward and draw at the same time the bolt 64 (engaging, by means of a pin, with the end of the arm 85) out of the wedge-shaped recess in the disk, so that now the worm 60, and by its means the spindle-table, can be rotated by the driving-shaft. The pitch of the worm 60 and the number of the teeth of the worm-wheel rim 61 are so chosen that a partial rotation of the table will have been completed after a determined whole number of revolutions of the worm. At this moment a stop 86*, Fig. 12, fixed to the table, strikes against the other elevated arm 86 of the lever 85 86 and moves this arm downward, so that the finger 84 is caused to move the lever 82, with the fork 83 and the bolt 64, back into their initial position, thus disengaging the clutch between the driving-shaft 66 and the worm-shaft. This last movement also serves to return the lever 79 back into the hypocycloidal path, where it remains until the pin 77 again moves the lever, and thus throws the clutch again into operation. By altering the intermediate wheels 70 and 71 and also by inserting several pins into the disk 75′ the length of the intervals or pauses may be regulated according to requirement.

Above the spindle-table 2 a number of tool-carriage or slide-rests 87 corresponding to the number of the rotary work-spindles are arranged on a drum 88, which is constructed at its periphery after the manner of a lathe-bed. These tool-rests are arranged to be movable on and removable from the drum. The drum 88 is keyed on the pillar 1 and is adapted to have vertical motion for the purpose of enabling the tool-rests to be moved farther away from or nearer to the work-spindles according to the height of the articles under treatment. This vertical adjustment of the drum is done by hand and enables the range of vertical movement of the tool-carriages to be set in proper relation to the work before the machine is started. Lathe-tools, tool-holders, screw-cutting apparatus, twist-drills, &c., may be employed as the tools. For the reception of the tools vertical tool-spindles 89 are employed having vertical motion in a long guide in the tool-slides 87. Each spindle 89 is balanced by a weight 90, which is heavier than the spindle, so that the spindle is raised until an adjustable stop-ring 91, mounted on the spindle, strikes against the tool-slide when no other force is acting upon the spindle. On one side of each of these spindles is fixed a rack 92, Fig. 1 and Fig. 4, which shows in one part a horizontal section on the line N O of Fig. 1, which prevents the spindle from rotating. With this rack 92 gears a pinion 93, which is rotated at the proper time and is arranged to cause the spindle to move down. On the opposite side of each spindle there is mounted in a long guide fixed on the slide-rest a horizontal shaft 94, Fig. 4, on one end of which is a driving toothed wheel 95 to receive a rotation and on the other end a short driven pinion 96, which rolls on a tooth-segment 97, bolted to the drum 88, Figs. 1 and 4, which shows in the part V W the under side view of the segment, and is thus capable of imparting horizontal motion to its slide-rest. As soon as this driving force ceases and after the worm 104 has been thrown out of gear the tool-rest is drawn by a weight 98 back again into its original position. For the purpose of imparting motion to the tool-carrying spindles there is mounted in the center of the machine a vertical shaft 99, which is driven at its lower part from the main shaft *j* by means of bevel-wheels *k* and *l*. The shaft 99 carries at its upper part a worm 100, Figs. 1 and 4, driving worm-wheels 101, corresponding in number to the tool-rests, Fig. 1 and Fig. 4, which shows in one part a horizontal section on the line J K of Fig. 1. Each of these worm-wheels 101 transmits its motion through a set of gearing 102 to a shaft 103, mounted on the side of the tool-rest, Fig. 3. This shaft transmits rotary motion to a worm-shaft 104, arranged above the tool-rest and having bearing in one arm of a lever 105, mounted on the tool-slide.

The other arm of this lever is connected to a downwardly-extending rod 106. The worm-shaft 104 is adapted to be swung into engagement with a ring of teeth 107, Figs. 1 and 3, on a drum 109, adapted to rotate on a pin 108, fixed to the tool-slide 87. A tension-spring 110, Fig. 3, connected at one end to the tool-slide and at the other end to the lever 105, has a constant tendency to move the worm-wheel 104 out of the engagement with worm-ring 107. For the purpose of throwing the worm 104 in and out of gear with the ring of teeth 107 the lower end of the rod 106 is connected to one arm of the bell-crank 111, mounted on the tool-slide 87, and the other arm of which is adapted to bear against the head of the rod 36, Fig. 1. This head *h* is cam-shaped and so formed that when the arm of the bell-crank slides along the edge of the head during the rotation of the spindle-table the bell-crank will be moved outward, so as to raise the rod 106, (while pulling out the springs 110,) and thus move the worm 104 into engagement with the ring of teeth 107. By the upward movement of the rod 106 a nose 125, Fig. 3, mounted thereon, is moved above one arm of a lever 126, which is mounted on the tool-slide 87 and is acted upon by a tension-spring. This lever prevents the rod 106 from moving back. For the purpose of throwing the worm 104 out of gear with the ring of teeth 107, formed on the drum 109, there is provided on the said drum a movable pin 127, which is caused by the rotation of the drum to rotate the lever 126 against the tension of its spring and from under the nose 125 on the rod 106, whereby the rod 106 will be moved down, and thus throw out of operation the driving mechanism of the drum. The lever 126 is shown in elevation in Figs. 1 and 3 and in plan in Fig. 4 in the part thereof which is a section on the line P Q of Fig. 1. In each drum, Figs. 1 and 3, there are two diametrically opposite non-rotatable but axially-movable pins 112 and 112′, each of which has loosely mounted thereon a pair of gear-wheels 113 114 and 113′ 114*, respectively. The gear-wheels 114 and 114* are provided on both sides of their hubs with clutch-teeth into which engage the wheels 113 and 113′, which are similarly toothed on their hubs, when these wheels are pressed by the pins 112 against the wheel 114 and 114*, respectively, which are prevented from moving axially. On the same pin there is keyed behind each of the wheels 114 and 114* a disk 115, which is also provided with clutch-teeth on its hub on the side facing the toothed wheels 114 and 114*, respectively, and which can be brought into engagement with its corresponding toothed wheel 114 or 114*, respectively. The toothed wheels 113 are in constant engagement with a common toothed wheel 116, which is keyed on the pin 108, and they roll on this toothed wheel when the drum 109 rotates. The toothed wheel 114 gears with a toothed wheel 117, which is fixed on a sleeve 108*, capable of rotating on the pin 108, and on the other end of this sleeve there is mounted a toothed wheel 118, (see Fig. 3 and that portion of Fig. 4 which shows a horizontal section on the line L M of Fig. 1,) which gears with the toothed wheel 121 and transmits rotary motion by this means to the pinion 93—that is to say, causes the tool to move down. The small wheel 114* engages with the toothed wheel 119, which is fixed on the hub of a toothed wheel 120, that is mounted so as to rotate loosely on the last-mentioned sleeve 108*. The toothed wheel 120 gears with a toothed wheel 95, Fig. 4, mounted on the axle 94, and it transmits rotary motion to the pinion 96, which rolls on the toothed segment 97, and thus moves the tool-slide in a horizontal direction. When the wheels 114 and 114* are coupled to their wheels 113 113′, they can rotate on their pins, and they roll on the wheels 117 and 119 during the rotation of the drum without rotating these wheels 117 and 119—that is to say, without causing any movement of the tool. When, however, the wheels 114 and 114* are in engagement with the clutch-halves of the disk 115, fixed on the pins 112, these wheels are prevented from rotating and are caused by the rotation of the drum to carry the wheels 117 and 119 round with them and by this means to transmit rotary motion to the pinions 118 and 120. Pinion 118 drives 121, which in turn rotates pinion 93 on the same shaft to move the rack 92 and feed the tool down to its work, while pinion 120 drives 95, that carries on its shaft pinion 96, gearing with rack 97 on drum 88 to move the tool-carriage, and consequently the tool, laterally. The wheels 114 and 114* are thrown in and out of gear by shifting the pins 112, one of which effects the vertical movement of the spindle and the other produces a horizontal movement of the tool-slide. These pins are each constantly pressed by a spiral spring, located in a recess in the drum 109, against a controlling-disk 122, mounted on the pin 108. This disk is provided with two adjustable controlling-cam-rings 123 and 124, of which the ring 124 controls the pin for the vertical motion and the ring 123 controls the pin for the horizontal motion of the tool-slide. Both rings are capable of adjustment quite independently of each other, and they allow of throwing the vertical motion and the horizontal motion in and out of engagement, as desired, either separately or together. The feeding mechanism is designed to give the tool the necessary feed in its work. As soon as this feed has been given the toothed ring 107 of the drum 109 is brought out of engagement with the driving-worm 104, and by means of the weights 98 and 90 the spindle 89, as also the tool-slide, are moved back into the initial position. The herein-described coupling of the wheel 114 and 114* is designed to prevent this return movement until the whole of the machining has been completed. The total feed of the tool is produced in a single revolution of the drum 109.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is—

1. In a self-acting multispindle-machine, the combination of a number of work-spindles and a rotary frame; of a corresponding number of tool slides or carriages arranged around the axis of the rotary frame, with means to operate each tool separately and independently of the other tools, said means including means for giving the tool a longitudinal feed and means for giving it a transverse feed, controlling means for such feeds adapted to permit the longitudinal feed, the transverse feed or both feeds together relative to the article under treatment.

2. In a self-acting multispindle-machine, the combination of a number of work-spindles and a rotary frame; of a corresponding number of tool slides or carriages arranged around the axis of the rotary frame, with means to operate each tool separately and independently of the other tools, said means including means for giving the tool a longitudinal feed and means for giving it a transverse feed, controlling means for such feeds adapted to permit the longitudinal feed, the transverse feed or both feeds together relative to the article under treatment, means for returning the tool into its initial position after completing its allotted partial machining of the article situated opposite to it.

3. In a self-acting multispindle-machine, the combination of a number of work-spindles and a rotary frame; of a corresponding number of tool slides or carriages arranged around the axis of the rotary frame, with means to operate each tool separately and independently of the other tool, said means including means for giving the tool a longitudinal feed and means for giving it a transverse feed, controlling means for such feeds adapted to permit the longitudinal feed, the transverse feed or both feeds together relative to the article under treatment, means for returning the tool into its initial position after completing its allotted partial machining of the article situated opposite to it, means to rotate the rotary frame relatively to the tools at any desired variable intervals of time, and means adapted to permit said rotation to be utilized for bringing the feed movement of the tools in operation.

4. In a self-acting multispindle-machine, a rotary frame and a number of rotary work-spindles mounted in a circle at equal distances apart in said frame, in combination with a corresponding number of tool slides or carriages arranged around the axis of the rotary frame, with means to operate each tool separately and independently of the other tools, said means including means to give the tool a longitudinal feed and means to give it a transverse feed, controlling means for such feeds adapted to permit the longitudinal feed, the transverse feed or both feeds together relative to the article under treatment, means to return the tool into its initial position after completing its allotted partial machining of the article situated opposite to it, means to set the said tool-feeding mechanisms into operation, and means on the frame coacting therewith; a separate mechanism situated outside of the machine and provided with its own driving power for rotating the rotary frame relatively to the tools at any desired variable intervals of time.

5. In a self-acting multispindle-machine, a rotary frame, a number of work-spindles mounted in a circle at equal distances apart in said frame, and a corresponding number of independent tool slides or carriages arranged around the axis of the rotary frame, means to rotate the work-spindles and move each of these spindles in the direction of its length separately and independently of the other work-spindles, and means for reversing the direction of movement of the work-spindles at desired intervals of time.

6. In a self-acting multispindle-machine, a rotary frame and a number of work-spindles mounted therein, in combination with a corresponding number of tool slides or carriages arranged around the axis of the frame, means to yieldingly hold each slide in normal position, means to laterally traverse the slides and against the action of their holding means, a tool-holder in each slide, means to normally hold each tool-holder in raised position, and means to feed each tool-holder toward the work-spindles and against the action of their holding means.

7. In a self-acting multispindle-machine, a rotary frame and a number of work-spindles mounted therein, in combination with a number of tool slides or carriages arranged around the axis of the frame a weight to yieldingly hold each tool-slide in normal position, means to traverse the slides and against the action of the weight, a tool-holder in each slide, a weight to hold each holder away from the work-spindles, and means to feed each tool-holder toward the work-spindles against the action of its respective weight.

8. In a self-acting multispindle-machine, a rotary frame and a number of work-spindles mounted therein, in combination with a number of tool slides or carriages arranged around the axis of the frame, means to yieldingly hold each slide in normal position, mechanism to traverse each slide, a tool-holder, means to normally hold each tool-holder away from the work, mechanism to feed each tool-

holder to the work against the action of its holding means, means for setting said mechanisms into operation and means on the frame coacting therewith.

9. In a self-acting multispindle-machine, a rotary frame and a number of work-spindles mounted therein, in combination with a number of tool slides or carriages arranged around the axis of the machine, means on each carriage to traverse the slide, a tool-holder in each slide, means on each carriage to feed the tool-holder, cams on each carriage to control the operation of both of said means, mechanism to drive said means, a device on the table to set said mechanism in operation, and a central driving device common to all of the carriages.

10. In a metal-working machine, a work-spindle, in combination with a tool slide or carriage, said tool-slide containing a spindle, a controlling-cam and a gear-wheel fixed on the spindle, a drum revoluble on the spindle having an external-toothed ring, two slidable pins mounted in the drum and planet-gears having clutch-faces on the pins and a gear-train clutched and operated by each planet-gear, one of said trains capable of traversing the carriage and the other of feeding the tool, said pins operated by the cam, and mechanism to rotate the drum.

11. In a self-acting multispindle-machine, a rotary frame and a number of work-spindles mounted therein, in combination with a number of tool slides or carriages arranged around the axis of the frame, means to yieldingly hold each tool-carriage in normal position, a spindle fixed to the carriage, a controlling-cam and a gear-wheel fixed on the spindle, a tool-holder in each carriage, means to yieldingly hold it away from its work, a drum having an external worm-ring, two slidable pins mounted in the drum, a planet-gear having a clutch-face on each pin and meshing with the gear on the spindle, a gear-train clutched and driven by each planet-gear, one of said trains of gear to traverse the carriage and the other to feed the tool-holder, a continuously-driven worm on each carriage means to move the worm into engagement with the drum by the movement of the rotary frame and a stop on the drum to throw said worm out of engagement to permit the carriage and tool-holder to return to normal position.

12. In a multispindle-machine, a pillar, a rotary frame and a friction-ring mounted thereon, a number of work-spindles mounted in the frame, means to drive the friction-ring, means driven by the friction-ring to operate the work-spindles, a corresponding number of tool-slides mounted around the pillar above the frame, with mechanisms for operating each tool separately and independently of the other tools, each of said mechanisms including means for giving the tool a longitudinal feed and means for giving it a transverse feed, controlling means for said feeds and a driven element common to all of said mechanisms to drive them.

13. In a self-acting multispindle-machine, a number of work-spindles mounted in a circle at equal distances apart in a rotary frame common to all of them and a corresponding number of independent tool slides or carriages arranged around the axis of the rotary frame, means to rotate the work-spindles and move each of these spindles in the direction of its length separately and independently of the other work-spindles, said means including a friction-drive with driving friction-cylinder, friction-bowls all driven by the friction-cylinder and a worm driving-gear for each work-spindle, the worm-shaft of these gears being freely movable in the direction of its length and adapted to utilize the thrust of the worm-wheel in the direction of the length of the worm-shaft to press the friction-bowls against the driving friction-cylinder with a force which increases with the thrust of the worm-wheel.

14. In a self-acting multispindle-machine, a central pillar, a drum 88 adjustable along the pillar, a number of tool slides or carriages mounted on the drum, with means to operate each tool separately and independently of the other tools, said means including means for giving the tool a longitudinal feed, means for giving it transverse feed, and controlling means for such feeds adapted to permit the longitudinal feed, the transverse feed or both feeds together relative to the article under treatment, and driving mechanism common to all the means to operate the tools, substantially as described.

15. In a multispindle-machine, a pillar, a rotary frame and a driven friction-ring mounted thereon, a number of work-spindles mounted in the frame, a number of tool-slides mounted around the pillar, a gear-wheel mounted on each spindle, separate means to rotate each gear-wheel driven from said ring, a mechanism to feed each spindle toward its tool driven from said spindle, and means on the frame for intermittently engaging said mechanism to set the same in operation.

16. In a self-acting multispindle-machine, a rotary frame, a number of work-spindles mounted in a circle at equal distances apart in said frame, a corresponding number of independent tool slides or carriages arranged around the axis of the rotary frame, means to rotate the work-spindles, a driven friction-ring having oppositely-situated friction-surfaces, friction-bowls and a worm driving-gear for each work-spindle driven by a bowl, the worm-shaft of the gears being freely movable in the direction of its length to contact the driving-bowl with either one of said surfaces, and a mechanism to move each worm-shaft

in the direction of the axis to reverse the direction of rotation of the work-spindle at desired intervals of time.

17. In a self-acting multispindle-machine, a number of tool carriages or slides arranged around the axis of the machine, means to operate each tool separately and independently of the other tools, said means including means to give the tool a longitudinal feed and means to give it a transverse feed, controlling means for such feeds adapted to permit the longitudinal feed, the transverse feed or both feeds together relative to the article under treatment, a rotary frame, a number of work-holding spindles mounted in said frame, mechanism to rotate said spindles, means to feed the spindles to and from the tools.

18. In a self-acting multispindle-machine, a rotary frame, a number of tool-slides mounted around the axis of the frame, means to operate each tool separately and independently of the other tools and a device on the frame to set the same in operation, said means including means to give the tool a longitudinal feed, and means to give it a transverse feed, controlling means for both of said feeds adapted to permit the longitudinal feed, the transverse feed or both feeds together relative to the article under treatment, a number of work-holding spindles in the frame, means to separately and independently rotate said spindles, mechanism to feed said spindles to and from the tools and means to set said mechanism into operation.

19. In a self-acting multispindle-machine, a rotary frame, a number of tool-slides mounted around the axis of the frame, means to operate each tool separately and independently of the other tools and a device on the frame to set the same in operation, said means including means to give the tool a longitudinal feed, and means to give it a transverse feed, controlling means for both of said feeds adapted to permit the longitudinal feed, the transverse feed or both feeds together relative to the article under treatment, a number of work-holding spindles in the frame, means to separately and independently rotate said spindles, means set in operation by the rotation of the frame to feed said spindles to and from the tools, and mechanism operated by the means to feed each spindle to control its feed independently of the feed of the other spindles.

20. In a self-acting multispindle-machine, a rotary frame, a number of tool-slides mounted around the axis of the frame, means to operate each tool separately and independently of the other tools and a device on the frame to set the same in operation, work-spindles mounted in the frame, a driven friction-ring having two friction-surfaces, a worm, worm-shaft and bowl capable of longitudinal movement, whereby said bowl can engage either of the friction-surfaces, mechanism driven by the worm to rotate the spindles, a loose gear-wheel having a clutch-face driven from its adjacent work-spindle, planet-gearing, a clutch actuated by the rotation of the frame to connect said planet-gearing to the loose gear-wheel, mechanism operated by the planet-gearing to move the worm-shaft and reverse the rotation of the spindle and means to control the number of reversals of rotation of each spindle.

21. In a self-acting multispindle-machine, a rotary frame, a number of tool-slides mounted around the axis of the frame, a number of work-holding spindles in the frame, means to operate each tool separately and independently of the other tools and a device on the frame to set said means in operation, a driven friction-ring having two oppositely-situated inclined friction-surfaces, a worm, a worm-shaft and a bowl on the shaft, a gear-wheel and a long pinion on each spindle, said gear-wheel driven from the worm, a shaft 31 mounted within the frame for each spindle, a loose gear having a clutch-face and a pinion thereon, a disk on shaft 31, a planet-wheel thereon, means to connect the loose gear and disk, a fixed pinion with which said planet-wheel gears, a rod to move the worm-shaft, a lever thereon, means on the planet-wheel to transmit movement to the lever to oscillate the rod, a notched element on the rod and a ratchet-wheel operated by the lever and in slidable engagement with the notched element to disconnect the loose gear.

22. The combination with a central pillar, of a rotary frame thereon, a ring having oppositely-situated friction-surfaces thereon, work-spindles in the frame, mechanism frictionally driven from the ring to rotate and axially move each spindle, controlling means to permit the axial movement of each spindle independently of the others and to determine the number of axial movements thereof to be driven by either one or the other of the friction-surfaces, a drum on the pillar, as many tool-carriages as there are spindles mounted on the drum, means to operate each tool separately and independently of the other tools, means common to all of the tool-operating means to drive the latter, and means on the frame to set said tool-operating means, and the mechanism to rotate the spindles in operation.

23. In a self-acting multispindle-machine, a rotary frame, a peripheral worm-ring thereon, a worm to drive the worm-ring, a continuously-driven shaft in alinement with the worm, a fixed internal-toothed ring, a pinion gearing therewith having an adjustable pin mounted therein, change-gears driven from the shaft to drive the pinion, lever mechanism in the path of said pin to throw the clutch into engagement to operate the worm and means on the frame to throw the clutch out of engagement.

24. In a multispindle-machine, the combi nation with a pillar, a frame and a driven friction-ring thereon, said ring having oppositely-positioned friction-surfaces; of a work-holding spindle mounted in the frame, a pinion thereon, a worm, worm-shaft and friction-bowl mounted on the frame and longitudinally movable to cause said bowl to contact with either of the friction-surfaces on the ring, gearing connecting the pinion and worm and means to axially move the worm, worm-shaft and bowl at desired intervals of time to change the direction of rotation of the spindle, substantially as set forth.

25. In a multispindle-machine, the combination with a pillar, a rotary frame thereon, a work-holding spindle mounted in the frame and mechanism to rotate the spindle; of mechanism driven by the spindle and means on the frame to set the mechanism in operation when the frame rotates to feed the work-holding spindle longitudinally.

26. In a multispindle-machine, the combination with a pillar, a rotary frame, indexing mechanism therefor, a work-holding spindle mounted in the frame to have both longitudinal and rotary motion, and a continuously-driven friction-ring on the pillar below the frame having oppositely-situated friction-surfaces; of a pinion through which the spindle can slide but not rotate, a long pinion fixed on the spindle, a worm, worm-shaft and bowl on the worm-shaft, gearing connecting said first-named pinion and worm to rotate the spindle, an idle clutch-wheel driven by the long pinion, mechanism clutched into gear with the idle wheel to feed the work-holding spindle in a longitudinal direction, including means to automatically reverse the feed of the spindle, and means to control the number of reversals both of the feed and the rotation of the spindle, substantially as described.

27. In a multispindle-machine, the combination with a pillar, a rotary frame, indexing mechanism therefor, a work-holding spindle mounted to rotate and longitudinally move in the frame, a screw on the spindle and a rotatable nut on the screw; of a worm, worm-shaft and bowl on the worm-shaft, a two-part rod capable of oscillation connected to the worm-shaft, the upper part of said rod longitudinally movable, gearing connecting the spindle and worm, a vertical shaft mounted in the frame, an idle clutch gear-wheel driven from the spindle, planet-gearing, a fixed element on the pillar, a lever to depress the upper part of said two-part rod and operated from the fixed element during the indexing of the frame, planet-gearing mounted on the vertical shaft to oscillate the rod, a clutch member between it and the idle gear-wheel, operated by the upper part of said rod, gearing connecting the vertical shaft and rotatable nut, and means on the rod actuated from the planet-gearing to control the number of oscillations of the rod and thereby the number of reversals of the spindle, substantially as and for the purposes set forth.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ERNST WIDMER-ABEGG.

Witnesses:
MORITZ VEITH,
A. LIEBERKNECHT.