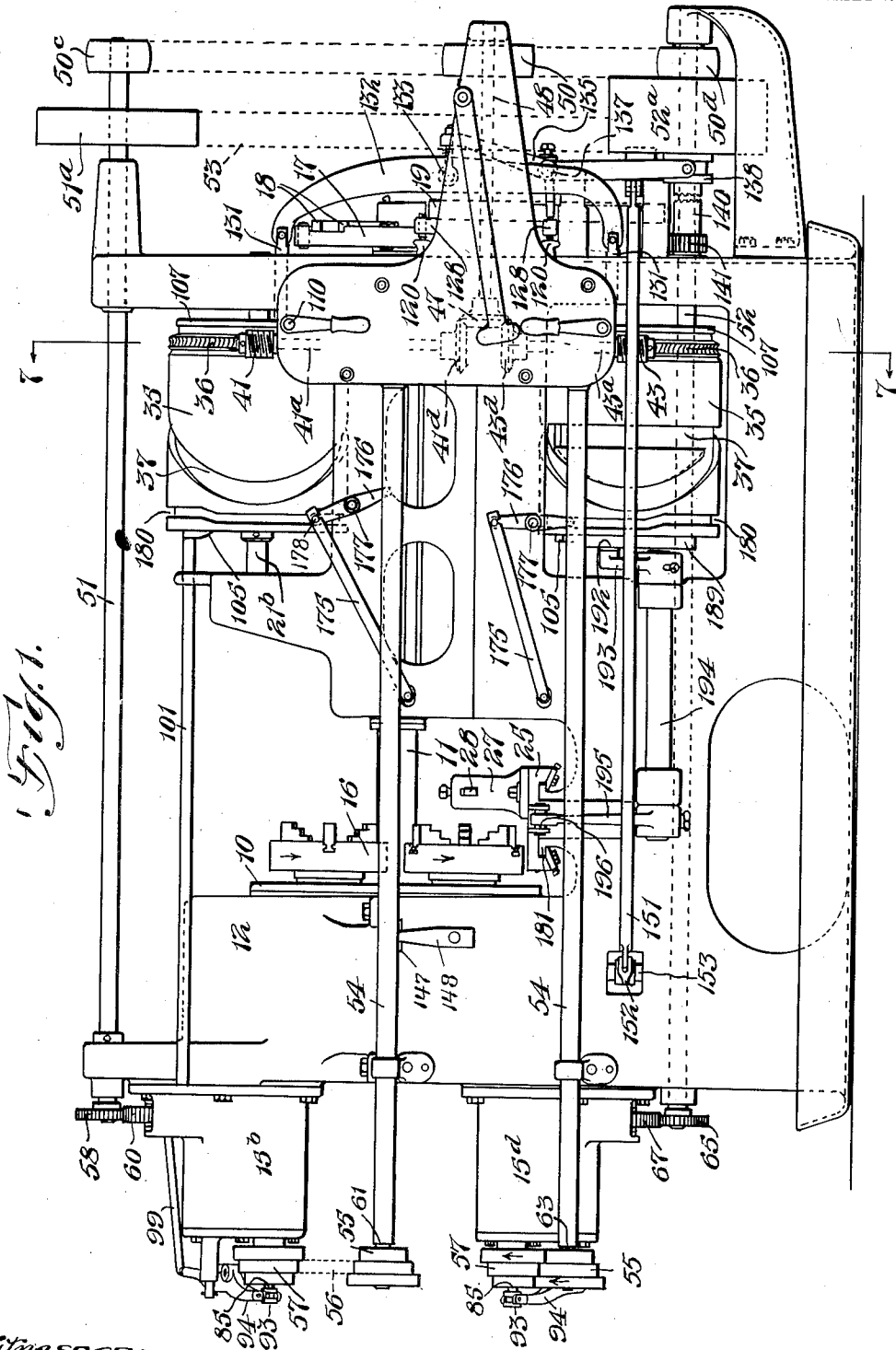


J. HARTNESS.
METAL WORKING MACHINE.
APPLICATION FILED AUG. 17, 1911.

1,063,681.

Patented June 3, 1913.

11 SHEETS—SHEET 1.

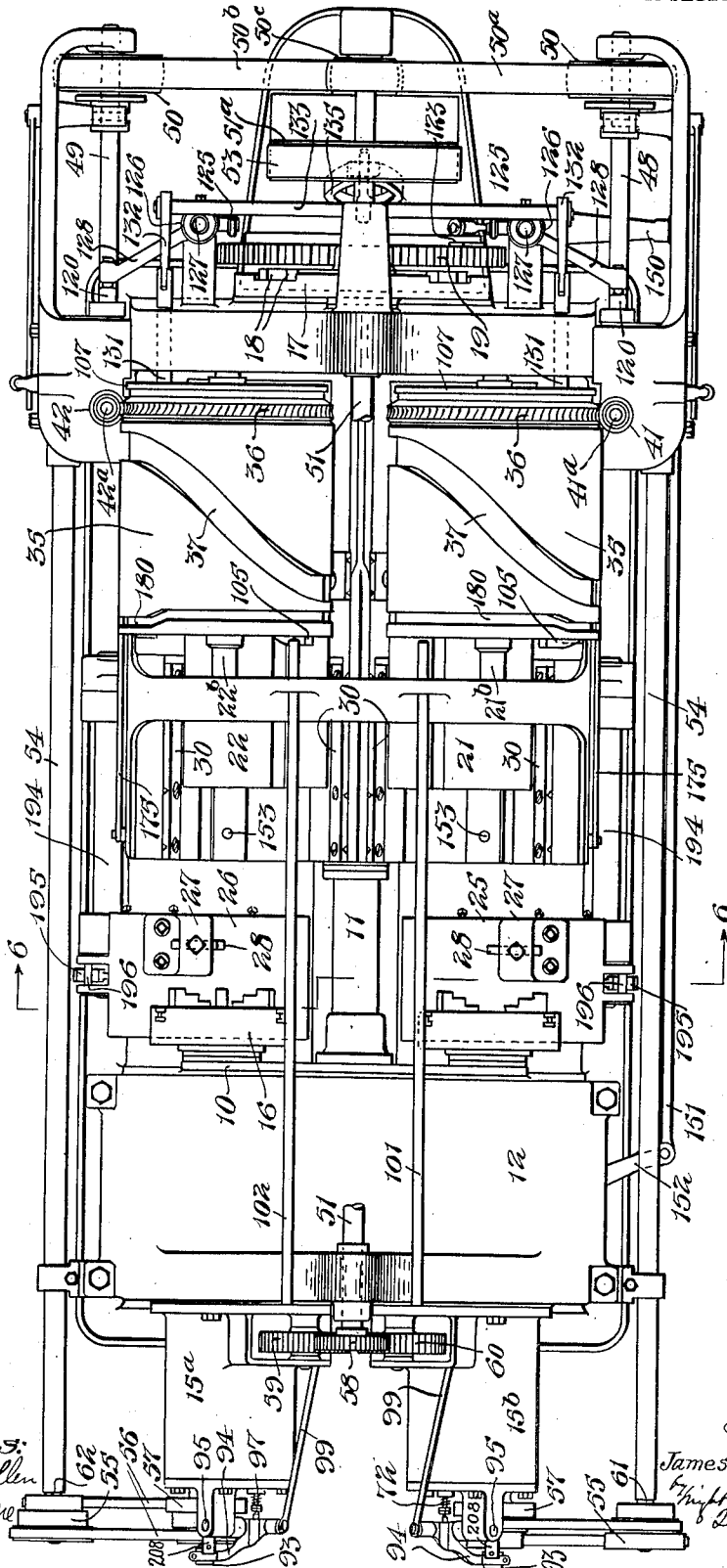


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11 SHEETS—SHEET 2.



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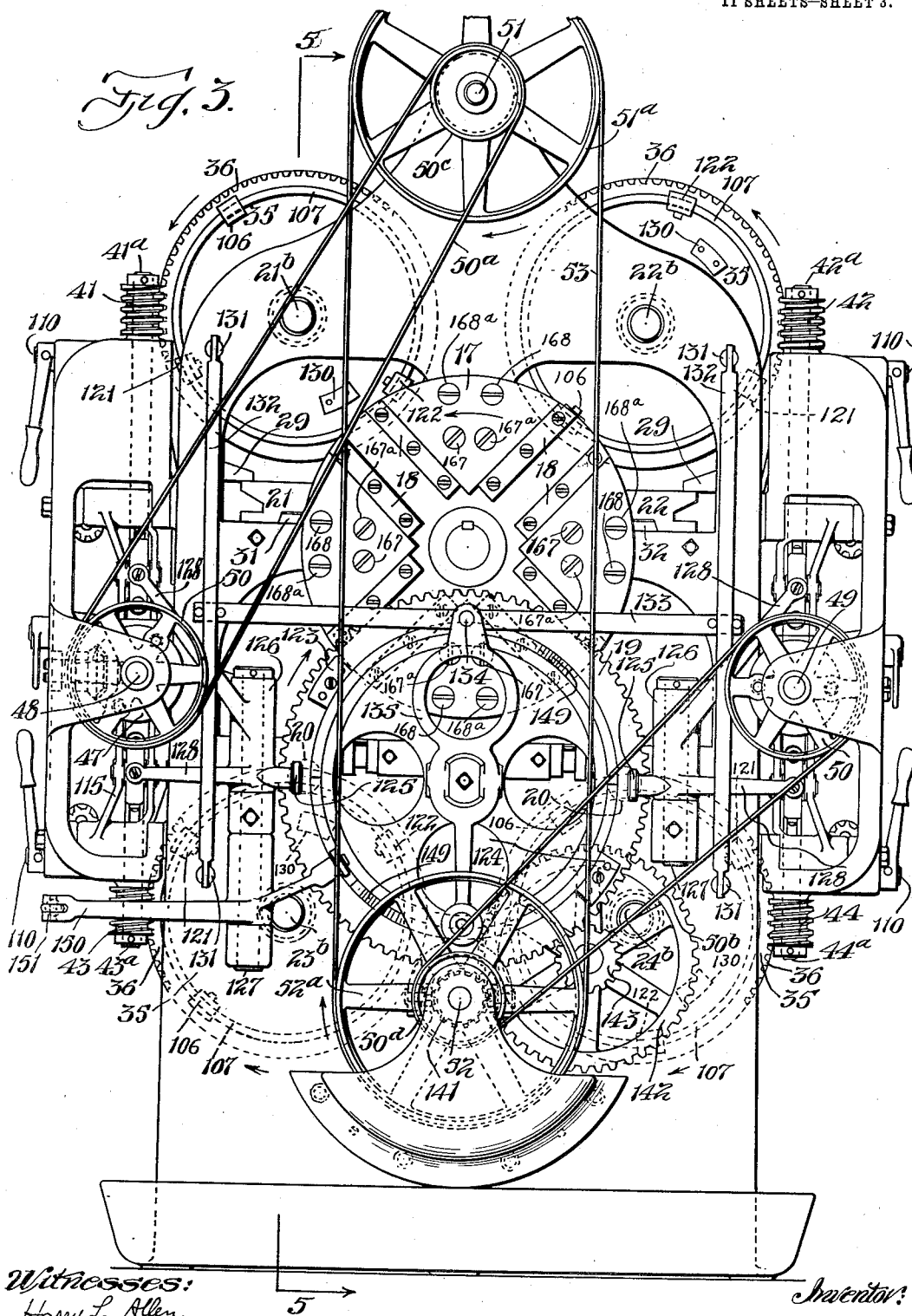
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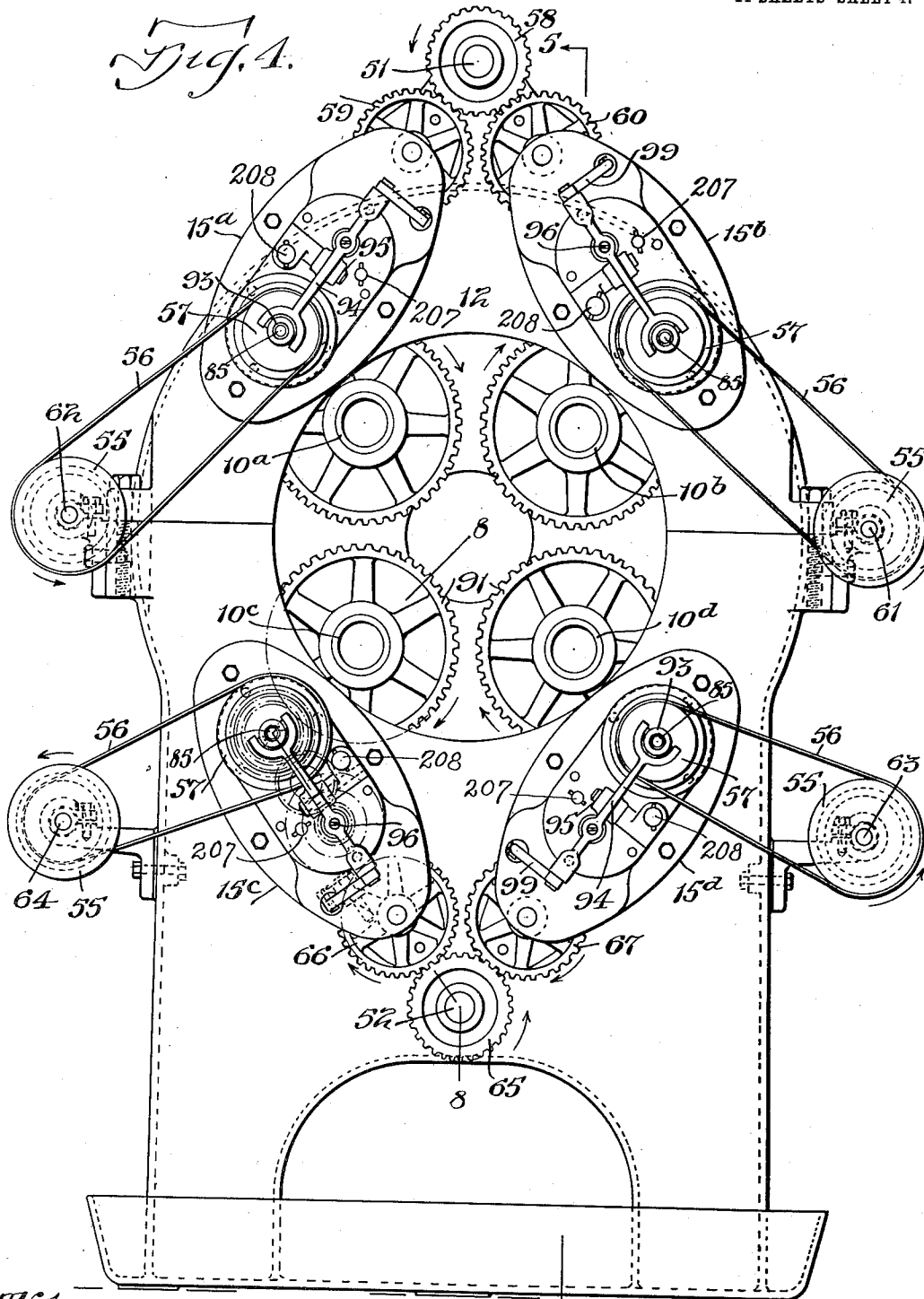
11 SHEETS—SHEET 3.



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11 SHEETS—SHEET 4.



Witnesses:
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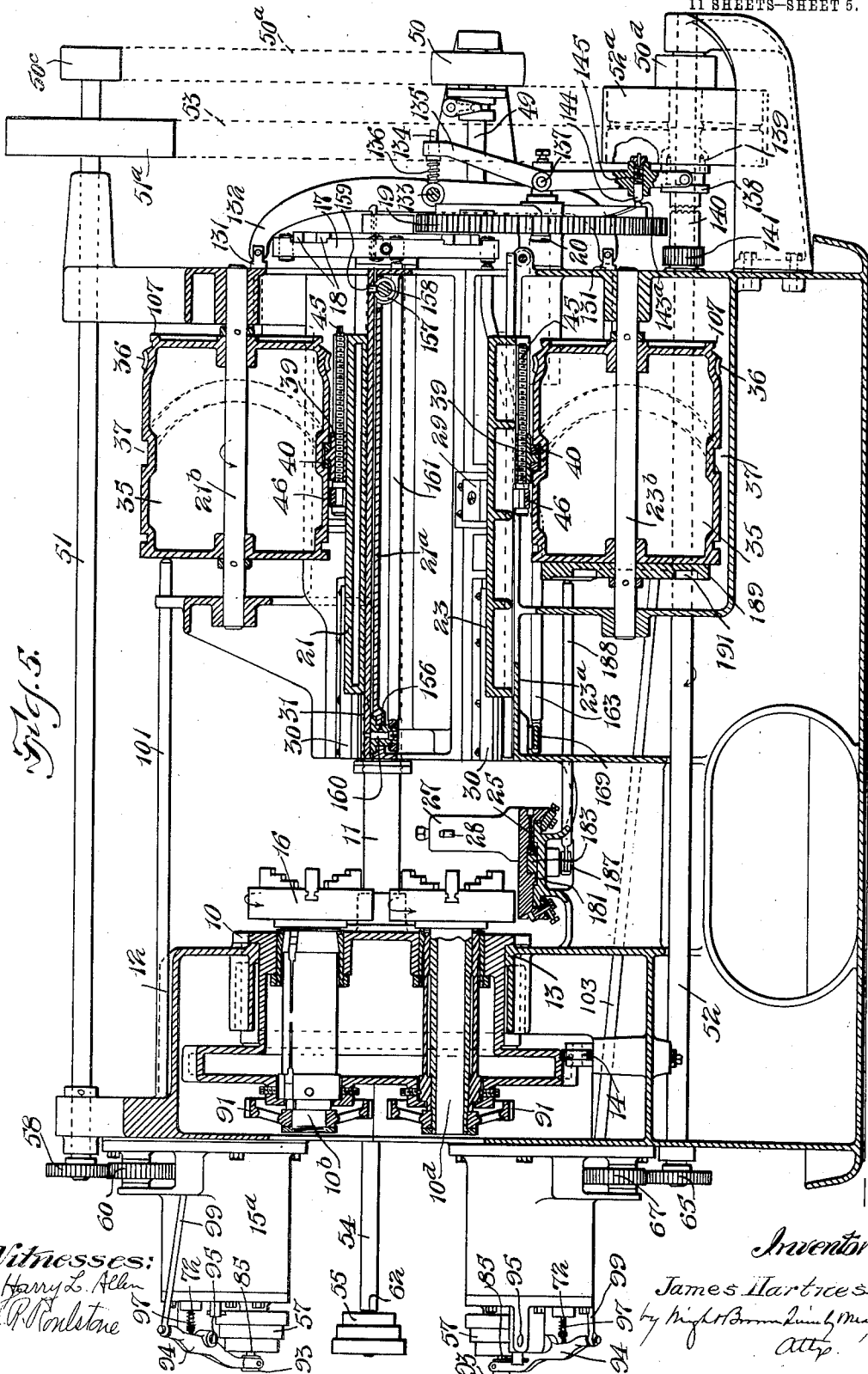
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11 SHEETS—SHEET 5.



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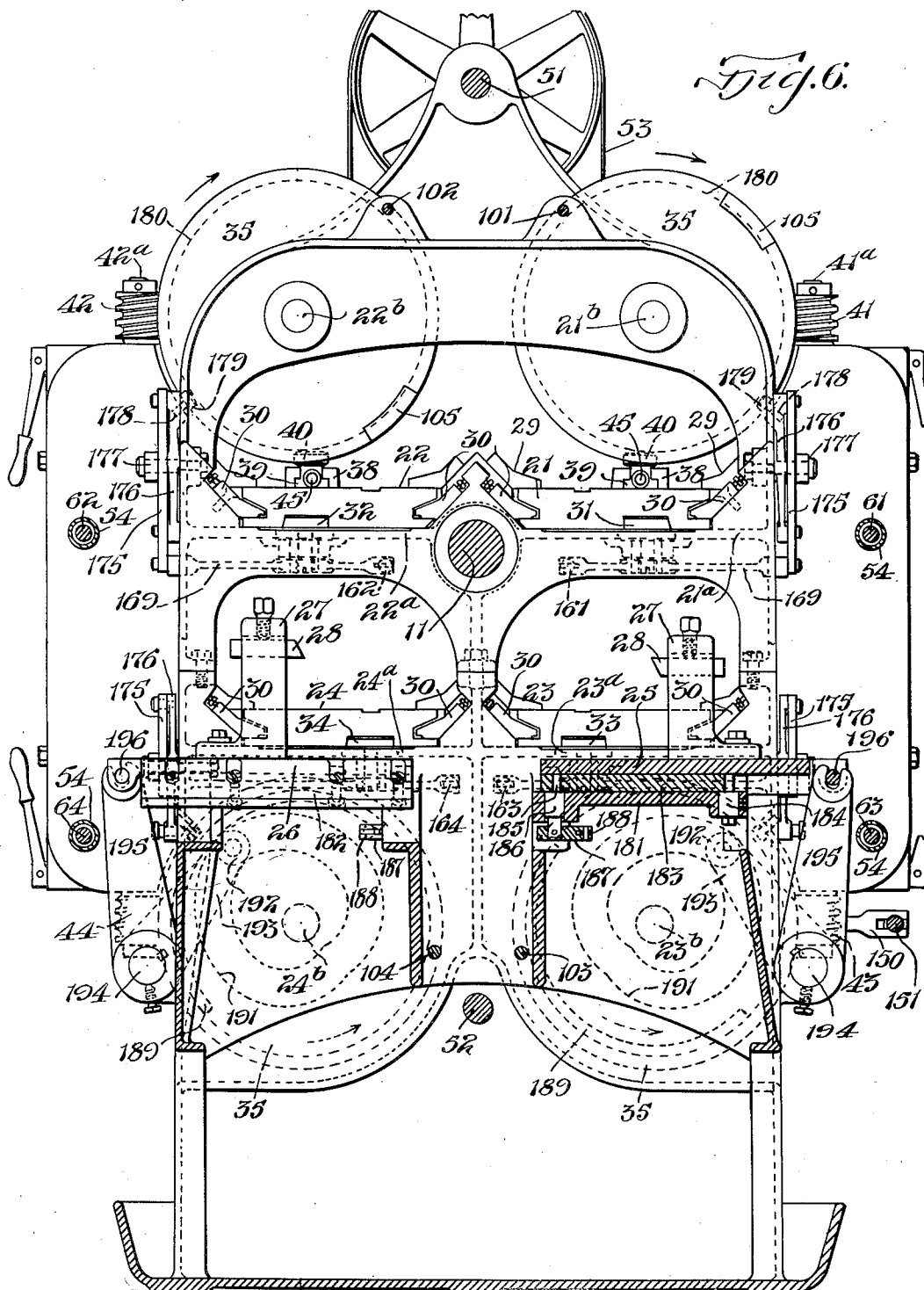
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11 SHEETS—SHEET 6.



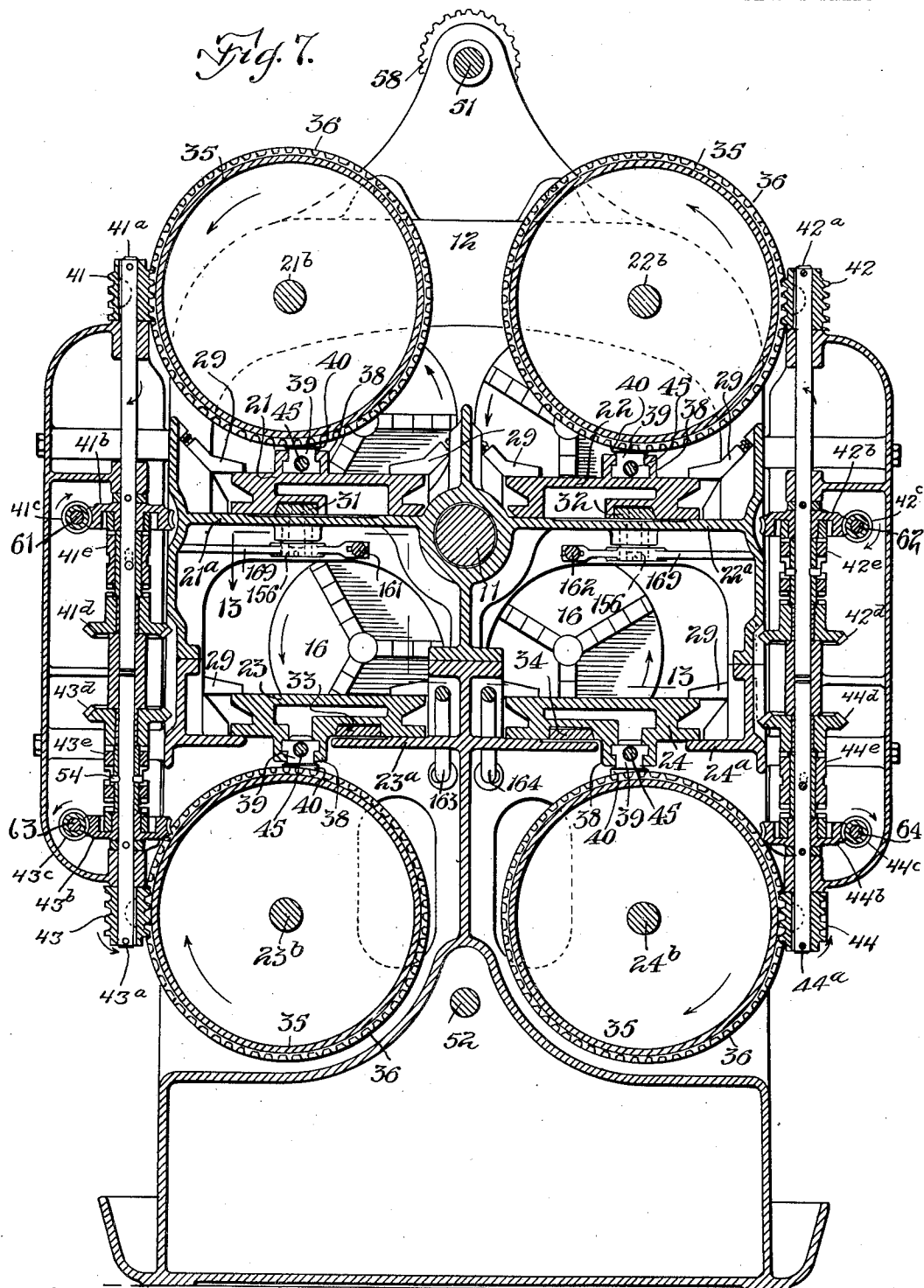
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1,063,681.

Patented June 3, 1913.

11 SHEETS—SHEET 7.



Witnesses:

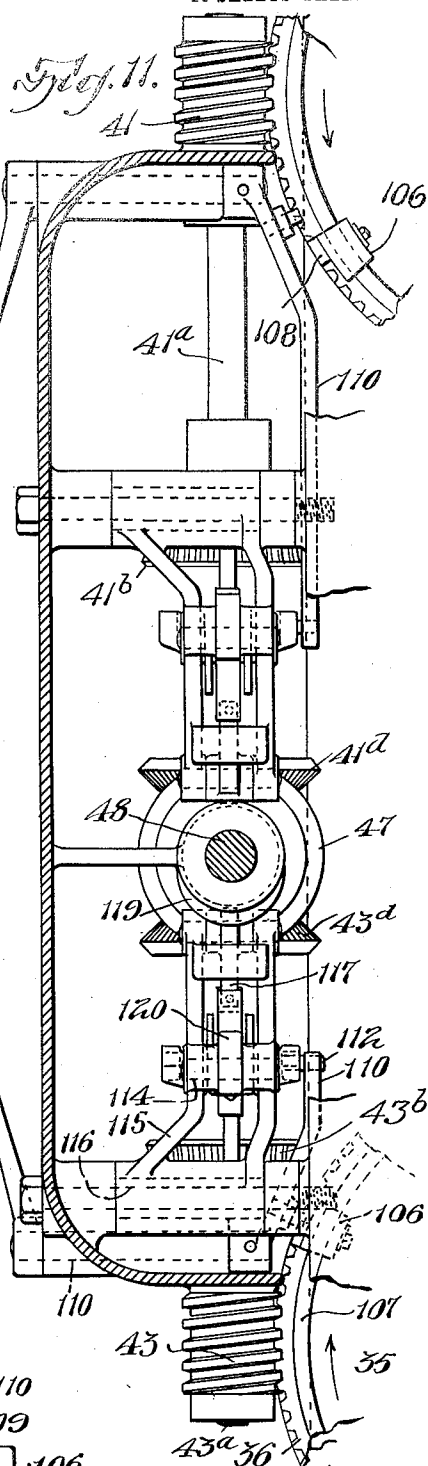
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1,063,681.

11 SHEETS—SHEET 9.



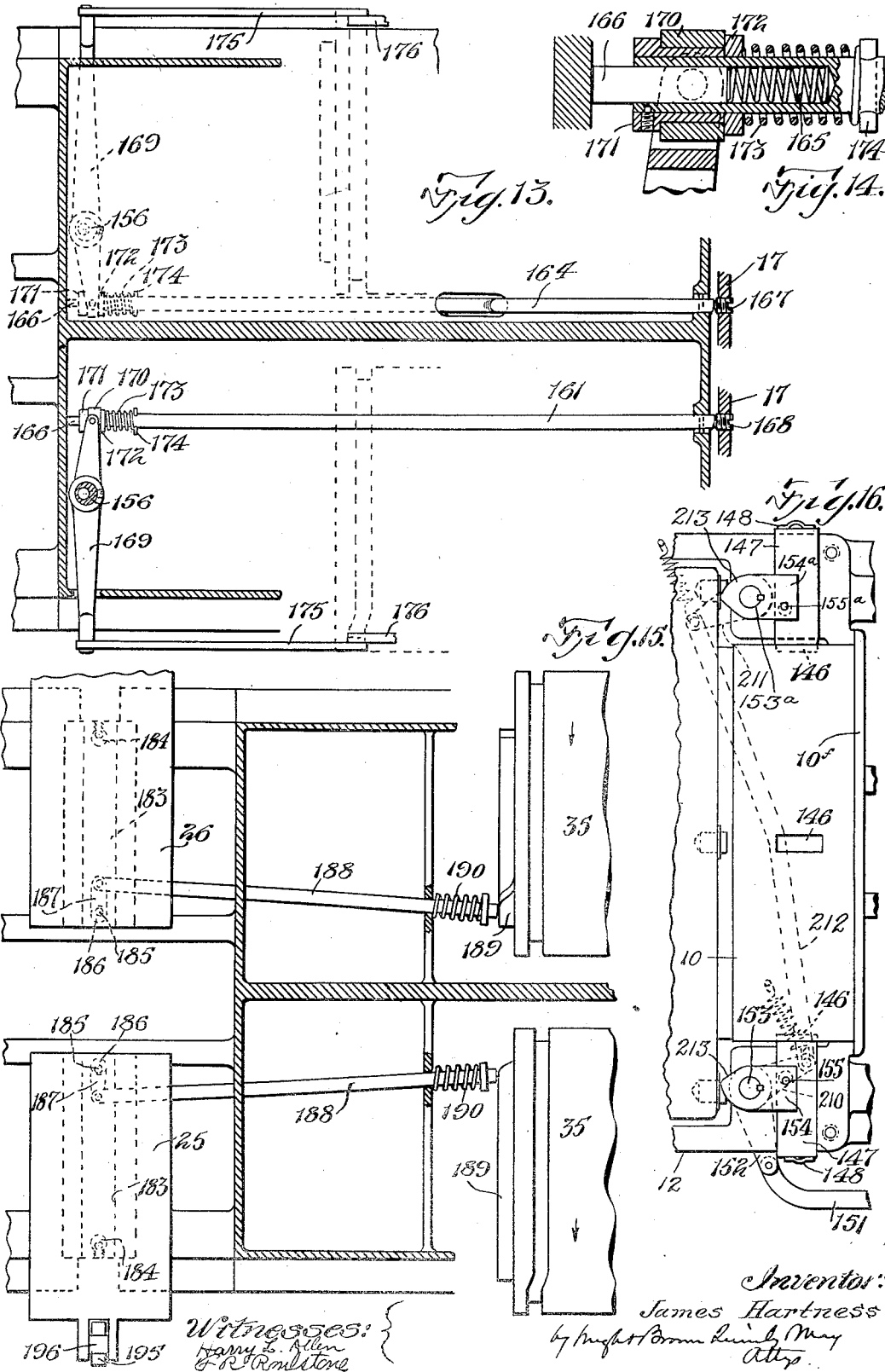
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J. HARTNESS.
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APPLICATION FILED AUG. 17, 1911.

1,063,681.

Patented June 3, 1913.

11 SHEETS—SHEET 10.

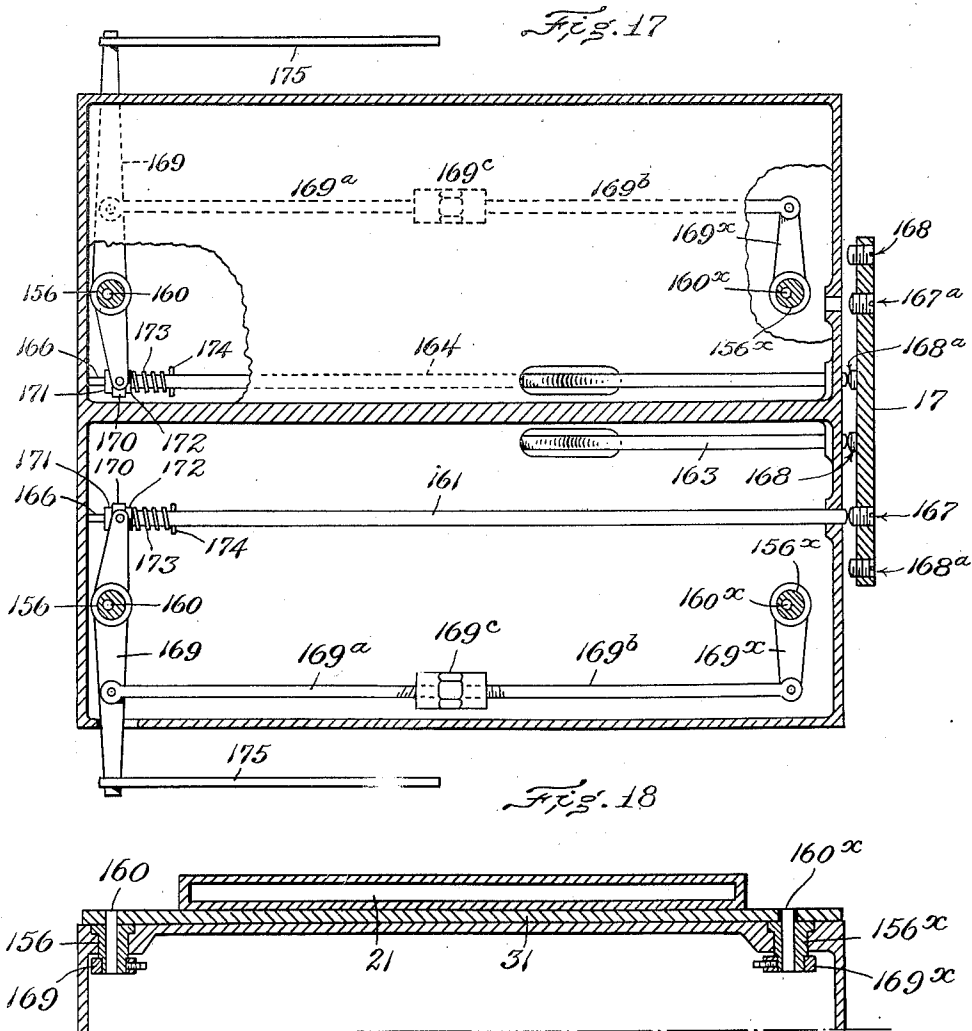


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11 SHEETS—SHEET 11.



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UNITED STATES PATENT OFFICE.

JAMES HARTNESS, OF SPRINGFIELD, VERMONT.

METAL-WORKING MACHINE.

1,063,681.

Specification of Letters Patent.

Patented June 3, 1913.

Application filed August 17, 1911. Serial No. 644,591.

To all whom it may concern:

Be it known that I, JAMES HARTNESS, of Springfield, in the county of Windsor and State of Vermont, have invented certain new and useful Improvements in Metal-Working Machines, of which the following is a specification.

This invention relates to metal-working machines, and especially to the multi-spindle type.

A machine of the same general character as that embodying the present invention forms the subject-matter of U. S. Letters Patent No. 912,676, granted February 16, 1909.

Like the invention set forth in said patent, one of the objects of the present invention is to secure the accurate registration of the successive work spindles with the several operating tools, for unless this is accomplished preparatory to the operation of the tools, the work will not be accurate when finished.

Another object of the invention is to secure an accessibility of the various operating parts, such for example as the slides which carry the tools, to permit the replacing of the tools with despatch.

In addition to the two principal features above named, the present invention has for its object to provide various other features of improvement which are hereinafter described and claimed and which are illustrated upon the accompanying drawings.

The general features which are common to the machine of the aforesaid patent and to the machine of the present invention are, first, a number of work spindles disposed about a common axis about which they are moved step by step in one direction, second, a number of tool holders likewise disposed about said common axis and operated so that the tools carried thereby may operate simultaneously upon the several pieces of work, and, third, automatic means for determining operative relation between each work spindle and each tool slide independently of the relation between the other work spindles and tool slides.

The present invention comprises a different form of tool holder, to wit, a substantially flat slide which may be gibbed upon its bed at its side edges so as to overcome any torsional thrust due to the engagement of the tool and the work. Each tool slide, in addition to its capacity for longitudinal feeding movement, is laterally movable,—

first, to obtain the desired registration with the work holder preparatory to operation of the tools upon the work, and, second, to retract the tools from the work at the end of the feed movement and thereby to prevent the tools from scratching finished surfaces of the work.

Of the accompanying drawings which illustrate one form in which the present invention may be embodied: Figure 1 represents a front elevation. Figure 2 represents a top plan view. Figure 3 represents an elevation of the right end. Figure 4 represents an elevation of the left end. Figure 5 represents a longitudinal vertical section in the plane indicated by line 5—5 of Fig. 4. Figure 6 represents a vertical cross section in two planes indicated by line 6—6 of Fig. 2. Figure 7 represents a vertical cross section in the plane indicated by line 7—7 of Fig. 1. Figure 8 represents a section through one of the gearing units, as indicated by line 8—8 of Fig. 4. Figure 9 illustrates a detail included in Fig. 8. Figure 10 represents an elevation, partly in section, of gearing and clutch mechanism for driving the cam shafts on one side of the machine. Figure 11 represents a view of the same mechanism as seen from the right of Fig. 10. Figure 12 represents a sectional view of a portion of a feed drum and a clutch-controlling lever operated by a cam on the drum. Figure 13 represents a horizontal section in the planes indicated by line 13—13 of Fig. 7. Figure 14 represents a detail section of a connection shown in Fig. 12. Figure 15 represents a horizontal section showing the mechanism for laterally shifting the cross feed slides. Figure 16 is a horizontal section showing mechanism for locking the work turret. Figure 17 represents a horizontal section similar to Fig. 13, showing mechanism for imparting lateral movement to both ends of the gibs which guide the tool slides. Figure 18 represents a vertical section through the same.

The same reference characters indicate the same parts wherever they occur.

In this embodiment of the invention there are four work spindles, four tool slides whose feeding movement is parallel to the axes of the spindles, and two cross slides whose feeding movement is transverse to the axes of the spindles. The spindles are rotatably mounted in a turret, and the turret is rotatably mounted in the frame of the machine, the axes of the several spindles be-

ing parallel to the axis of the turret. The spindles are arranged equidistantly about the axis of the turret so that they form an endless series. The turret is rotated step by step in one direction, each step carrying it through an arc of 90 degrees. The spindles being equally spaced, each moves successively to the position occupied by the spindle next in advance. The axis of the work turret is horizontal, and the step by step rotation of the turret is begun and ended when two of the spindles are in one horizontal plane and when the other two spindles are in another horizontal plane. In other words, the relation of each spindle to the axis of the turret, when the turret is stationary, is in a radius which is 45 degrees from the horizontal plane of the turret axis.

The four tool slides whose feeding movements are parallel to the axes of the spindles are mounted on horizontal beds, the two slides corresponding to the upper spindles being arranged in one horizontal plane and the two slides corresponding to the lower spindles being arranged in another horizontal plane, each upper slide being immediately above the corresponding lower slide. This arrangement of the tool slides renders the slides equally accessible, because one lower slide and one upper slide are in the same vertical plane near the front of the machine, and the other lower slide and upper slide are in another vertical plane near the rear of the machine, where the operator can easily reach them.

The work turret is indicated at 10, and the four work spindles which are rotatably mounted in the turret are indicated at 10^a, 10^b, 10^c, and 10^d. (See Fig. 4.) The turret is formed or affixed on one end of a shaft 11 which is driven intermittently, as hereinafter explained. The turret 10 is almost entirely inclosed within a casing 12 forming a part of the frame of the machine, the casing being formed with a bearing 13 in which the outer end of the turret is supported. (See Fig. 5.) The inner end of the turret is supported by rollers such as that indicated at 14.

The machine is provided with four independent driving mechanisms, one for each of the work spindles, said driving mechanisms being inclosed in heads or casings indicated at 15^a, 15^b, 15^c and 15^d affixed to the frame. The spindles are hollow, as shown by Figs. 4 and 5, and each is provided with a chuck 16.

Turret turning mechanism.—The mechanism by which the work turret is rotated step by step is shown by Figs. 2, 3 and 5. A grooved wheel or disk 17 is affixed to the other end of the shaft 11 to which the turret is affixed. The outer face of the disk 17 is provided with four pairs of strips or guides

18 which are so arranged as to form four radial grooves at angles of 90 degrees from each other. A gear wheel 19 carries two studs or anti-friction rolls 20, 20, disposed diametrically opposite each other, and adapted to enter first one and then another of the grooves between the strips 18 and turn the disk 17 step by step through arcs of 90 degrees each. At the end of each quarter rotation of the work turret, the turret is locked by mechanism, hereinafter explained, to hold it stationary until the beginning of the next quarter rotation. The gear 19 is not rotated continuously but is stationary during the feeding movement of the tool slides and is automatically set in motion to turn the work turret only when all the tool slides have been retracted from the work.

Tool slides.—Referring now to Figs. 5, 6 and 7, the upper front tool slide is indicated at 21, the upper rear tool slide at 22, the lower front tool slide at 23, and the lower rear tool slide at 24. The front cross slide is indicated at 25, and the rear cross slide at 26. The slides 21, 22, 23 and 24 are substantially flat, and they constitute one set whose feeding movement is parallel to the axis of the spindles. These slides may be termed the longitudinal slides to distinguish them from the cross slides 25 and 26. Each slide may be provided with one or more suitable tools, the cross slides 24, 25, being shown as equipped with tools 27 having cutters 28. The longitudinal slides are mounted upon horizontal beds formed or secured in the frame as indicated respectively at 21^a, 22^a, 23^a and 24^a. The beds 21^a and 22^a are in the same horizontal plane, and the beds 23^a and 24^a are in a lower horizontal plane. The beds 21^a and 23^a are in the same vertical plane near the front of the machine, and the beds 22^a and 24^a are in another vertical plane at the rear of the machine. The longitudinal slides are held upon their beds by gibs 29 which engage the upper surfaces of the slides, and by gibs 30 which engage flanges at the bottoms of the slides. The gibs 30 are arranged at the ends near the work turret, and the gibs 29 are arranged at the ends near the grooved wheel or disk 17. The gibs 29 and 30 which are located at the side edges of said slides serve no other function than to keep the slides seated upon the beds, and those on one side are separated far enough from those at the other side to permit a lateral movement of the slides relatively thereto. The longitudinal movement of the slides is controlled by movable gibs 31, 32, 33 and 34. These gibs occupy longitudinal grooves formed in the under surfaces of the slides. The movable gibs are substantially parallel to the axes of the spindles, but they are moved laterally, as hereinafter explained, to bring about the

desired registration of the tools and the work, and to retract the tools laterally from the work at the end of the feed strokes so that the tools will not engage and scratch the work when the slides are retracted.

Mechanism for reciprocating the tool slides.—The longitudinal tool slides are operated independently of each other, so that one may advance at a relatively rapid speed while another is moving at a relatively slow speed. For this reason the machine is provided with four cam shafts, one for each of the longitudinal slides. The cam shafts are indicated at 21^b, 22^b, 23^b and 24^b, and derive their power centrally either from the work spindle driving mechanism, or else more directly from the main drive, according to the speed with which said shafts are to be rotated to feed the tool slides. Each of these cam shafts is provided with a cam for feeding the tool slide to the work and for retracting the same, and with various other cams whose functions are hereinafter explained. For structural reasons the cams are all formed upon or attached to drums 35 mounted upon the cam shafts and arranged in proximity to the longitudinal tool slides. Each drum is provided with a worm gear 36 by which it is driven. The several worm gears coöperate with worms 41, 42, 43 and 44, arranged at the sides of the machine. The worms are driven, as hereinafter described, to rotate the drums independently of each other.

The path cams for operating the slides are grooves 37 in the peripheries of the drums. Each tool slide is provided with longitudinal guides 38 in which is arranged an adjustable holder 39 for a cam roll 40. The members 39 are fixed with relation to the slides by adjusting screws 45, the screws being threaded in the members 39 and having unthreaded shouldered portions engaging lugs 46 on the slides. (See Fig. 5.) The worms 41, 42, 43 and 44 may be connected with gearing actuated by the main driving shaft for driving them at a rapid rate of speed, or with independent gearing driven from the spindle-driving mechanisms for driving them at a relatively slow rate of speed, said gearing being located in casings at the sides of the machine. As shown by Fig. 7, the worm 41 and the worm 43 are affixed respectively to vertical shaft sections 41^a and 43^a which are arranged in alinement with each other in one of said casings. In like manner the worms 42 and 44 are affixed respectively to shaft sections 42^a and 44^a which are arranged in alinement with each other in the other of said casings. The several shaft sections are independent of each other and are driven by independent gearing. Loosely mounted on the shaft 41^a is a worm wheel 41^b, and on the other shaft sections are similar worm wheels, indicated

respectively at 42^b, 43^b and 44^b. These worm wheels are engaged by worms 41^c, 42^c, 43^c and 44^c, which are driven intermittently, as hereinafter explained, to drive the cam shafts at relatively slow speeds. For driving the cam shafts at relatively rapid speeds, bevel gears 41^d, 42^d, 43^d and 44^d are provided. These bevel gears are loosely mounted on bushings which surround the shaft sections.

As shown by Fig. 10, the gears 41^d and 43^d are driven by a gear 47, whereas the gears 42^d and 44^d at the rear of the machine are driven by a bevel gear which is similar to that at 47. Inasmuch as the gearing at the back of the machine is in all respects like that at the front, a description of the front gearing will be sufficient for both sets. Still referring to Fig. 10, the gear 47 is affixed to a shaft 48 which is continuously driven, the shaft 49 (see Fig. 2), by which the gearing at the rear of the machine is driven being also continuously driven. The shafts 48 and 49 are provided with pulleys 50, which are driven by belts 50^a and 50^b (see Figs. 3 and 5), the belt 50^a passing over a pulley 50^c, and the belt 50^b passing over a pulley 50^d. The pulley 50^c is affixed to a shaft 51 mounted in bearings in the upper part of the machine, and the pulley 50^d is affixed to a shaft 52 mounted in bearings at the lower part of the machine. The shafts 51 and 52 are provided with pulleys 51^a and 52^a, and the pulleys are connected by a belt 53. The pulley 52^a (see Fig. 1) is relatively broad and is continuously rotated by a main driving belt. (Not shown.)

As previously stated, the worm gears and bevel gears on the shaft sections 41^a, 42^a, 43^a and 44^a are all loose with relation to the shaft sections, and the bevel gears are continuously driven whereas the worm gears are intermittently driven. The hubs of the worm gears and bevel gears are provided with clutch teeth adapted to be engaged by complemental clutch teeth on the ends of sliding clutch members 41^e, 42^e, 43^e and 44^e, so that said clutch members are adapted to couple either the worm gears or the bevel gears with their respective shaft sections and cause the shaft sections to be driven at relatively slow or relatively rapid speeds. As shown by Fig. 7, the clutch collars are slotted and the shaft sections are provided with pins 54 which occupy the slots in the collars. The collars 41^e and 42^e are shown coupled with the worm gears 41^b and 42^b, while the collars 43^e and 44^e are shown coupled with the bevel gears 43^d and 44^d. By reason of these driving connections, as illustrated, the two upper tool slides are being fed at relatively slow speeds while the two lower tool slides are being fed at relatively rapid speeds. The four worms 41^c, 42^c, 43^c and 44^c are affixed to horizontal shafts 61, 62, 63, and 64, respectively. These

shafts are arranged on the front and rear sides of the machine and are inclosed in tubes 54 to protect the operator from contact therewith. The shafts extend toward the four gear cases or spindle-driving heads 15^a, 15^b, 15^c and 15^d. Each shaft is provided with a cone pulley 55 to be driven by a belt 56 passing over the complemental cone pulley 57, of which one is associated with each of the four sets of gearing inclosed in the driving heads or gears cases 15^a, 15^b, 15^c and 15^d. The four sets of gearing inclosed in the said gear cases are identical in structure and arrangement except that they are disposed at different angles, as shown by Fig. 4.

Change speed gear mechanism.—The variable speed power transmitting mechanisms are arranged to drive the work spindles at varying speeds according to the cut to be performed by the tool, and they also control the speed at which tool slides are fed while making their slow cutting strokes. The gear trains inclosed in the cases 15^a and 15^b derive their power from the continuously rotating shaft 51, and those in the cases 15^c and 15^d derive their power from the continuously rotating shaft 52. The shaft 51 is provided with a gear 58 which engages gears 59 and 60. (See Fig. 4.) The gear 59 drives the change-speed gearing in the casing 15^a, and the gear 60 drives similar gearing in the casing 15^b. In like manner the shaft 52 is provided with a gear 65 which engages gears 66 and 67. The gear 66 transmits power to the gearing in the casing 15^c, while the gear 67 transmits power to the gearing in the casing 15^d. Through the four trains of gearing in said gear cases, power is transmitted to the worms 41^c, 42^c, 43^c and 44^c, by which the slide-moving cams are slowly rotated to feed the tool slides, and also the four work spindles. The gearing inclosed in the casing 15^c, which is like the others, is illustrated in detail by Fig. 8, and a description thereof will be sufficient for the four sets.

The gear 66 drives a gear 68 which constitutes one member of a friction clutch of the disk type. The disks are indicated as a whole at 69, and the complemental clutch member is indicated at 79. The clutch members are mounted upon a hollow shaft 80 through which extends an operating rod 72 for controlling the clutch. The clutch member 79 is pinned to the hollow shaft 80, but the gear 68 is loosely mounted upon the shaft. The gear 68 is driven continuously, and through it the work spindle may be rotated at various speeds, according to the arrangement of the various combinations of gears contained in the gear case. The arrangement of gears shown on the drawing is adapted to drive the work spindle at the slowest speed. The train of gears for this speed may be traced as follows: pinion 70

formed on the hub of the gear 68, gear 71 loosely mounted on countershaft 81, pinion 73 formed on the hub of gear 71, and gear 74 loosely mounted on hollow shaft 75. Gear 74 is formed with an annular recess which is occupied by an annular flange having external ratchet teeth 76.

The toothed flange is a part of a collar 77 which is affixed to a hollow shaft 75. The gear 74 carries a pawl 78 which is adapted to cooperate with the ratchet teeth 76 to drive the shaft 75. The shaft 75 is driven continuously, either by the pawl 78 or by one of the various trains of gears which are adapted to drive it faster. Whenever one of the faster gear trains is operatively coupled, the shaft 75 is free to be driven at a faster speed, since the ratchet and pawl do not in any way limit the speed of the shaft. When the shaft is driven at a faster speed, the gear 74 nevertheless continues to rotate at its constant slower speed.

The hollow shaft 75 carries a flanged collar 82. The flange of the collar 82 is bored for the reception of dowel pins 83 which are affixed to a clutch disk 84. The disk 84 is affixed to one end of an operating rod 85 which extends through the hollow shaft 75 and projects beyond the outer end thereof. The disk 84 is provided with teeth such as the one indicated at 86, which teeth are adapted to engage similar teeth 87 formed on a clutch disk 88. The disk 88 is mounted upon a stud shaft 89 affixed in the work turret 10. A pinion 90 is formed on the hub of the disk 88 and cooperates with a gear 91 affixed to one of the work spindles in the turret.

The spring 92 acting upon the rod 85 normally projects the clutch disk 84 into operative engagement with the clutch disk 87. While the disk 84 is moved back and forth, the pins 83 slide in the flange of the collar 82 and preserve driving relation. A grooved collar 93 is affixed to the outer end of the operating rod 85 and is engaged by an operating lever 94. The lever is pivoted at 95 and carries a setscrew 96 which is adapted to abut against the outer end of the operating rod 72. A spring 97 acting upon the rod 72 normally sets the disk clutch 68, 69, 79, but when the toothed clutch 84, 88, is disconnected, the disk clutch is released.

The cone pulley 57 is loosely mounted on the other end of the hollow shaft 75. This pulley is internally tapered so as to cooperate with a friction cone member 98 affixed upon shaft 75. The collar 93 on the outer end of the operating rod 85 is adapted to engage one end of the cone pulley 57 when the clutch 84, 88, is connected, and to hold the pulley 57 in frictional engagement with the cone clutch member 98. The members 57 and 98 are normally pressed together so long as the operating rod 85 is not retracted

against the tension of the spring 92. The spring 92 has two functions, one of which is to couple the toothed clutch 84, 88, to drive the work spindle, and, second, to couple the friction clutch members 57, 98, to drive the gearing which is provided for operating the tool slides at slow speed. Each lever 94 is automatically operated by its corresponding cam shaft at the completion of retrograde movement of the corresponding tool slide, with two results: first, the corresponding cam shaft becomes stationary because of the release of the friction clutch members 57, 98, and, second, driving connection with the corresponding work spindle is broken by retraction of the toothed clutch member 84. When all the clutch members 84 have been retracted, the work turret is free to be advanced through an arc of 90 degrees, whereupon the four clutch members 88 are moved into registration with the complementary clutch members 84 next in advance. After each quarter rotation of the work turret, the operating levers 94 are released, with the result that the toothed clutch members 84, 88, become automatically engaged to drive the spindles, and the friction clutch members 57 and 98 are again pressed together to drive the cam shafts and the cam drums at slow speed to find the tool slides slowly. Incidentally, the disk clutch 68, 69, 79, is released when the other two clutches are released. The releasing of the disk clutch is a precautionary measure to avoid undue shock when starting, when the shaft 75 is connected through one of the faster trains of gears to be driven at a speed faster than its slowest speed. The disk clutch performs its functions immediately after coupling the toothed clutch 84, 88. The relation of these two clutches may be understood by assuming that they are about to be thrown into operative driving relation from the position shown by Fig. 8. When the operating lever 94 is moved, both clutches are released, as shown in this figure; but when the operating lever 94 is released so that it may move from the position indicated by solid lines to its normal position indicated by dotted lines, the clutch member 84 engages the clutch member 88 before the disk clutch is tightly set. Under the conditions illustrated, the spindle 75 is being driven at slow speed, because the disk clutch is released. It therefore moves into engagement with the clutch member 88 only when it is being driven at slow speed; but after having moved into engagement with the clutch member 88 the disk clutch becomes tightly set, whereupon one of the higher-speed gear trains may be set in motion to drive the clutch member 84 at a greater speed.

Referring again to Fig. 8, it will be noted that for driving the work spindles at said higher rates of speed, the shaft 80 is pro-

vided with the two change or slip gears 200, 201, splined thereon to move into engagement alternately with the gears 202, 203, respectively, pinned to the intermediate shaft. The shaft 75 has likewise splined upon it the two change or slip gears 204, 205, adapted to intermesh alternately and respectively with the gears 202, and 206 on the intermediate shaft. By virtue of this construction the spindle driving shaft 75 may be driven at any one of nine speeds. Any suitable devices may be employed for shifting the change gears, and I have not illustrated the same in detail, though I have shown in Fig. 4, at 207 and 208, the ends of two controller rods by which such devices may be actuated manually by the operator. Each operating lever 94 is connected to one end of a rod 99, and each rod 99 is operated by a rod which extends toward and abuts against the corresponding cam drum 35. The four rods which engage the cam drum are indicated at 101, 102, 103 and 104. (See Figs. 6 and 8). The form of connection between the latter rods and each of the rods 99 is shown by Fig. 9, which includes the rod 104. A lever 100 is mounted upon a stationary pivot stud 100*. One end of the rod 99 is pivotally connected to one end of the lever 100. The other end of the lever 100 is provided with a socket for the reception of the semi-spherical end of the rod 104. The rod 104 is a thrust rod and is adapted to rock the lever 100 in one direction only, so as to retract the rod 99 against the tension of the springs 92 and 97. The springs hold the other end of the rod 104 always against the end of the corresponding cam drum. Each cam drum is provided with a cam block for operating the corresponding thrust rod, said blocks being indicated in Figs. 1, 2 and 6 at 105. These cams are so located on the drums that when the tool slides have been retracted preparatory to the rotation of the turret to advance the work spindles one step, and said drums are just coming to a state of rest, said cams respectively engage the rods 104 and release the disk clutches, and at the same time unclutch the driving shafts 75 from the spindles, and unclutch the cone pulleys 57 from the shafts 75, whereupon the worm mechanism for driving the shaft sections 41* to 44* are all rendered inactive.

The mechanism by which the cam drums are again set in motion after the turret has been rotated and indexed will subsequently be explained.

I shall now explain how the cam drums are driven at various speeds by their respective driving mechanism, to advance and retract the tool slides, and how the clutches 41*, 42*, 43* and 44* are automatically controlled to accomplish this purpose. It may be stated preliminarily that said clutches are

controlled in part by the cam drums themselves, and in part by devices actuated by the turret-rotating mechanism, the latter serving to start the drums after the turret has completed its step and has advanced the work spindles to the next succeeding tool sides. Each cam drum is provided with adjustable cam blocks 106, 121 and 122 for shifting the clutch mechanism shown by Figs. 7, 10 and 11, whereby the feeding of the tool slides may be made either fast or slow. One of these cam blocks is illustrated in detail by Fig. 12. Said cam block is split and is adapted to be clamped upon an annular flange 107 at one end of the drum. The block 106 may be placed at any desired position on the flange and may be clamped by a suitable screw. The block is provided with a beveled projection 108 which is adapted to engage a pin 109 carried by a lever 110. (See Figs. 10 and 11). It will be understood that there are four levers similar to the lever 110, each of said levers being adapted to control one of the sliding clutch collars, 41°, 42°, 43° and 44°. The lever 110 is pivotally mounted upon a rock shaft 111 and is formed to engage a pin 112 carried by a fork or shipper 113, said rock shaft being equipped with a handle 111^a by which it may be manually operated if desired. The shipper 113 engages the corresponding sliding clutch member which is indicated at 43° at the lower part of Fig. 10 and at 41° at the upper part of Fig. 10. The shipper 113 is pivotally mounted upon a stud 114 carried by a rock arm 115, and the latter is mounted upon a stationary pivot indicated at 116 and may be yieldingly held in either of two positions by a spring latch 115^a. A three-fingered member 117 is mounted upon a pivot stud at the free end of the rock arm 115. One of the fingers of said member 117 is adapted to be engaged by a cam 118, and another of said fingers is adapted to be engaged by a cam 119. The cams 118 and 119 are affixed to the shaft 48 or the shaft 49, as the case may be, which said shafts are continuously rotated by the main drive. The third finger of the member 117 extends into a notch formed in a portion of the shipper 113.

When the lever 110 is thrown in one direction or another, it moves the rock arm 115 so as to place the three-fingered member 117 in the path of the cam 118 or the cam 119, in consequence of which the three-fingered member will be swung about its pivot in one direction or the other by the cam, so that its third finger will rock the shipper 113 about the pivot 114 and thus throw the sliding clutch member into engagement with either the fast speed gear 43^a or into engagement with the slow speed gear 43^b. The rock arm 115 is provided with a member 120 by which it may be otherwise turned about its pivot

116, as hereinafter explained, to shift the three-fingered member from one of said cams to the other, and start the rotation of the drums after the turret has been advanced one step.

Each cam drum is provided with three cam blocks for operating the lever 110. In addition to the cam block 106 there are two other blocks, indicated at 121 and 122. (See Fig. 3.) The function of each cam block 121 is to place the sliding clutch collar in driving relation with the slow speed gear when the tool slide is advancing the tool toward the work. The function of each cam block 106 is to place the sliding clutch member in engagement with the fast speed gear at the end of the feed stroke of the tool slide so that the tool slide will be retracted at fast speed; and the function of the cam block 122 is to shift the sliding clutch collar back into engagement with the slow speed gear at the end of the retrograde movement of the feed slide, so that the cam shaft may be entirely disconnected from all driving mechanism by the action of the thrust rod 104 which disconnects the driving mechanism as previously explained.

After each quarter rotation of the work turret has been completed, the sliding clutch collars 41°, 42°, 43° and 44° are thrown into engagement with the fast speed bevel gears by the action of one of two cams carried by the gear 19 for the purpose of starting the cam drums in action again. (See Fig. 3.) The said cams are indicated at 123 and 124, and they are adapted to act alternately upon rolls 125 carried by sleeves 126. As shown by Fig. 2, one of said sleeves is arranged near the front of the machine, and the other is arranged near the rear of the machine, diametrically opposite. Said sleeves are mounted on operating spindles 127 about which they are adapted to oscillate. Each sleeve is provided with two arms, said arms being indicated at 128. Each of the four arms 128 is adapted to abut against one of the members 120 of the shipper mechanism shown in Fig. 10, to shift the corresponding rock arm 115 to the position shown by the lower part of Fig. 10. In this way the four cam shafts are started or set in action at fast speed. Thus after each quarter revolution of the work turret, the cam shafts are actuated at fast speed until the sliding clutch collars are shifted into engagement with the slow speed gears by the action of the cam blocks 121 to cause said shafts and cam drums to rotate at slow speed for feeding the tool slides. The several cam blocks will be positioned to shift the sliding clutch collars in due time to connect the cam shafts with the slow driving mechanism before the tools engage the work, so that the tools will be fed slowly along the work.

Starting mechanism for work turret.—As

has been indicated, each of the cam drums is automatically disconnected from all driving mechanism upon completion of a cycle of operations, the cam drums being independent of each other in thus controlling themselves. As shown by Fig. 3, each cam drum carries a cam block 130, and these blocks are arranged to engage and displace four plungers 131 which are shown by Figs. 1, 2, 3 and 5. Each of the upper plungers 131 is connected with one of the lower plungers by a link or yoke 132. The two yokes are connected midway between their ends by a bar 133, and this bar, midway between its ends, is pivotally connected to a stud 134 which projects through the upper end of a clutch lever 135. A compression spring 136 is placed upon the stud 134 (see Fig. 5) between the bar 133 and the lever 135. The lever is pivotally mounted on a stationary stud 137, and its lower end is forked and engages a grooved collar 138, which is loosely mounted on the shaft 52 and is adapted to slide longitudinally. The collar 138 is connected with the hub of the main driving pulley 52^a by dowel pins 139 so that it may slide along the shaft and at the same time be continuously driven by the pulley. The sliding collar is provided with clutch teeth adapted to engage complementary clutch teeth formed on a sleeve 140, loosely mounted on the shaft 52, and provided with a pinion 141.

Referring now to Fig. 3, the pinion is connected with the large gear 19 through reducing gearing comprising a gear 142 and pinion 143, the gear 142 engaging the pinion 141, and the pinion 143 engaging the gear 19. Thus power is imparted to the turret-rotating mechanism. The clutch member 138 is controlled in the following manner: The cam blocks 130 are so arranged on their respective cam drums as to engage the plungers 131 immediately before the cam drums are disconnected from all driving mechanism, and just as they are coming to a state of rest, so that the cam blocks 130 will stop while in cooperative engagement with the plungers. As each plunger is repelled by its cam block, it moves one end of one of the vertical links or yokes 132. The movements of the plungers are combined as each plunger is repelled, and the movements are transmitted to the crossbar 133. The combined movements of two or three of the plungers are not sufficient to move the clutch 138 into driving relation with the clutch member 140, but all four of the plungers must be repelled in order to impart sufficient movement to couple the clutch members. When the last of the four cam drums becomes stationary, the sliding clutch member 138 is moved into engagement with the clutch member 140, thus forming a driving connection between the continuously driven pulley 52^a and the

gear 19, whereupon one of the two rolls or studs 20 on the gear 19 will cooperate with the grooved wheel or disk 17 to turn the work turret. The gear 19 carries two projections such as that indicated in Fig. 5 at 143^a, which are disposed at diametrically opposite points, their function being to disconnect the clutch member 138 when the gear 19 has been rotated through 180 degrees and has completed the rotative movement of the turret. For this purpose the clutch lever 135 is provided with a plunger 144, arranged in a socket formed therein, and normally projected toward the gear 19 by a spring 145. The tension of the spring 145 is greater than that of the spring 136 and is adapted to disengage the clutch member 138, against the tension of the spring 136, when the plunger 144 is repelled by one of the projections 143^a.

Mechanism for locking work turret.—

Four notches 146 are formed in the periphery of the turret 10. (See Fig. 16.) These notches are adapted to receive locking bolts or index pins 147 arranged to slide in a socket in the casing 12. Flat springs 148 acting against the outer ends of the bolts normally tend to throw the bolts into locking position. (See also Fig. 1.) The bolts are automatically retracted against the tension of the springs by cams 149 on the gear 19. There are two cams for this purpose, as shown by Fig. 3, and they are disposed diametrically opposite each other. Each of said cams is extended through a relatively long arc for the purpose of holding the locking bolt retracted while the work turret is moving from one position to another. The cams cooperate with a lever 150 pivotally mounted on one of the upright spindles 127. The lever is pivotally connected to one end of the rod 151. (See Figs. 1 and 2.) The other end of the rod is pivotally connected to an arm 152 keyed or otherwise affixed to an upright rock shaft 153. (See Fig. 16.) The said shaft carries a plate 154 on which is affixed a pin 155, occupying an opening in the bolt 147. A similar rock shaft 153^a carries a block 154^a having a pin 155^a occupying an opening in the other locking bolt 147; and the two rock shafts have arms 210, 211, respectively extending in opposite directions, which are connected by a link 212. Said rock shafts carry cams 213, which when the bolts are in locking position bear against the face of the turret and force its flange 10^a against the bearing in which the turret is journaled.

Lateral adjustment of tool slides.—As hereinbefore stated, the movable gibs 31, 32, 33 and 34 for the longitudinal tool slides are movable laterally and are automatically moved first to place the tool slides in the desired operative relation to the work and to guide them during their feeding movements,

and then to retract the tools laterally from the work to avoid scratching the work when the slides are moved backward. The mechanism for operating the movable gibs is shown by Figs. 5, 7, 13 and 14. These gibs are supported at one end by oscillatory studs 156 and at the other end by collars 157 formed on or affixed to shafts 158. The gibs are provided with pins 159 which occupy grooves formed in the peripheries of the collars 157. The collars 157 are eccentric with relation to the shafts 158 and their function is to adjust the gibs vertically with relation to the tool slides. By sliding said collars on the shafts the gibs may be set angularly to cause the tools to cut tapering surfaces. One edge of each gib is inclined, as shown by Figs. 3 and 7, and the confronting face of the tool slide is correspondingly inclined. If there is any lateral play between the slides and the movable gibs, the same may be eliminated by turning the shafts 158 to raise the gibs. The pins 159 fit closely in the grooves of the eccentric collars 157. The studs 156 at the other ends of the movable gibs have eccentric pins 160 which project into the gibs. The pins are affixed to the studs, and the latter are adapted to be turned in their bearings to impart movement to the gibs through the medium of the eccentric pins, the eccentric pins being so arranged as to move the gibs laterally when the studs are turned. The pins 159 at the opposite ends of the gibs act as pivots when the gibs are moved by the pins 160. The gibs are so long relatively to the movement of the tool slides that there will be practically no variation in the diameter of the work due to a minute angularity of the gib relatively to the work axis.

The eccentric studs for the four gibs are operated by rods indicated at 161, 162, 163 and 164, which are arranged to abut against the inner face of the turret-rotating wheel or disk 17, as shown by Figs. 5 and 13. Each rod is bored for the reception of a spring 165 and follower 166, and the followers are arranged to abut against portions of the frame of the machine so that the operating rods may be held in contact with the disk 17 by the tension of the springs. (See Fig. 13). The disk 17 is provided with adjustable gages or abutments which are adapted to coact with the ends of the operating rods to position the same, and the rods are operatively connected with their respective studs 156, whereby they are adapted to determine the lateral positions of the several gibs. The adjustable gages or abutments carried by the disk 17 are illustrated in the form of setscrews. They are divided into four sets, each set comprising four gages to register successively with each gib-controlling rod. For convenience, some of the gages are arranged in a rela-

tively large circle, and others are arranged in a smaller circle. The operating rod 161 is engaged successively by the gages 167, and the rod 162 is engaged successively by the gages 167^a, all in the inner circle, and the operating rods 163 and 164 are arranged to be respectively and successively engaged by the gages 168, 168^a, in the outer circle.

The operating or gib-controlling rods are connected with their respective studs 156 by levers 169. The levers are affixed to the studs and are loosely connected to the operating rods. The operating levers are pivotally connected to collars 170 which loosely surround sleeves 171 on the operating rods, said sleeves being affixed upon the rods and being provided with flanges at their outer ends, as shown by Fig. 14. Washers 172 loosely surround the operating rods and are normally held against the collars 170 by springs 173 which are compressed between the washers and pins projecting through the rods. This form of yielding connection is provided for permitting the levers 69 to move in one direction independently of the operating rods for a purpose hereinafter explained.

The gages 167, 167^a, 168 and 168^a, are set at the desired positions when the machine is erected, and it is not necessary to readjust them after they have once been accurately adjusted except for the purpose of taking up lost motion in the operating mechanism due to wear. The radial positions of the gages are such that four of them will register with the four operating rods when the work turret is stationary, and consequently the operating rods 161, 162, 163 and 164 are positioned each time the position of the work turret is changed. The movement imparted to the operating rods by the gages is transmitted to the collars 170 which are confined between the washers 172 and the flanges on the sleeves 171. The tension of the springs 173 is sufficient to transmit the desired movement to the operating levers 169, and in this way the studs 156 are rotatively positioned to position the laterally movable gibs. When the disk 17 advances so as to move the gages out of registration with the operating rods, the rods are moved slightly toward the disk by the springs 165 acting upon the followers 166. It may be understood from the foregoing description that the studs 156 are turned in one direction through the medium of the springs 165, and in the opposite direction through the medium of the springs 173.

The lateral positioning of the movable gibs by the mechanism just described occurs when the tool slides are farthest from the work, and the purpose of positioning them in this manner and at this time is to determine the desired registration of the tools with the work. The tools mounted upon the

longitudinal slides determine the various diameters of the work, and for this reason it is important to locate with precision the paths of the tool slides in order to determine with accuracy the various diameters of the work. It is for this reason that each gib is laterally positioned each time a work spindle is moved into position to be operated on by a tool on the slide controlled by said gib. Instead of swinging the gibs about the pins 159, they may be moved laterally bodily as shown in Figs. 17 and 19. That is to say, in lieu of the pins or studs 159, the studs 156^x having eccentric pins 160^x may be employed, in which case they are connected by levers 169^x and extension rods (169^b 169^c 169^a) with the levers 169. By this arrangement, both ends of the gibs are moved to the same extent to preserve the exact parallelism of the path of the tool and the axis of the work.

The studs 156 are operated by other mechanism at the end of the feeding movements of the tool slides for the purpose of retracting the tools laterally from the work so that the tools may avoid scratching the finished surfaces during retrograde movement of the slides. For this purpose the operating levers 169 are pivotally connected to links 175. As shown by Fig. 1, each link 175 extends to a lever 176, pivoted midway between its ends on a pivot stud 177. At each end of each lever 176 is a stud 178 which is adapted to receive the adjacent link 175. The link is formed with a notch in one edge whereby it is adapted to be coupled with the stud 178 at one end of the lever 176 or with the stud at the other end of the lever. Each of the levers 176 is mounted adjacent to one of the cam drums 35 and is provided with a cam roll 179. (See Fig. 6.) The four drums are formed with cam grooves 180 in which the rolls 179 are arranged. The cams 180 hold the levers 176 stationary while the tool slides are being advanced to feed the tools to the work; and at the end of the feed stroke each lever 176 is moved slightly by its cam 180 so as to impart movement to the corresponding lever 169. If the links 175 are connected to the upper studs 178, they will be moved in one direction, whereas if they are connected to the lower studs 178 they will be moved in the opposite direction. The selection of studs 178 depends upon whether the tool or tools of the corresponding slide are operating upon the interior or exterior of the work. If they are operating upon the interior they must be moved in one direction to retract them laterally from the work, but if they are operating upon the exterior of the work they must be retracted laterally in the opposite direction. The action of the levers 176 is positive, whereas the connections between the levers 169 and the four operating rods 161, 162, 163 and 164

are yielding, and for this reason the levers 169 may respond to the action of the levers 176 without injuring the connections with the operating rods. Similar mechanism is provided for moving the cross slides laterally of their feeding movement to retract the tools from the work face. As shown by Fig. 6, the cross slides 25 and 26 are mounted upon horizontal beds 181, 182, and are held seated upon their beds by suitable gibs, their under surfaces being grooved, as shown by Fig. 5, for the reception of laterally movable gibs 183. One end of each gib 183 is slotted for the reception of a pivot stud 184, and the other end is bored for the reception of an eccentric pin 185 formed upon a stud 186. Each stud is provided with an arm 187 by which it may be oscillated. The arms 187 are pivotally connected to operating rods 188 which extend into the paths of cams 189 on the ends of the two lower drums 35. The rods are normally held against the drums by springs 190. (See Fig. 6.) The rods are moved positively in one direction by the cams 189, and in the opposite direction by the springs 190, and the eccentric pins 185 are thus drawn first in one direction and then in the opposite direction to position the gibs 183.

The forward and backward movements of the cross slides is obtained from path cams 191 on the ends of the lower drums. The cams coöperate with rolls 192 carried by arms 193 affixed to rock shafts 194. Each rock shaft carries a second rock arm, indicated at 195, the free end of which is slotted, as shown by Fig. 6, to embrace a transverse pin 196 with which each cross slide is provided. The cams 191 cause the cross slides to move toward the work substantially in unison with the feed movement of the lower longitudinal slides. At the end of the feed movements of the cross slides they are moved laterally by the eccentric pins 185 so that the tools carried thereby will not engage the face of the work during retrograde movement. At the end of retrograde movement the eccentric pins are again actuated to position the slides for the next feed movement.

From the foregoing description it will be apparent that the machine is constructed to operate upon large pieces of work with great accuracy and nicety. The work spindles are journaled in a large turret so that the work may be held without danger of springing, much as it is held by the spindle in a turret lathe. Then as each piece of work is brought into approximate registration with one of the tools on a longitudinal tool slide, said slide and tool are automatically positioned by an individual gage for that identical piece, moved into position as the work is carried around by the turret, so that the cutter will be located with the greatest nicety to operate upon said piece. When the cut is

completed the tool slide and tool are retracted from the work, and the slide is then longitudinally withdrawn at high speed. The tool slides are fed, each at its own speed, independently of the others, and by locating the tools at different distances from the ends of the slides, the tools will make cuts of different lengths on the respective pieces of work. The cam drums which effect the longitudinal forward and reverse feeding of the tool slides, control the gearing by which they are rotated, and one by one come to a state of rest; and it is not until they are all quiescent, and they have been disengaged from their driving mechanism, and not until the work spindles have likewise been unclutched from their respective driving heads, that the turret-rotating mechanism is set in motion to impart a rotative step to the turret.

Having thus explained the nature of my said invention, and described a way of constructing and using the same, although without attempting to set forth all the forms in which it may be made or all the modes of its use, what I claim is:

1. In a metal-working machine, a laterally movable work spindle, a series of tool slides, means for moving the spindle into operative relation with said slides one after another, and means for positioning each slide laterally with reference to the spindle registering therewith.

2. In a metal-working machine, a revolvable turret, a plurality of work spindles disposed about the axis of the turret, a tool slide, gibs for the side edges of said slide, means for revolving the turret step by step to move said spindles successively into coöperative relation with said slide, and automatic means for laterally positioning the slide relatively to its gibs independently for each of said spindles.

3. In a metal-working machine, a revolvable turret, a plurality of work spindles disposed about the axis of the turret, a plurality of tool slides arranged in coöperative relation with the respective spindles, means for revolving said turret step by step to cause said spindles to move successively into coöperative relation with the several tool slides, and automatic means for independently and laterally positioning the several slides for each of the work spindles.

4. In a metal-working machine, a laterally movable work spindle, a series of tool slides, means for moving said spindle into coöperative relation with each of said slides one after another, independent means for laterally adjusting each of said slides, and a gage movable with the work for operating each adjusting means.

5. In a metal-working machine, a revolvable turret, a series of work spindles arranged therein, a tool slide, means for turn-

ing the turret step by step to place said spindles successively in coöperative relation with said slide, means for operating said slide, means for laterally adjusting said slide, and a plurality of gages one for each spindle, said gages being movable with said spindles and adapted to operate said adjusting means to position laterally the slide for each piece of work.

6. In a metal-working machine, a revolvable turret, a plurality of work spindles arranged therein, a plurality of tool slides arranged in coöperative relation to said spindles, means for revolving said turret step by step to move the spindles successively into coöperative relation with each of said slides, a plurality of gages connected with the turret to move about the axis thereof, and independent adjusting means for each slide, said means being adapted to be operated by said gages for positioning the slide laterally of its feeding movement.

7. In a metal-working machine, a work spindle, a series of tool slides, means for moving the spindle laterally into coöperative relation with each of said tool slides one after another, means for feeding and retracting said tool slides, independent means for adjusting each slide transversely of its feeding movement, and automatic means for operating each adjusting means to position each slide prior to the feeding movement of the slide.

8. In a metal-working machine, a revolvable turret, a plurality of work spindles arranged therein, a tool slide, means for turning the turret step by step to place said spindles successively in coöperative relation with said slide, means for feeding the slide, a plurality of gages movable with the turret about the axis thereof, and means adapted to be operated by each of said gages, for adjusting said slide transversely of and prior to its feeding movement.

9. In a metal-working machine, a revolvable turret, a plurality of spindles arranged therein, a plurality of tool slides arranged in coöperative relation to said spindles, feeding means for each of said slides, gages movable with said turret about the axis thereof, and mechanisms for adjusting said slides transversely of their feeding movement independently of each other, said mechanisms being adapted to be operated by said gages, whereby each slide is adjusted for each piece of work.

10. In a metal-working machine, a work spindle, a series of tool slides, means for moving said spindle to present the work successively to the several tools, each slide having feeding means for moving it longitudinally toward and from the work, and automatic means for moving each slide laterally at the end of the working stroke to separate the tool from the work, whereby

scratching the work is avoided when the tool slide is retracted.

11. In a metal-working machine, a plurality of work spindles, a plurality of tool slides in coöperative relation to said spindles, means for moving said spindles simultaneously into coöperative relation with the several tool slides one after another, each slide having a separate feeding mechanism for moving it toward and from the work, the several feeding mechanisms being adapted to move their several slides at different speeds, and means for moving each slide laterally of its feeding movement at the end of its working stroke and prior to its return stroke to disengage the tool from the work, whereby the tool is held out of contact with the work during the return stroke.

12. In a metal-working machine, a work spindle, a series of tool slides, means for moving the spindle into coöperative relation with said tool slides one after another, each slide having feeding mechanism for moving it toward and from the work, and means for moving each slide laterally, when retracted, to position the slide with relation to the work, and to move said slide laterally at the end of the feeding stroke to disengage the tool from the work prior to the return stroke of the slide, whereby scratching the work is avoided.

13. In a metal-working machine, a work spindle, a series of tool slides, means for moving said spindle into coöperative relation with said slides one after another, each of said slides having mechanism for feeding it toward and from the work, and each slide being movable transversely of its feeding movement, yielding means for normally holding each slide laterally away from its operating path, and automatic means for moving each slide laterally away from its normal position into its operating path.

14. In a metal-working machine, a plurality of work spindles, a plurality of tool slides in coöperative relation to said spindles, means for moving said spindles simultaneously so as to cause them to occupy coöperative relation with said slides successively, said means including a clutch, independent feeding mechanisms for each of said slides, said feeding mechanisms being adapted to operate at different speeds, and means controlled in part by each of said feeding mechanisms for operating said clutch when the whole number of slide feeding mechanisms have completed their individual cycles of operation.

15. In a metal-working machine, a series of tool slides, a movable work carrier, means for moving said carrier successively into operative relation with each of said slides, feeding mechanism for each of said slides, each slide being movable laterally of its feeding movement and having means inde-

pendent of the other slides for shifting it laterally, and means movable with the work for operating each of said shifting means to determine the lateral position of each slide with reference to the piece of work.

16. In a metal-working machine, a revoluble turret having a series of work spindles, a tool slide, means for turning the turret step by step to move the spindles successively into coöperative relation with the tool slide, means for feeding the slide toward and from the work, said slide being movable transversely of its feeding movement, and automatic means for determining the transverse position of said slide for each piece of work.

17. In a metal-working machine, a plurality of work spindles disposed and movable about a common axis substantially parallel therewith, a plurality of longitudinally movable tool slides correspondingly disposed about said axis, stationary gibs parallel to said axis for guiding the longitudinal movement of said slides, said tool slides being laterally movable with relation to their respective gibs to position the tool thereon relatively to the work, and means for holding the several slides in the positions to which they may be laterally moved.

18. In a metal-working machine, a plurality of tool slides disposed about a common axis, longitudinally stationary gibs substantially parallel with said axis for guiding the longitudinal movement of said tool slides, said slides being movable transversely to said gibs and being also longitudinally movable thereof for feeding the tools, means for holding the several slides in the positions to which they may be laterally moved, and a work spindle movable laterally about said axis into coöperative relation with each of said slides one after the other.

19. In a metal-working machine, a plurality of work spindles disposed about a common axis in parallelism therewith, a plurality of tool slides correspondingly disposed about said axis, means for moving said spindles successively into working relation with the several tools, gibs arranged longitudinally of said axis for each slide for guiding it longitudinally of said axis, and means for moving each slide laterally relatively to its gibs to position the tool thereon with respect to the work upon which it is to operate.

20. In a metal-working machine, a plurality of work spindles movable about a common axis in parallelism therewith, a plurality of tool slides disposed about said axis, said slides corresponding in number and position to said spindles and being movable longitudinally of said axis for feeding and movable transversely of said axis for registration with said spindles, a plurality of abutments movable with said spindles, and

means adapted to be engaged and positioned by said abutments for determining the lateral positions of said slides.

21. In a metal-working machine, a plurality of work spindles movable about a common axis in parallelism therewith, a plurality of independent driving mechanisms for driving said spindles about their individual axes, said mechanisms being arranged about said common axis and fixed as to location, means for moving said spindles to cause each spindle to register with said driving mechanisms one after another, and a plurality of tool slides disposed about said common axis, said slides being movable for feeding the tools along the work carried by the spindles.

22. In a metal-working machine, a revolvable turret, a plurality of work spindles rotatively mounted in the turret in parallelism to the axis of the turret, said spindles being equidistant from each other and from said axis, a plurality of independent driving mechanisms fixed as to location and disposed about said axis so as to be adapted to be coupled respectively with said spindles, a plurality of tool slides disposed about said axis, means for turning said turret step by step, and means for locking said turret against rotation when said spindles are in coöperative relation with said driving mechanisms and said tool slides.

23. In a metal-working machine, a work holder, a tool slide, means for guiding the tool slide toward and from the work, said guiding means being movable transversely of the feeding movement of the slide, a gage movable in a predetermined path, and means adapted to be positioned by the gage for determining the lateral position of said guiding means.

24. In a metal-working machine, a work holder, a tool slide, a laterally movable gib for guiding said slide, a gage, and means adapted to be engaged and positioned by said gage for determining the lateral position of said gib.

25. In a metal-working machine, a work holder, a tool slide, means for guiding the tool slide, said means being movable transversely of the feeding movement of the slide, means for moving the slide along said guiding means, a movable gage, and means adapted to be positioned by said gage for determining the lateral position of said guiding means.

26. In a metal-working machine, a plurality of work spindles equidistantly disposed about a common axis in parallelism to said axis, a plurality of tool slides disposed about said axis in coöperative relation to said spindles, means for feeding said tool slides toward and from the work, said slides being movable independently of each other

transversely of their feeding movement, means for moving said spindles about said common axis into coöperative relation with said slides one after another, and means for determining the lateral position of each slide with reference to each piece of work preparatory to feeding movement of the slide and for moving each slide laterally away from its predetermined position at the end of the feeding movement and before the return movement of the slide.

27. In a metal-working machine, a plurality of spindles disposed in parallelism about a common axis, a plurality of tool slides, means for supporting said slides in coöperative relation to said spindles, said spindles being movable in fixed relation to each other about said axis so as to present the pieces of work to the several tools one after another, guides engaging said slides for guiding them upon said supporting means, means for moving said slides along said guides, said guides being movable laterally of the relative movement of the slides, and means for moving said guides laterally to position the tools.

28. In a metal-working machine, a plurality of spindles disposed in parallelism about a common axis, a plurality of tool slides, means for supporting said slides in coöperative relation to said spindles, said spindles being movable in fixed relation to each other about said axis so as to present the pieces of work to the several tools one after another, guides engaging said slides for guiding them upon said supporting means longitudinally of said axis, means for moving said slides along said guides, said guides being movable laterally relatively to the longitudinal movement of the slides, and means for moving said guides laterally preparatory to feeding the tools to the work, to determine the path of feeding movement of the tools and for moving said guides laterally at the end of the feeding movement to disengage the tools from the work, whereby scratching the work is avoided when the tool slides are retracted.

29. In a metal-working machine, a tool slide, a bed therefor, means for guiding the slide along the bed, said guiding means being movable laterally with relation to the bed, mechanism for laterally moving said guiding means, means for operating said mechanism to move said guiding means in one direction, and independent means for operating said mechanism to move said guiding means in the opposite direction.

30. In a metal-working machine, a tool slide, a bed therefor, means for guiding said slides along the bed, said guiding means being laterally movable, an eccentric connected with said guiding means to move the same laterally in one direction or the other,

and automatic means for turning said eccentric to determine the path of movement of said slide.

31. In a metal-working machine, an even number of horizontal work spindles disposed in parallelism about a common horizontal axis, said spindles being spaced equally in the number of degrees about said axis, a like number of horizontally movable tool slides arranged in pairs about said axis, the slides of each pair being in the same horizontal plane, and means for moving said spindles step by step about said axis into coöperative relation with said tool slides one after another.

32. In a metal-working machine, a bed, a work spindle, a tool slide movable longitudinally along said bed, gibs for the side edges of said slide, and a guide arranged between said gibs to guide the slide in its longitudinal movement, said guide being movable laterally with respect to said longitudinal movement.

33. In a metal-working machine, a frame, a rotatable turret thereon, a plurality of equidistant work spindles journaled to rotate in said turret and arranged about the axis of rotation of said turret, a series of beds in said frame and arranged in substantially parallel planes, substantially flat tool slides movable on said beds longitudinally of said work spindles, means for rotating said turret, and means for feeding and retracting said tool slides.

34. In a metal-working machine, a frame, a rotatable turret thereon, a plurality of equidistant work spindles journaled to rotate in said turret and arranged about the axis of rotation of said turret, a series of beds in said frame, substantially flat slides gibbed on said beds, and a plurality of cam drums for moving said slides longitudinally of said spindles.

35. In a metal-working machine, a set of work carriers and a set of coöperative tool carriers all arranged longitudinally of a common center, means for revolving the carriers of one set into successive registration with the carriers of the other set, a set of independent cam-carriers each rotatable about its individual axis to feed lengthwise a carrier of one of the first-mentioned sets, and independent variable-speed driving mechanisms for the several cam-carriers, in consequence of which each cam-carrier may be rotated at a rate of speed different from that at which the others are rotated.

36. In a metal-working machine, a set of work carriers, a set of tool carriers, means for revolving the carriers of one set into registration with the carriers of the other set, a set of independent cam carriers, each rotatable about its individual axis, to move the carriers of one set and effect a lengthwise feed of said carriers relatively to the

other carriers, an independent driving mechanism for each cam carrier, and means controlled by each cam carrier for disconnecting it from its driving mechanism.

37. In a metal-working machine, a set of work carriers, a set of tool carriers, means for revolving the carriers of one set into registration with the carriers of the other set, a set of independent cam carriers, each rotatable about its individual axis, to move the carriers of one set and effect a lengthwise feed of said carriers relatively to the other carriers, an independent driving mechanism for each cam carrier comprising variable speed gearing whereby said carrier may be fed independently of the others and at any one of several different speeds, and means for disconnecting said driving mechanisms from their respective cam carriers.

38. In a metal-working machine, a set of work carriers, a set of tool carriers, means for revolving the carriers of one set into registration with the carriers of the other set, a set of independent cam carriers, each rotatable about its individual axis, to move the carriers of one set and effect a lengthwise feed of said carriers relatively to the other carriers, a set of driving heads for the work carriers, and power-transmitting connections between said driving heads and said cam carriers respectively.

39. In a metal-working machine, a set of work carriers, a set of driving heads, one of said sets being movable about an axis to register successively with the members of the other set, a set of tool carriers, a set of cam carriers, each rotatable about its own axis, to advance and withdraw the tool carriers independently of each other, and means controlled by each cam carrier independently of the others for controlling the operation of the corresponding driving head.

40. In a metal-working machine, a set of tool carriers, a set of corresponding cam carriers for feeding the tool carriers, each cam carrier being rotatable about its individual axis, a set of corresponding driving heads, a set of rotatable work carriers movable successively into registration with the driving heads and the tool carriers, and means controlled by each cam carrier for connecting the corresponding driving head with the work carrier which registers therewith.

41. In a metal-working machine, a set of tool carriers, a set of corresponding independent cam carriers, each movable independently of the others for feeding its corresponding tool carrier, a rotatable turret carrying a set of work carriers and rotatable to present said work carriers successively to said tool carriers, means for rotating said turret with a step-by-step movement, and mechanism by which said means is controlled by the cumulative or combined actions of said cam carriers.

42. In a metal-working machine, a set of tool carriers, a set of corresponding independent cam carriers, each movable independently of the others for feeding its corresponding tool carrier, a rotatable turret carrying a set of work carriers and rotatable to present said work carriers successively to said tool carriers, means for rotating said turret with a step-by-step movement; means 10 for locking said turret, and mechanism by

which the operations of said turret-locking means and said turret-rotating means are controlled by the combined actions of said cam carriers.

In testimony whereof I have affixed my 15 signature, in presence of two witnesses.

JAMES HARTNESS.

Witnesses:

G. M. LACE,

J. W. WALKER.
