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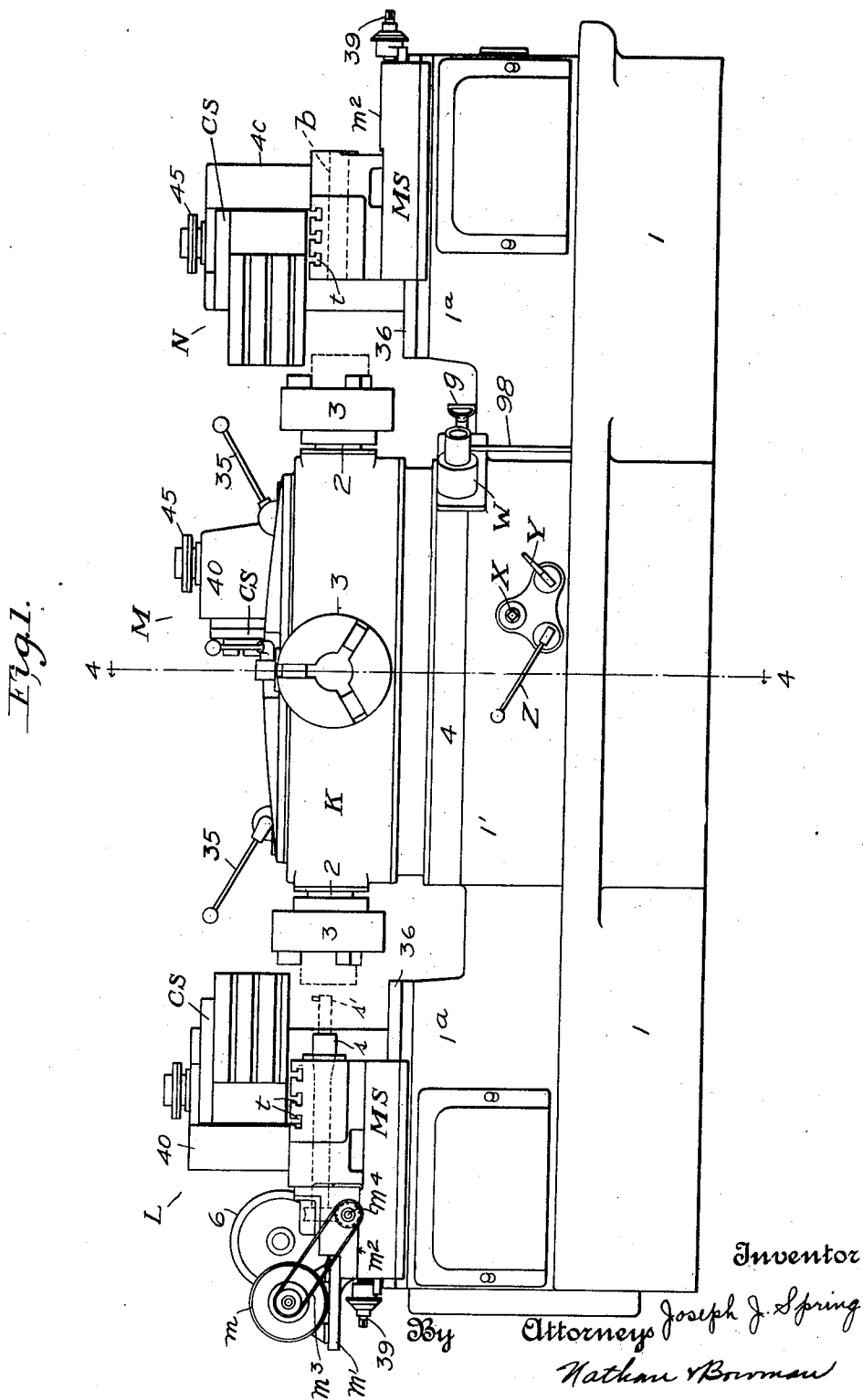
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1,933,500

RADIAL SPINDLE CHUCKING MACHINE

Filed March 1, 1930

14 Sheets-Sheet 1



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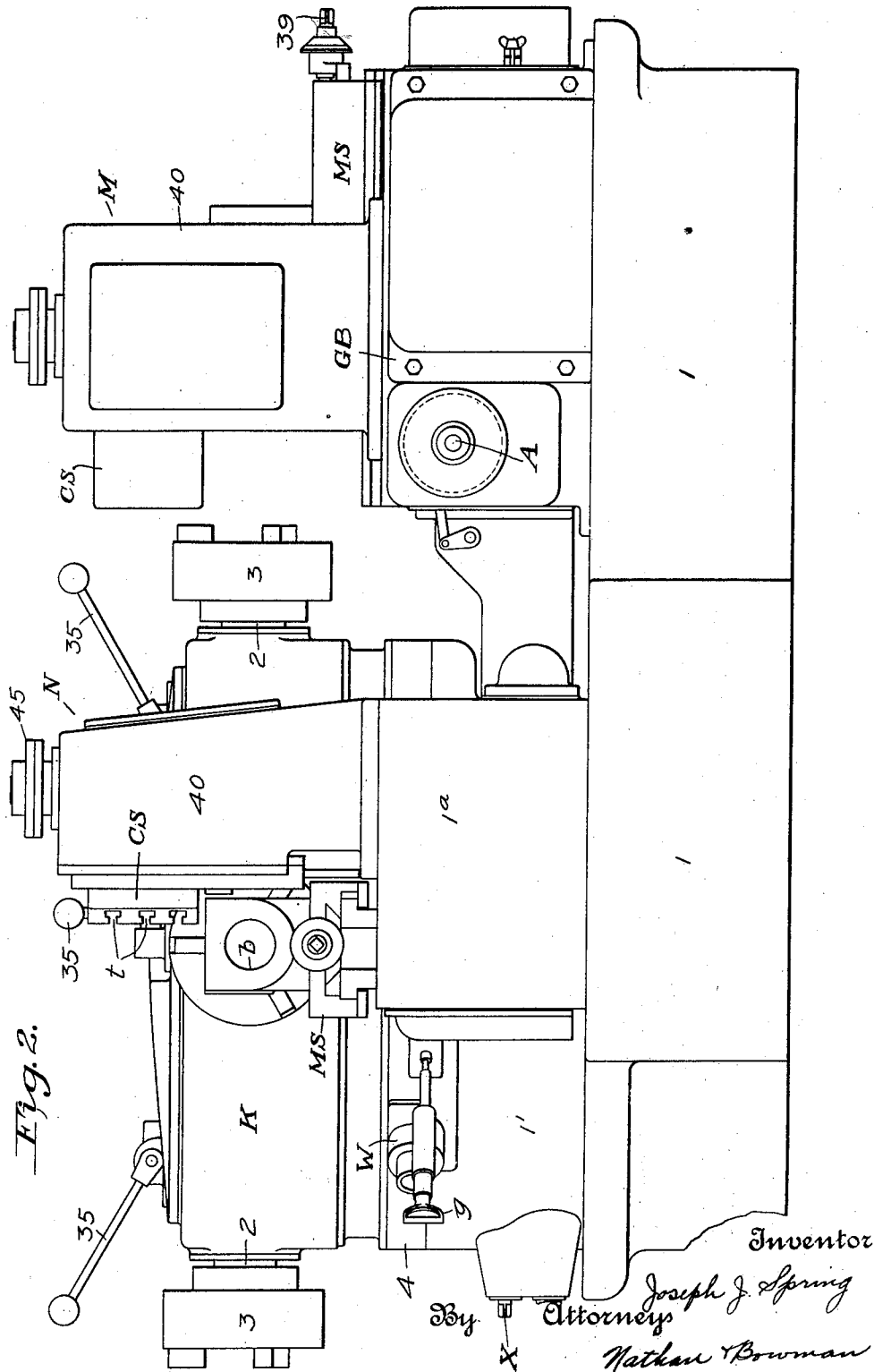
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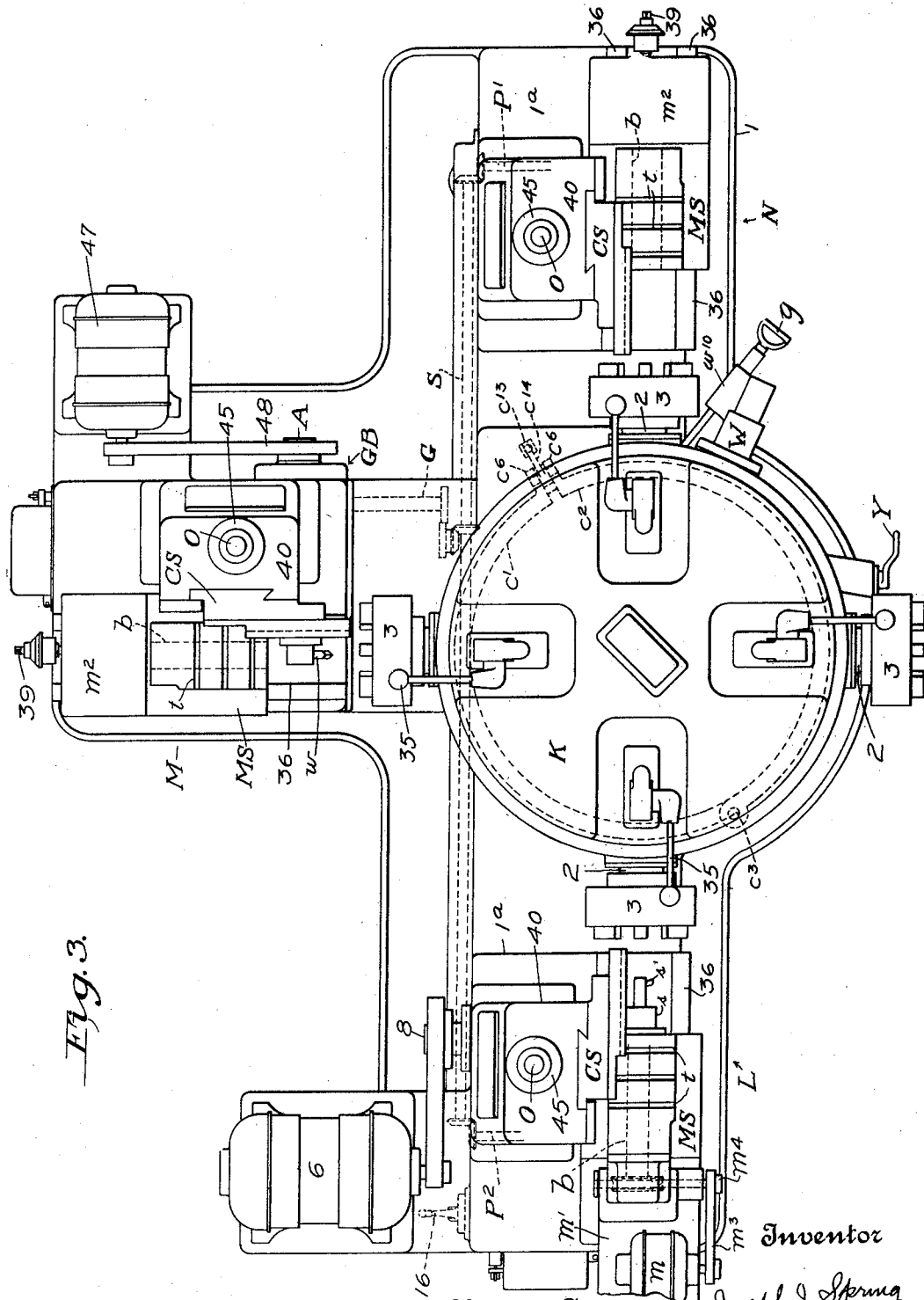


Fig. 3.

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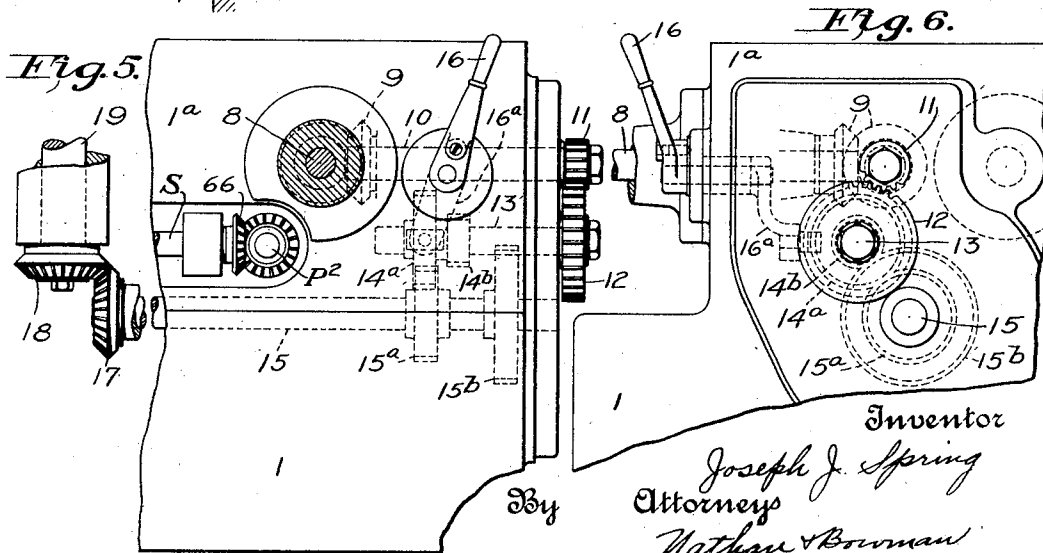
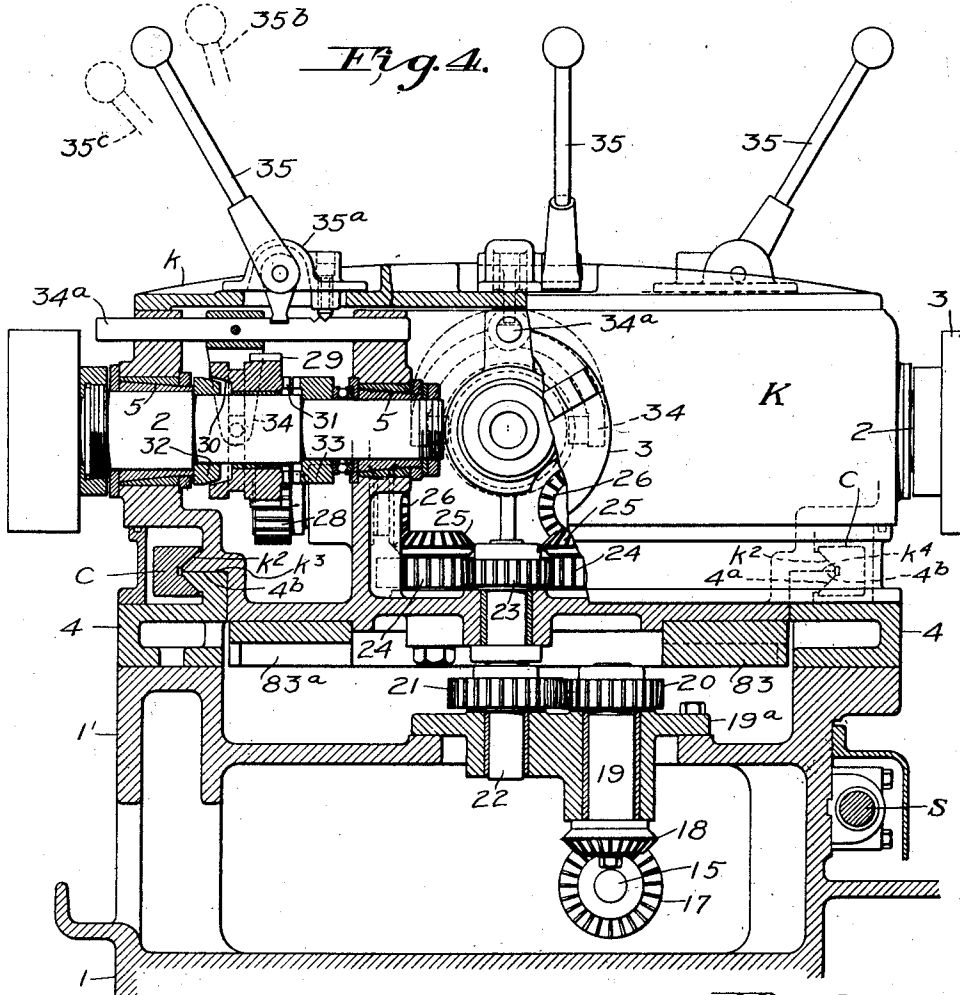
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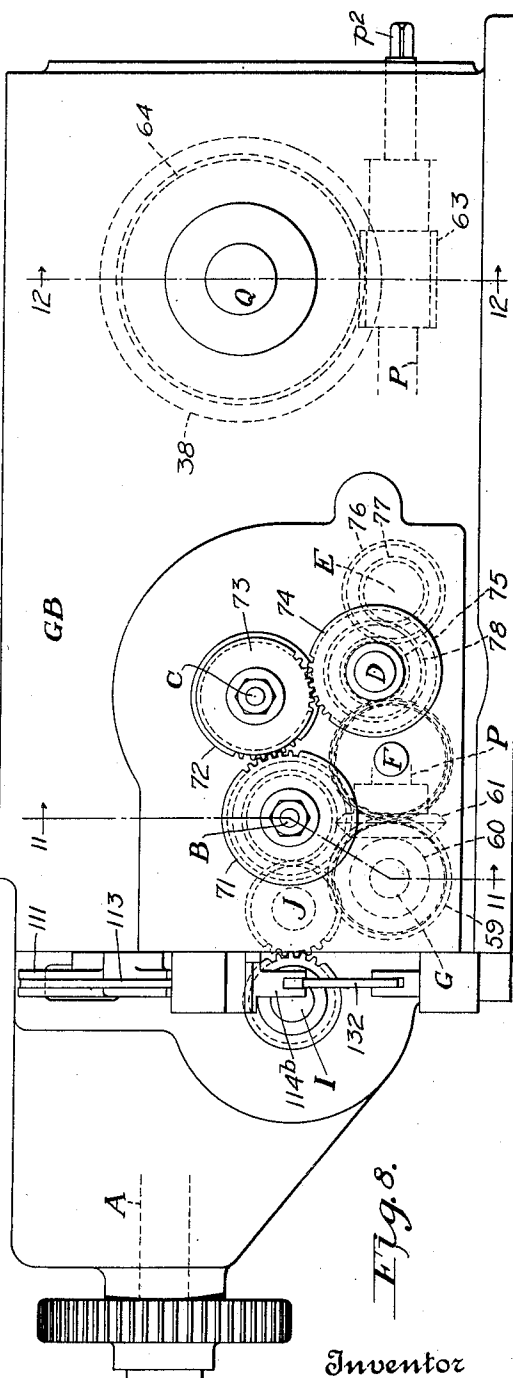
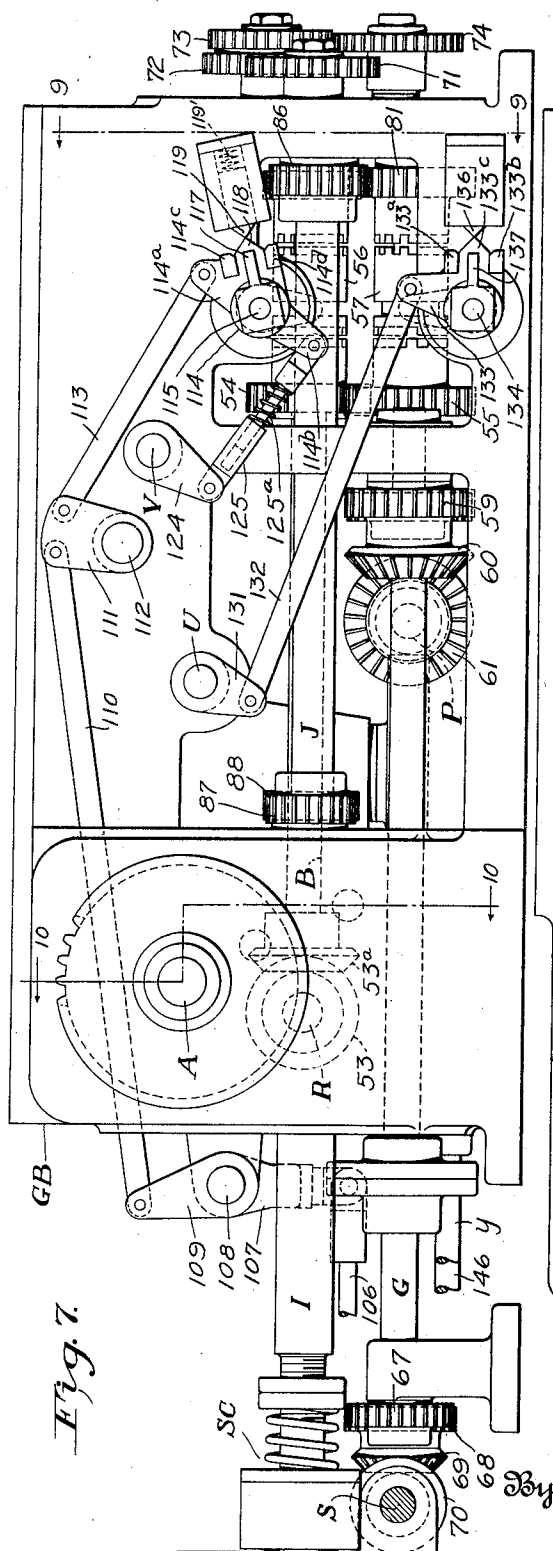
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RADIAL SPINDLE CHUCKING MACHINE

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RADIAL SPINDLE CHUCKING MACHINE

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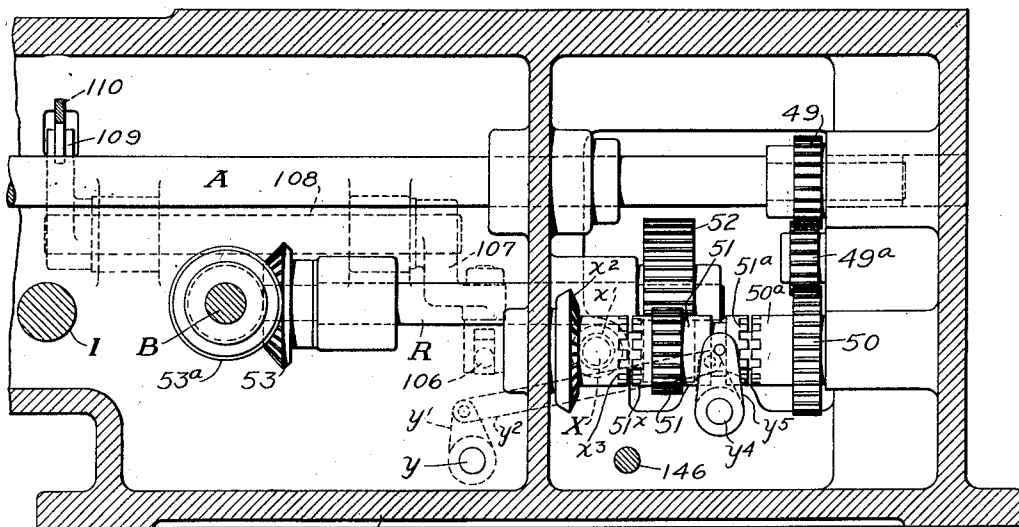


Fig. 10.

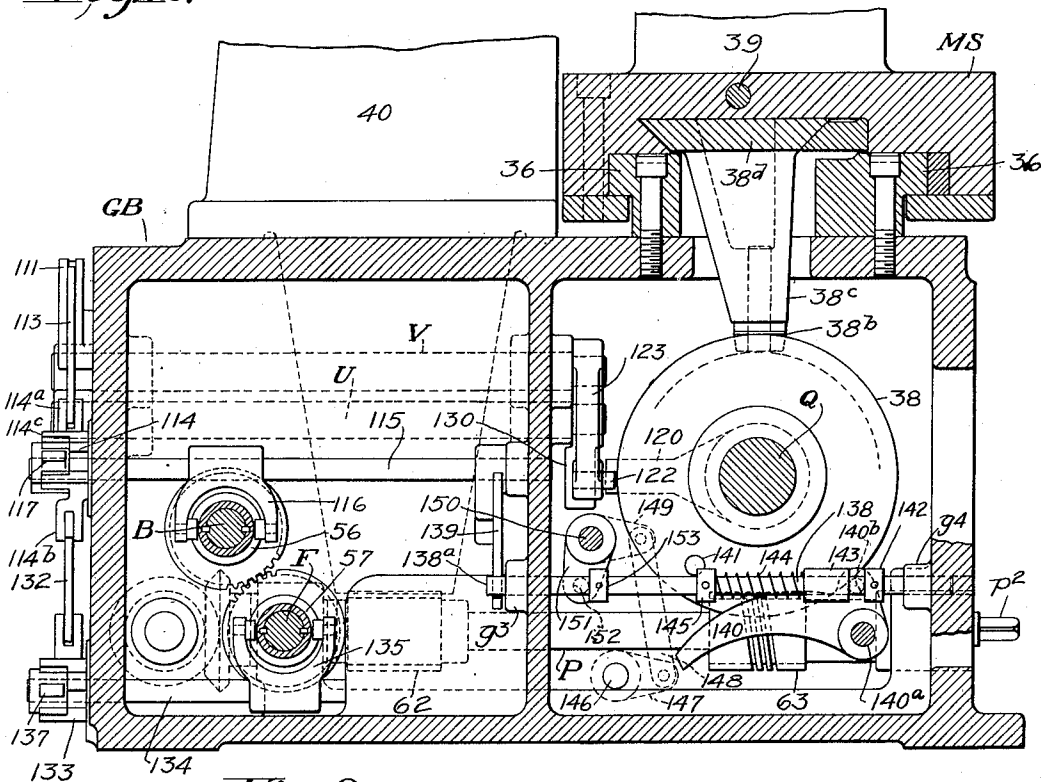


Fig. 9.

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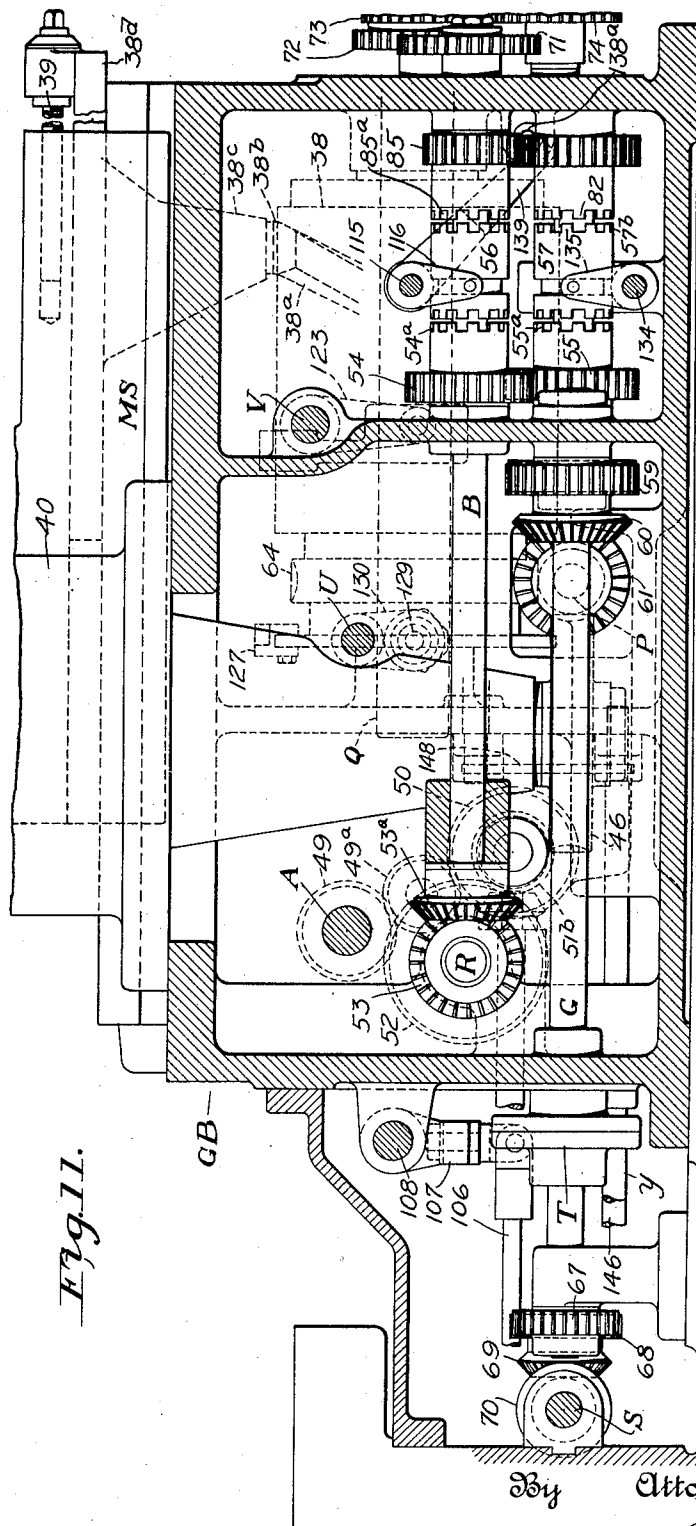


Fig. 11.

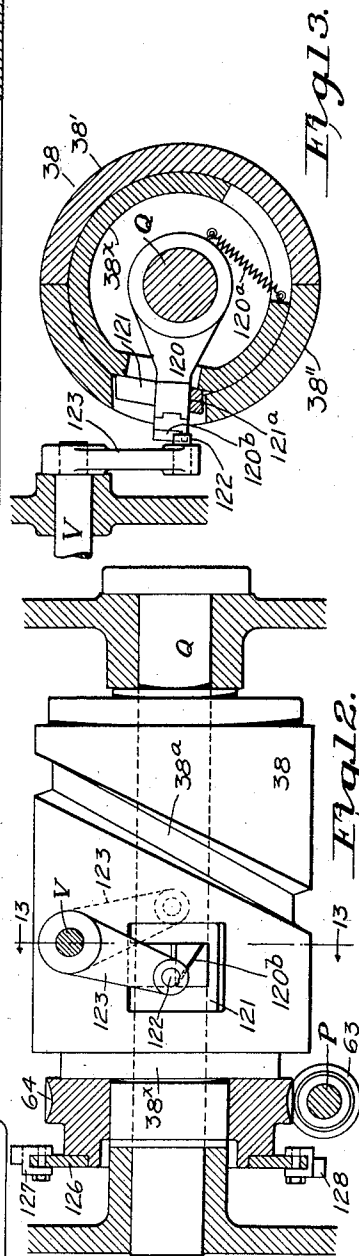


Fig. 13.

Fig. 12.

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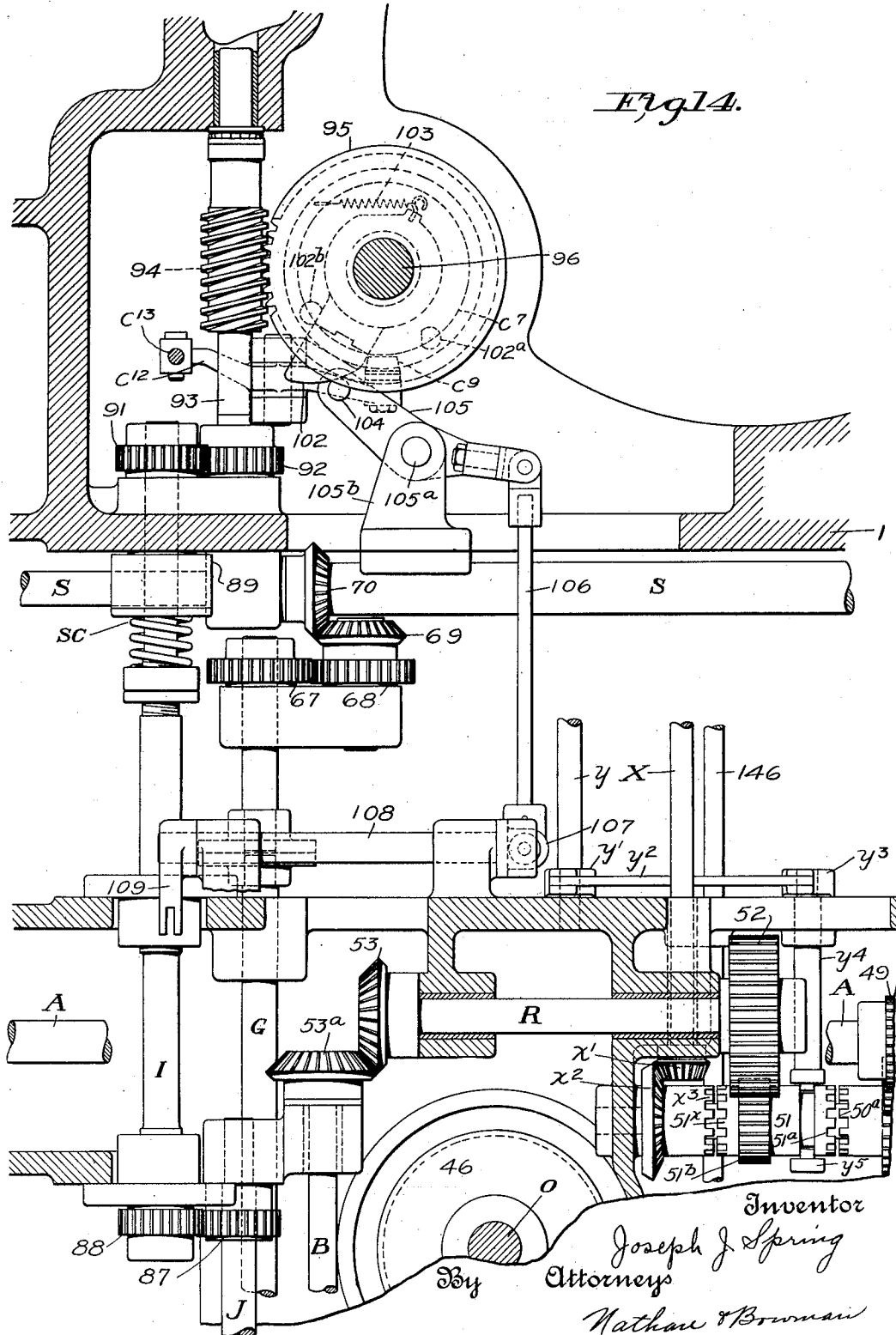
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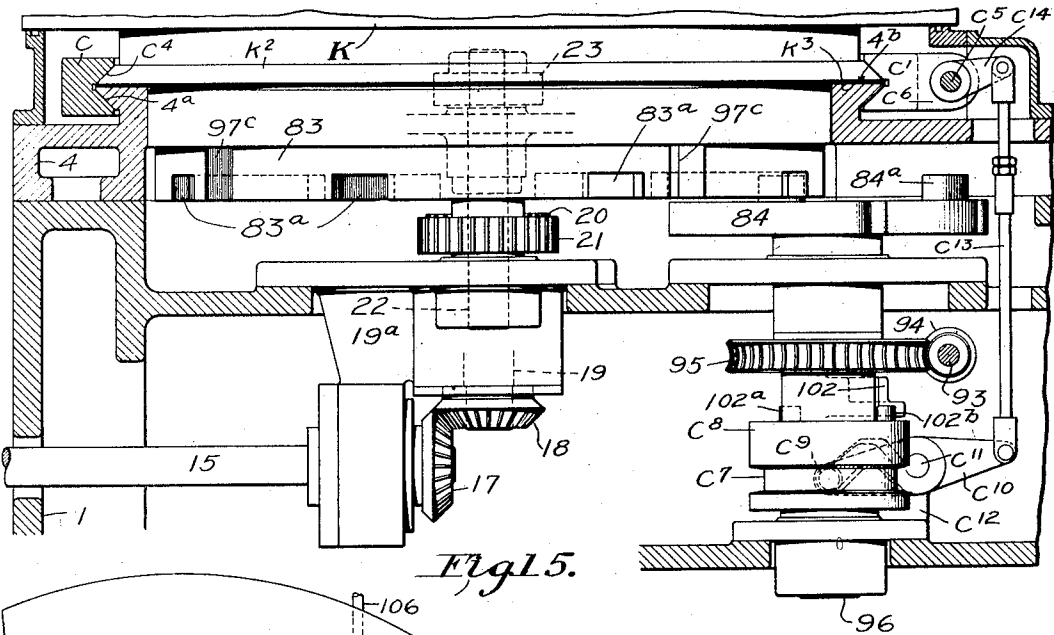


Fig. 15.

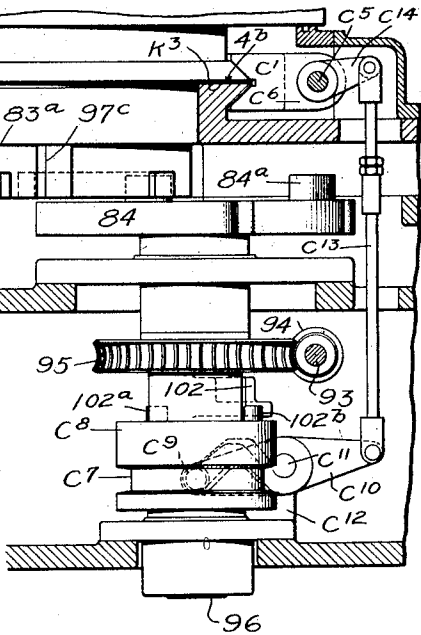
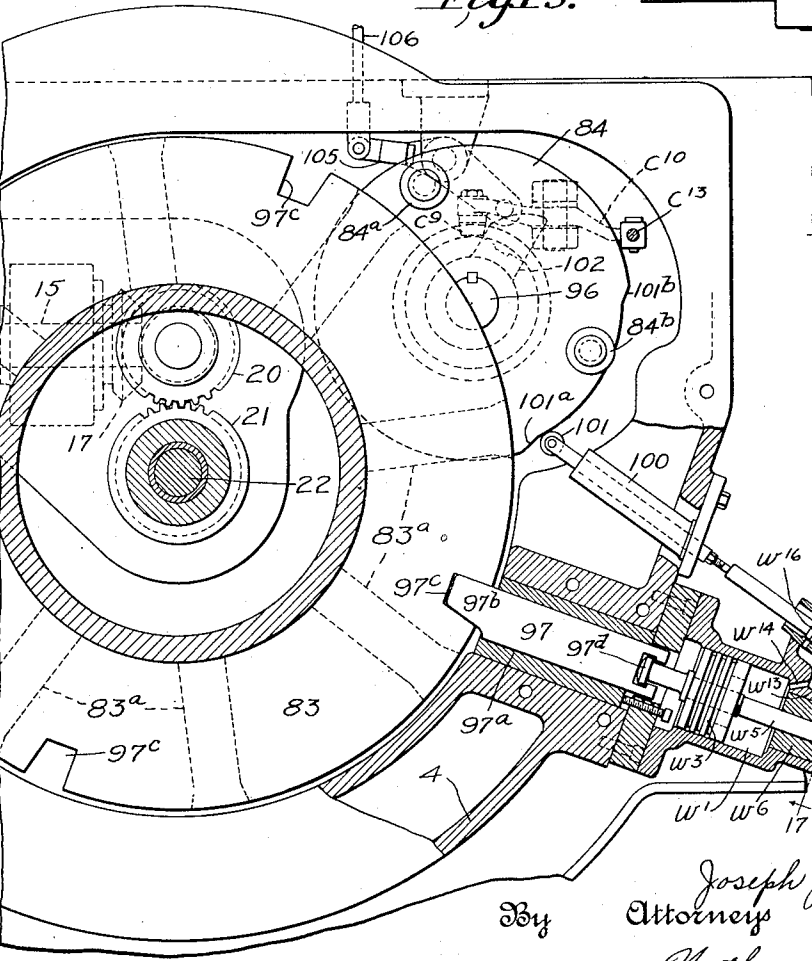


Fig. 16.



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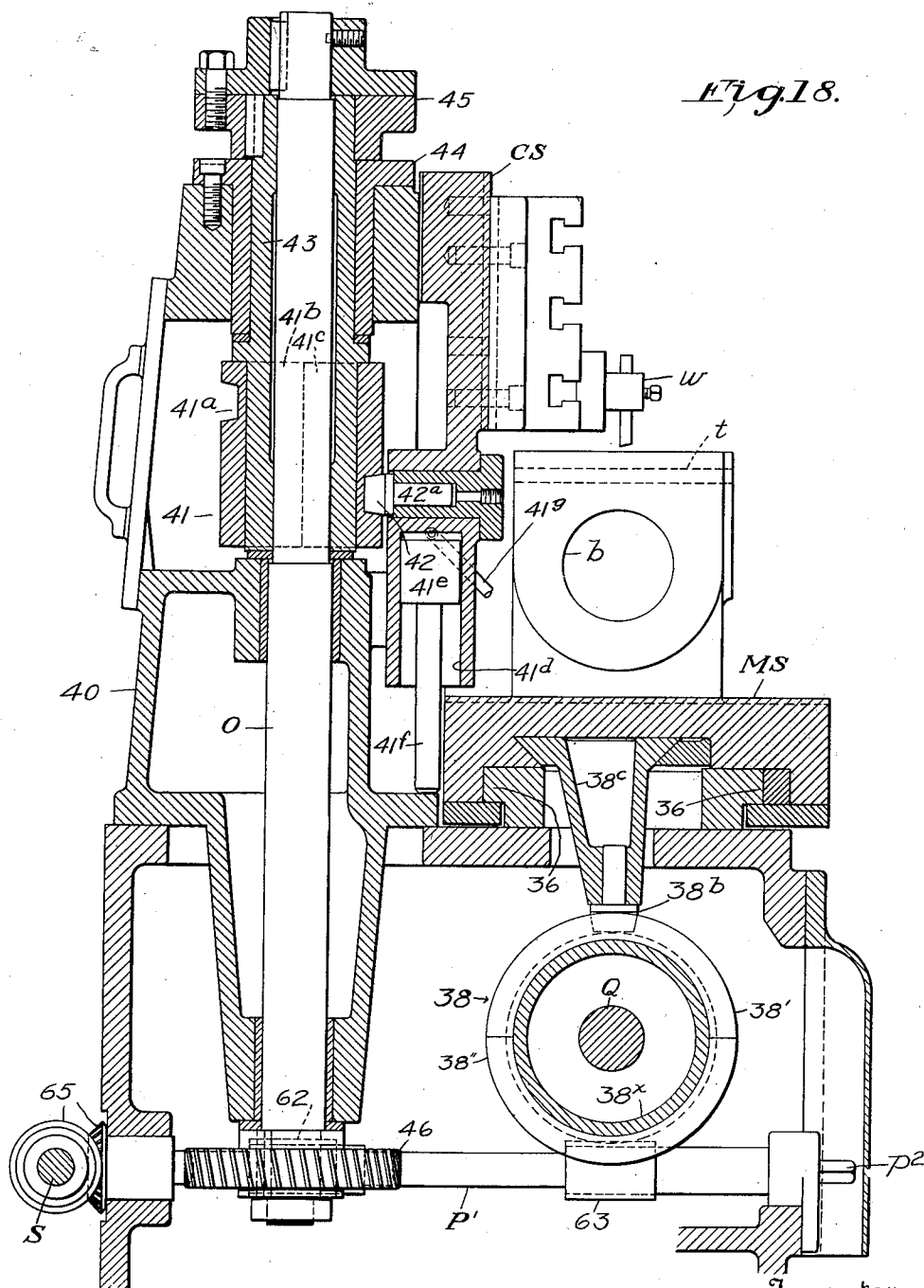
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RADIAL SPINDLE CHUCKING MACHINE

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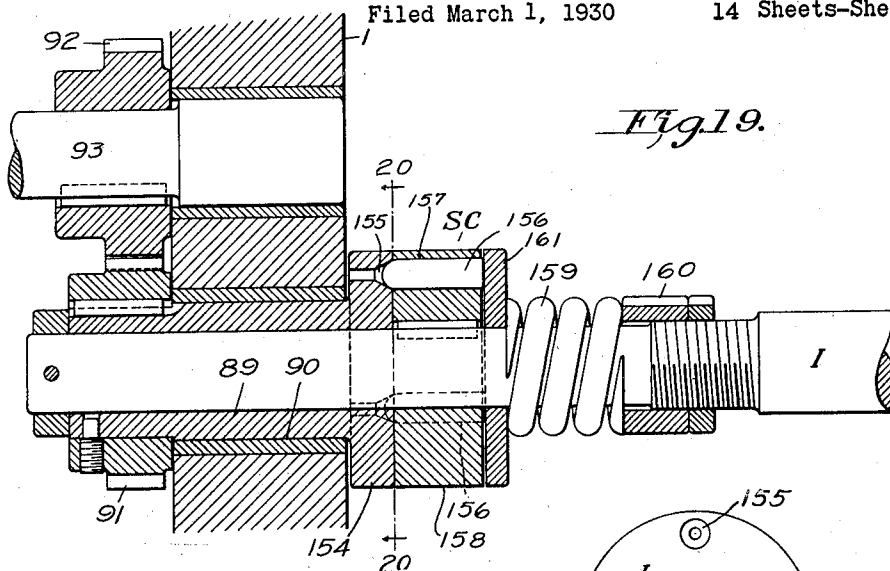


Fig. 19.

Fig. 20.

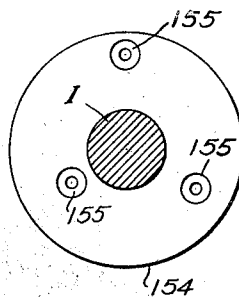


Fig. 22.

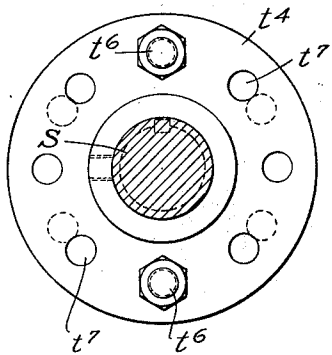


Fig. 21.

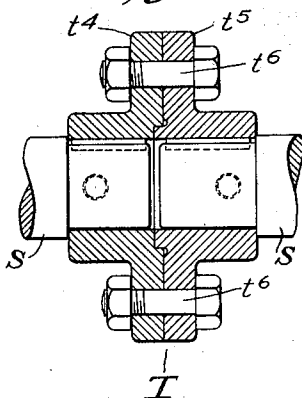
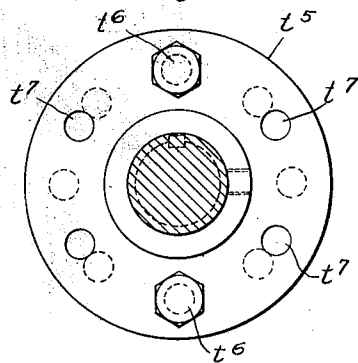


Fig. 23.



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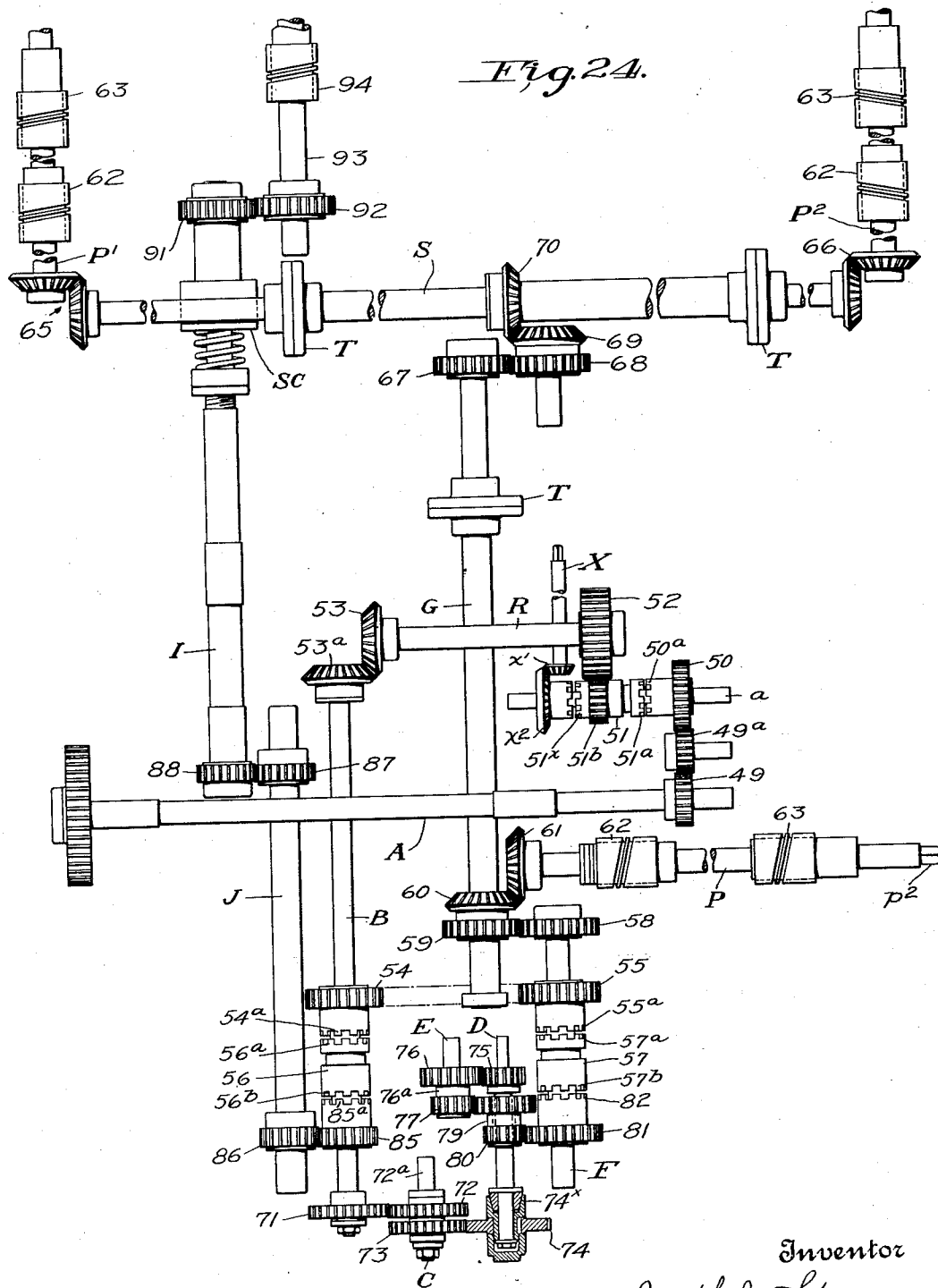
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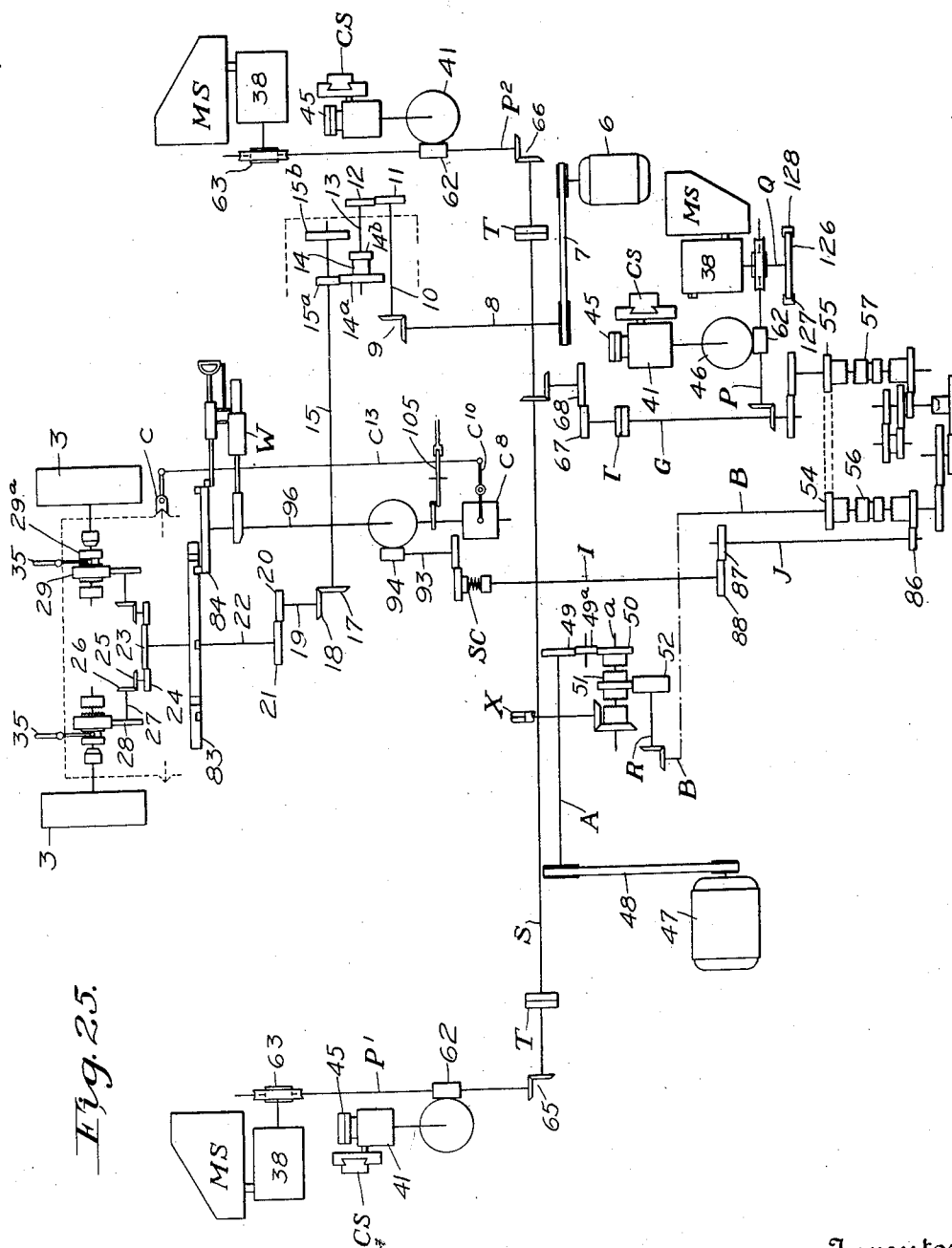


Fig. 25.

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Fig. 26

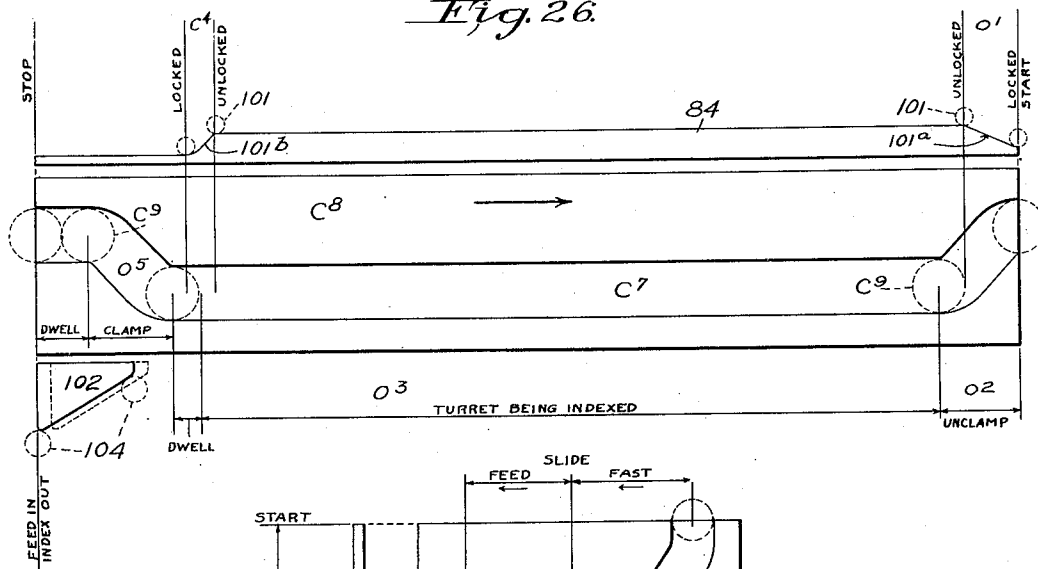
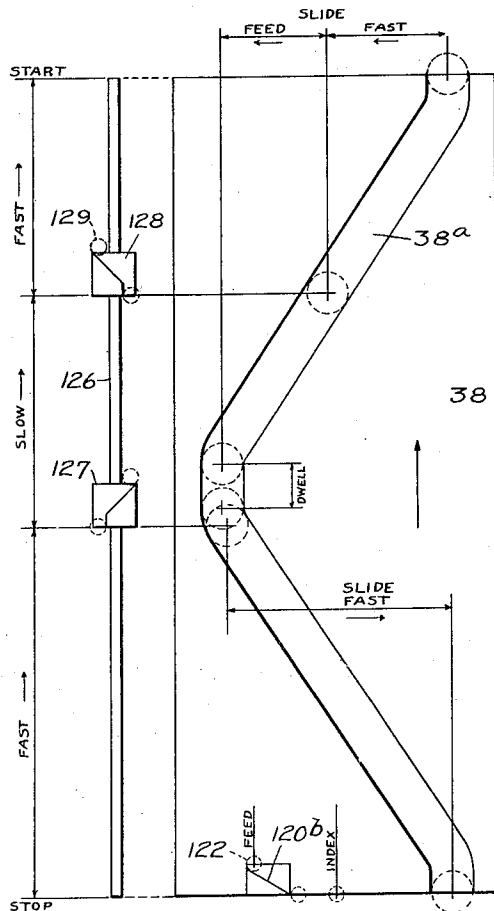


Fig. 27



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UNITED STATES PATENT OFFICE

1,933,500

RADIAL SPINDLE CHUCKING MACHINE

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Britain, Conn., a corporation of Connecticut

Application March 1, 1930. Serial No. 432,296

30 Claims. (Cl. 29—38)

This invention relates to chucking machines of that type in which work-pieces are carried by radially disposed rotating spindles and are presented successively to the action of a plurality of suitable tools located at separated tooling stations. A chucking machine of this type is disclosed in my application Serial No. 268,386, filed March 31, 1928, of which this application is, in part, a continuation.

One of the objects of this invention is to provide a chucking machine capable of handling relatively large work-pieces and so to construct the machine, that it will be comparatively universal in its action, being adapted to perform either internal or external operations (or both) at each of its tooling stations.

Another object is to provide common means for synchronously rotating all of the work spindles; to provide speed change means for simultaneously varying the rate of rotation of all of said spindles; to combine therewith means for giving to each tool an individual rate of feed and to provide individual means for varying the rate of relative rotation between certain ones of said work-spindles and certain ones of said tools.

A further object of the invention is to provide a simplified transmission for effecting rapid traverse and slow feeding movements of the tools, and indexing movements of the work turret and simplified automatic controls therefor, whereby all of those movements may be effected automatically in a predetermined cycle with comparatively few elements.

Still another object is so to combine the feed and index trains that each is adapted partially to control itself and the other and to embody in the feed trains means whereby it will be capable of varying its own rate of action.

A further object is so to combine the various trains that normally the operative cycle of the machine would be automatically repeated and to provide automatically actuated interference means, under the control of the operator, for bringing the machine to rest just prior to the beginning of a new indexing movement.

Another object is to eliminate the possibility of breakage of any part of the machine should for any reason, movement of the work turret be interfered with during the time that the turret indexing mechanism is in operation and to prevent any of the mechanisms getting out of time due to such interference.

A still further object of the invention is so to construct the machine parts and the various transmissions that they readily may be assembled and to provide in said transmissions means, in the nature of timing couplings, whereby each feed-cam may be timed individually with respect to its drive shaft.

Another object is to provide an improved pneumatically actuated turret locking means.

An object of the invention also is to provide a pneumatic counter-balance for one of the cam-actuated elements of the machine tool.

Other objects and advantages will be in part indicated in the following description and in part rendered apparent therefrom in connection with the annexed drawings.

To enable others skilled in the art so fully to apprehend the underlying features hereof that they may embody the same in the various ways contemplated by this invention, drawings depicting a preferred typical construction have been annexed as a part of this disclosure and, in such drawings, like characters of reference denote corresponding parts throughout all the views, of which:—

Figure 1 is a front elevation of a radial spindle chucking machine embodying this invention. Fig. 2 is a right end elevation thereof. Fig. 3 is a plan of Fig. 1. Fig. 4 is a section (partly in elevation) substantially on the line 4—4 of Fig. 1 showing the work-spindle driving train. Figs. 5 and 6 are side and end elevations, respectively, of a portion of the machine casing showing a speed change mechanism, later to be referred to, for varying the speed of rotation of all the work-spindles. Fig. 7 is a side elevation of a gear box containing speed change gearing and actuating means therefor, for varying the rate of translation of the tool-heads, said gear box also containing mechanism to render the feed and index mechanisms effective alternately. Fig. 8 is a right end elevation of the gear box illustrated in Fig. 7. Fig. 9 is a section substantially on the line 9—9 of Fig. 7. Fig. 10 is a section substantially on the line 10—10 of Fig. 7. Fig. 11 is a section substantially on the line 11—11 of Fig. 8. Fig. 12 is a section substantially on the line 12—12 of Fig. 8 showing the drive for one of the slide actuating cams, a portion of the index control means and a portion of the means alternately to render effective a fast and a slow feed train, all later to be described. Fig. 13 is a section substantially on the line 13—13 of Fig. 12 the parts being shown moved in the direction indicated by the arrow approximately ten degrees from the positions shown in Fig. 12. Fig. 14 is a horizontal sectional view through the gear box and a portion of the machine frame showing the drive to the index shaft, a portion of the tool feed actuating train and a portion of a feed control mechanism later to be described, said mechanisms being shown as viewed from the rear of the machine. Fig. 15 is a vertical sectional view through the turret support showing more particularly the indexing means for the turret and a turret clamping mechanism later to be described. Fig. 16 is a horizontal sectional view disclosing the turret in-

dexing mechanism and a turret locking mechanism later to be described, together with an automatically actuated control for said locking mechanism. Fig. 17 is a detail section on the line 17—17 of Fig. 16. Fig. 18 is a central vertical section through one of the main slides and one of the cross sides and their actuating means, all later to be described. Fig. 19 is a detail sectional view of an impositive driving coupling embodied in the index drive train. Fig. 20 is a section on the line 20—20 of Fig. 19. Fig. 21 is a central section of a timing coupling one of which is embodied in each of the three tool-head feed trains. Fig. 22 is a left side elevation of the timing coupling shown in Fig. 2. Fig. 23 is a right side elevation thereof. Fig. 24 is a development of the tool-head feed and turret indexing trains. Fig. 25 is a diagrammatic figure illustrating the spindle driving trains, the tool-head feed trains, the turret index trains, and the turret locking and clamping mechanisms. Fig. 26 is a diagrammatic view illustrating the relative timing of the turret lock, turret clamp, and turret indexing mechanisms. Fig. 27 is a diagrammatic view illustrating the main slide reciprocating cam in conjunction with the dogs which shift a clutch member alternately to render effective rapid and slow drives for said cam.

Referring more specifically to the drawings, the invention is disclosed as embodied in a chucking machine comprising a substantially T-shaped main frame or base 1 affording at its extremities, tooling stations indicated generally as L, M and N, each of which is adapted to be provided with one or more tools. Intermediate the tooling stations the base supports a turret K within which are rotatably journaled four equally spaced and radially disposed rotating work-spindles 2, each carrying, at its outer end, a suitable work-holder or chuck 3.

As clearly shown in Fig. 3 there is one more work-holder than there are work-stations, thus, during the machining operations, one work-holder will always be located between the tooling stations N and L. This idle position is used as a loading and unloading station at which the operator is located to place the unfinished work-pieces in the work-holders and to remove the finished work-pieces therefrom after they have been machined.

Stated briefly, the present machine includes the following mechanisms:

- (a) Spindle rotating mechanism,
- (b) Feed and traverse mechanism for tool slides,
- (c) Turret indexing mechanism,
- (d) Turret lock,
- (e) Turret clamp;

and suitable controls for all of said mechanisms.

For convenience, these mechanisms will be described in the order named:

Spindle rotating mechanism (Figs. 1, 4, 5, 6, 15 and 25)

As shown in Figs. 1 and 4, the turret K is journaled in and supported upon a ring 4, secured upon a central upstanding part 1' of the base 1. Within the turret are journaled, as in bearings 5, the rotatable work spindles 2 previously referred to. Power to rotate the spindles 2 is derived from a motor 6 mounted on the machine frame as shown in Figs. 1 and 3. This motor is connected by a chain 7, or other suitable transmission (see Fig. 25) with a shaft 8 journaled in an upstanding portion 1^a of the main frame 1.

A bevel gear set 9 connects the shaft 8 with a shaft 10 also journaled in the frame portion 1^a and which, as shown in Figs. 5 and 6, has one end extending exteriorly of said portion and has removably secured thereto a gear 11. This gear meshes with, and drives, a gear 12 removably secured upon the exposed free end of a shaft 13 also journaled in the frame portion 1^a. The gears 11 and 12 are in the nature of pick-off gears and may be removed and replaced by others having a different ratio, thereby to vary the speed ratio between the shafts 10 and 13.

Splined to shaft 13 is a gear unit 14 providing gears 14^a and 14^b adapted selectively to be meshed with complementary gears 15^a and 15^b on a shaft 15 journaled lengthwise of the machine frame. A hand lever 16, and arm 16^a actuated thereby, serve to shift the gear unit 14 selectively to mesh said gears.

The shaft 15 extends to within the upstanding portion 1' of the machine frame and carries at its forward end a bevel gear 17 which drives a similar gear 18 secured upon a short vertical shaft 19, journaled in a bearing bracket 19^a, secured to a portion of the main frame. A gear 20 fixed upon the upper end of the shaft 19 drives a gear 21 fixed upon a shaft 22 journaled, at one end, in the bracket 19^a and adjacent the other end in the turret K. To the upper end of shaft 22 is secured a gear 23, which meshes with and drives four gears 24, each of which carries a bevel gear 25 which in turn serves as a driver for a similar gear 26 fixed to a shaft 27 journaled in the turret K. A gear 28, also secured upon each of the shafts 27 is maintained permanently in mesh with a gear 29 provided by a spool 29^a rotatably and translatably journaled on each of the work spindles 2. Each of the spools 29^a affords also a friction clutch element 30 and a tooth clutch element 31 adapted selectively to be engaged respectively with a friction cone 32 and a tooth clutch element 33 both fixed upon the work spindle 2. A fork 34 engaging the spool 29^a, is secured upon an endwise movable rod 34^a journaled in the turret. Clutch actuating levers 35 journaled in brackets 35^a supported by a turret cover plate K, have portions engaging the slide rods 34^a selectively to engage the friction and toothed clutches. In the operation of the machine, after placing a work-piece in one of the chucks, the operator first pushes the lever forward to the position indicated by the dotted lines 35^b (Fig. 4). This connects the friction clutch element 30 on the continuously rotating spool 29^a with the then stationary clutch element 32 fixed to the tool-spindle, thus, starting the rotation of the spindle and work-piece impositively and without shock and undue strain on the spindle drive. After the spindle has attained a substantial speed of rotation the operator pulls the lever 35 to the position 35^a, thus, shifting the spool inwardly and engaging the toothed clutch elements 31 and 33. Thereafter the spindle is rotated positively.

From the foregoing it will be perceived that all of the work spindles are rotated in the same direction and at a common speed, which speed, however, may be varied as hereinbefore explained.

Tool slides and actuating means therefor

To effect relative bodily movement between the work-piece and the tools adapted to operate thereon, tools, located at the tooling stations L, M and N, preferably are supported on slides and these slides are given the necessary movements, 1st to carry the tool into contact with the work-

piece, 2nd to give the tool a feeding movement during the machining operation, and 3rd to retract the tool after the tooling operation is completed. Inasmuch as the machine is adapted to perform various types of operations, both internal and external, on various forms of work-pieces, it has been found advantageous to provide at each tooling station a plurality of tool supports. These supports are adapted to carry the tool required to perform the desired operation on the work-piece being machined. The machine is illustrated as providing, at each tooling station, a main slide MS fitted to move horizontally toward and from the work on guides 36 (see Fig. 13). At the stations L and N the guides 36 are provided by upstanding portions 1^a of the main frame, but at station M, for convenience of manufacture, they are provided by a sub-frame or gear-box GB supported upon the main frame and housing certain mechanism later to be described. The gear-box is in effect a portion of the main frame and may be so considered. Each of the main slides is given reciprocatory motion from a cam 38 secured upon a supporting drum 38^x carried by a rotary shaft Q journaled respectively in the upstanding portions 1^a and in the gear box GB. A cam groove 38^a formed in each of said cams is tracked by a roller 38^b carried by an arm 38^c depending from a slide 38^d having an adjustable connection with the main slide. The cam 38 is preferably made of two semi-cylindrical sections 38' and 38'' removably secured to a drum 38^x, as shown in Figs. 13 and 18. These sections may be removed and replaced by others affording a different cam groove, should the nature of the operation to be performed make this desirable.

An adjusting screw 39, journaled in an upward extension of each slide 38^d, is threaded into main tool slide and affords means for manually adjusting each main slide toward and from the work-piece and relative to its actuating cam.

Each main slide is provided at its upper side with a seat having therein a plurality of T-slots *t* adapted to have secured thereto any suitable form of tool-holder. Inasmuch as the tool-holder and the tool carried thereby may be conventional and form no part of this invention detailed illustration and description thereof is deemed unnecessary.

For certain operation, such, for example, as drilling, boring and reaming, it may be desirable to produce, between one or more of the tools and the work, a speed of relative rotation either faster or slower than the speed at which all of the work spindles are rotated. To that end, each of the main slides is preferably provided with a bore *b* within which may be journaled a tool spindle *s* adapted to carry a suitable tool *s'*. In Figs. 1 and 3, the main slide at the station L is shown as fitted with a rotary tool spindle. The main slides at the stations M and N may also be so fitted if the nature of the operation to be performed at those stations demands it.

To enable the tool spindle to be rotated either in the direction of, or in opposition to, the direction of rotation of the work spindle, thereby either to decrease or increase the rate of relative rotation between the work and the tool, individual variable speed reversible motors *m* may be secured upon brackets *m*¹ fitted to seats *m*² provided by each of the main slides. The motors *m* are each connected by a chain *m*³, or other suitable transmission, with a transverse shaft *m*⁴, journaled in the bracket *m*¹, which shaft is connected, as by a worm and worm-wheel, with the

tool spindle *s*. Conventional means (not shown) is provided for controlling the speed and direction of rotation of the motors *m*.

Certain machining operations require the use of an externally operating tool movable transverse to the axis of the work-piece. Any one or all of the stations L, M and N may, therefore, be provided with an upright standard 40 (see Figs. 1, 2, 3 and 18) upon which is slidably mounted, a vertically movable cross slide CS adapted to have a suitable tool secured thereto. The standards 40 are removably secured upon seats provided by the main frame and the gear-box. Reciprocatory movements are given to the cross-slides by a rotary cam 41 having a cam-groove 41^a tracked by a roller 42 journaled on a stud 42^a carried by the cross-slide. The cam 41 is preferably made of two semi-cylindrical portions 41^b and 41^c (similar to those of cams 38) which are secured upon a sleeve 43 journaled in a bearing 44 supported by the standard 40. A cam drive shaft O journaled in the standard 40 extends upwardly through the sleeve 43 and is connected to the sleeve by a timing coupling 45 similar to that disclosed in Figs. 21, 22 and 23 later to be described. A gear 46 on the lower end of each shaft O serves to transmit rotation to said shafts.

To reduce the load on the cross-slide cams 41 and thereby reduce wear on the cam grooves 41^a and rollers 42, pneumatic means is provided for sustaining the weight of the cross-slides and the parts carried thereby. This is effected by forming in the cross-slide a vertically disposed cylinder 41^d into which is fitted a piston 41^e fixed to a rod 41^f which rests upon a portion of the standard 40. Air pressure is admitted into the upper end of the cylinder as through a pipe 41^g. Sufficient air pressure is applied between the end of the piston and the cylinder end wall to substantially support the weight of the cross-slide and its attached parts thereby substantially balancing the cross-slide. The cam groove 41^a is, therefore, required to exert only a relatively slight pressure on the roller 42 to move the cross-slide either upwardly or downwardly.

Any suitable tool may be carried by the cross-slides CS and these tools may work independently of or in conjunction with the tools carried by the main slides. One form of tool-holder and tool *w* is illustrated in Fig. 18 and at station M in Fig. 3. It is to be understood, however, that other forms of tool-holders and tools may be substituted and that the cross-slides at the stations L and N also may carry tools.

Power to rotate the cams 38 and 41 is provided by a motor 47 mounted on a suitable portion of the machine frame. This motor is connected by a chain 48 or other suitable transmission, with one end of a shaft A journaled in the gear-box GB supported upon the rearwardly extending portion of the main frame, adjacent the tooling station M. The opposite end of the shaft A carries a gear 49 which drives, through an intermediate gear 49^a, a gear 50 rotatably journaled on a short shaft *a* secured in the gear-box. A spool 51 rotatably and translatably mounted on the shaft *a* provides a toothed clutch element 51^a, adapted to engage a toothed clutch element 50^a integral with the gear 50, and a gear 51^b permanently in mesh with a gear 52 fixed upon a shaft R also journaled in the gear-box. The shaft R carries a bevel gear 53, which drives a similar gear 53^a secured upon a shaft B. Power may be taken from the shaft B through either of two trains, thereby to rotate the tool-slide feed-

cams 38 and 41 either at a rapid rate to effect rapid traverse of the tools to and from the work or at a slow feeding rate during the machining operation. For convenience, one train may be considered the main transmission and the other a supplemental transmission. The rapid traverse train will be described first.

Rapid traverse for tool slides

- 10 Rotatably journaled on the shaft B is a gear 54 permanently in mesh with a gear 55 rotatably mounted on a shaft F journaled in the gear-box. A clutch spool 56, splined to the shaft B, provides toothed clutch teeth 56^a adapted to be engaged with similar clutch teeth 54^a integral with the gear 54. A similar clutch spool 57 splined to the shaft F has clutch teeth 57^a adapted to engage clutch teeth 55^a carried by the gear 55. Thus when the clutch elements 56 and 57 are shifted to the left in Figs. 7 and 11 and upwardly in Figs. 24 and 25, rotation will be transmitted to the shaft F at substantially the speed of rotation of the shaft B. A gear 58, fixed upon the shaft F drives a gear 59 secured upon a shaft G, also journaled in the gear-box. A first branch line feed shaft P, journaled in the gear-box transverse to the shaft 6 and driven therefrom by bevel gears 60 and 61, carries a first worm 62 which meshes with and drives the cross-slide driving gear 46, and a second worm 63 meshing with a worm-wheel 64 fast upon the main-slide cam-shaft Q.

- Journalled lengthwise of the main frame 1 is a shaft S, (see Figs. 3, 4, 11, 24 and 25) connected by bevel gear sets 65 and 66 with second and third branch line feed shafts P¹ and P² similar to shaft P extending beneath the tooling stations N and L respectively. Each of these shafts also has secured to it a cross-slide actuating worm 62 and a main slide actuating worm 63 connected to actuate said slides as hereinbefore described. The shaft S is driven from the shaft G by spur gears 67 and 68 and bevel gears 69 and 70.

- With the clutch elements 56 and 57 engaged with the clutch teeth 54^a and 55^a rapid rotation will be transmitted to the cams 38 and 41 located at each of the tooling stations and this rapid rotation is employed rapidly to translate the tools to and from the work-pieces. These rapid movements are highly desirable inasmuch as it reduces, to a minimum, the time required for the working cycle.

Slow feed for tool slides

- 55 As hereinbefore stated, rotation may be transmitted from the shaft B to the shaft F at a reduced rate and thence to the tool slides to give to the tools a relative slow feeding movement during the tooling operation. This is effected as will now be described. Removably secured upon the shaft B, exteriorly of the gear-box is a gear 71 which drives a gear 72 journaled on a stub shaft 72^a secured in the gear-box. Removably secured to the gear 72 is a gear 73 which drives a gear 74 removably and frictionally secured at 74^x upon one end of a shaft D also journaled in the gear-box. The gears 71—72 and 73—74 are in the nature of pick-off change gears and may be removed and interchanged with others having a different ratio. Adjacent the other end of the shaft D, there is secured a relatively small gear 75 which drives a larger gear 76 forming a part of a gear unit 76^a rotatably journaled on a stub shaft E and affording also a smaller gear 77. This latter gear drives a

larger gear 78 forming a part of a gear unit 79 rotatably journaled on the shaft D. A smaller gear 80, also provided by the gear unit 79, is permanently in mesh with a relatively large gear 81 rotatably journaled on the shaft F. Integral with the gear 81 is a toothed clutch portion 82 adapted to be engaged by a toothed portion 57^b of the clutch element 57 previously referred to. From the foregoing it will be perceived that with the clutch element 56 shifted to engage the clutch teeth 56^a and 54^a and the clutch element 57 shifted to engage the clutch teeth 57^a and 54^a rapid rotation will be transmitted to the shaft F, whereas by leaving the clutch teeth 56^a and 54 engaged and shifting the clutch element 57 to engage the clutch teeth 57^b and 82 slow rotation will be transmitted to the shaft F. The speed of rotation of the feed cams, and thereby the speed of translations of the tool slides, is proportionate to the speed of rotation of the shaft F. The frictional mounting of the gear 74 comprises a safety device for the feed train.

The power drive from the main feed shaft A to the feed drive trains may be interrupted by manually shifting the spool 51 to the left (Figs. 10, 14 and 24), thereby disengaging the clutch-teeth 50^a and 51^a. For this purpose a feed control lever Y is located at the front of the machine. This lever is fixed upon one end of a shaft y having at its other end an arm y¹ connected by a link y² to a similar arm y³ secured to a shaft y⁴ journaled in the gear-box. A clutch shifting fork y⁵ is secured upon the shaft y⁴ and engages the spool 51 to move it axially.

Hand feed and index

Manual means also is provided for actuating the feed trains and turret index. This means comprises a shaft X extending to the front of the machine, and having a squared end adapted to receive a suitable actuating crank, not shown. On the inner end of shaft X, there is secured a bevel gear x¹ which meshes with a bevel gear x² rotatably journaled on the shaft a. Fixed to gear x² is a clutch element affording clutch teeth x³ adapted to be engaged by clutch teeth 51^x provided by the spool 51. The lever Y and the parts connected therewith, also serve to shift the spool 51 to engage the clutch teeth 51^x and x³ thereby to render the manual drive effective. This manual drive may be used to advantage in setting up the machine for any specific work-piece.

Turret indexing mechanism

As hereinbefore stated, the work turret K is periodically indexed to carry a work-piece from the initial or loading station successively to the tooling stations L, M and N and thence back to the initial station where the finished work-piece is removed from the chuck. Each of these ninety degree movements of the work turret is effected by a two-stage index movement produced by an improved Geneva index mechanism comprising a slotted disk 83 secured to the underside of the work turret and having radial slots 83^a formed therein. These slots are engaged by rollers 84^a and 84^b carried by a rotary disk 84 which is given one complete rotation for each ninety degree movement of the turret. The rollers are so located on the disk 84, that they are not on diametrically opposite sides of the axis thereof. This produces a continuous movement of the turret, after which the disk 84 has a further movement for a purpose later to be explained.

Power to actuate the indexing mechanism may

be obtained from any suitable source but preferably it will be taken from the tool-feed train as shown in Figs. 24 and 25. To that end, there is rotatably journaled on the shaft B a gear 85 adapted, at certain times, to be secured to said shaft by the clutch spool 56, clutch teeth 56^b of said spool being adapted to engage similar teeth 85^a formed on the hub of the gear 85. This gear drives a gear 86 fixed adjacent one end of a shaft J journaled in the gear-box, which shaft carries adjacent its opposite end a gear 87 connected by gear 88 with a shaft I having its rear end journaled in the gear-box. The forward end of the shaft I is fitted within a sleeve 89 journaled in a bearing 90 provided by the main frame (see Fig. 19). A slip coupling SC, later to be described, intervenes between the shaft I and the sleeve 89. A gear 91, secured upon the sleeve 89, drives a gear 92 fixed to a shaft 93 journaled in the main frame and upon this shaft is secured a worm 94 which drives a worm-wheel 95 fixed upon a shaft 96, to which the index disk 84 also is secured.

Turret lock

To accurately locate the turret and to insure against its accidental movement during the machining operation a turret-locking mechanism is rendered effective after each complete indexing movement of the turret. This mechanism comprises a lock-bolt 97 slidably fitted in a guide-way 97^a provided by the ring 4. The forward end of the bolt is tapered as indicated at 97^b and this tapered end engages similarly shaped notches 97^c formed in the periphery of the disk 83. One wall of each notch 97^c and the complementary wall of the lock-bolt are arranged substantially radial to the disk 84. The opposite walls of the notch and lock-bolt are at a substantial angle to said radial wall and serve, upon advance of the lock-bolt, to cam the turret to a predetermined angular position, which position is determined by engagement of said radial walls. By reason of this construction, the radial walls serve merely as abutments and are not subjected to wear. Any wear on the bolt and walls of the locking notches is effected on the inclined sides thereof and this does not affect the accurate positioning of the work turret but merely necessitates a slightly greater movement of the locking bolt. The lock-bolt 97 is preferably actuated by fluid pressure and its movements are automatically controlled in timed relation with the indexing mechanism.

A differential fluid-pressure motor W having relatively large and small cylinders w^1 and w^2 , (see Fig. 16), separated by a partition w^6 , contain similarly large and small pistons w^3 and w^4 , respectively. These pistons are secured to a piston rod w^5 and the cylinders are supported by the ring 4 adjacent the rear end of the lock-bolt. The pistons are connected with the lock-bolt by any suitable means, such for example as by the connection 97^d shown in Fig. 16. A fluid pressure line 98 is permanently connected by a port w^7 with the smaller cylinder w^2 at a point between the partition w^6 and the piston w^4 , whereby the fluid pressure in the cylinder w^2 constantly tends to retract the lock-bolt. The fluid pressure line is also connected by a port w^8 , with a chamber w^9 formed in a valve casing w^{10} . A piston valve w^{12} slidable in the casing w^{10} permits (in one position) fluid under pressure to flow from the chamber w^9 through ports w^{13} and w^{14} into the large cylinder w^1 between the piston w^3 and the partition w^6 . Thereupon the pressure on the larger piston overcomes the pressure on the smaller piston and advances

the lock-bolt into locking position. In another position of the valve w^{12} a cylindrical portion w^{15} of the valve closes the port w^{13} and opens an exhaust port w^{16} whereupon the cylinder w^1 is opened to the atmosphere and pressure in the cylinder w^2 behind the piston w^4 retracts the lock-bolt.

A spring 99, enclosed in the valve casing, normally tends to shift the valve inwardly to the position shown in Fig. 16. To effect automatic actuation of the valve in timed relation with the indexing mechanism the inner end of the valve stem is passed through a guide 100 and carries a roller 101 which tracks the periphery of the index disk 84. A cam 101^a on the periphery of the disk 84 acts upon initial movement of the disk, to force the valve outwardly in opposition to the spring 99 to effect retraction of the lock-bolt. Near the end of the indexing movement of the disk 84, the roller 101 rides down the incline 101^b and thereby the valve is shifted to the position which causes the lock-bolt to be advanced. The valve w^{12} also may be retracted manually by the hand grasp g should circumstances require it.

Turret clamp

To insure absolute rigidity during the machining operations, this invention provides means rendered operative after each indexing of the turret, for clamping the turret to a stationary part of the machine. This is preferably effected by a clamp c of annular form comprising two semi-circular members c^1 and c^2 (see Figs. 3, 4 and 15) hinged together at c^3 and having inner V shaped grooves c^4 with walls diverging outwardly to receive and cooperate with opposed annular tapered flanges k^2 and 4^a provided by the turret K and ring 4, respectively.

The clamping ring members surround the flanges k^2 and 4^a peripherally and the tapered walls of the grooves embrace the tapered flanges laterally. The ring members are adapted to be constricted about the tapered flange walls thereby to force the lower horizontal seat k^3 of the turret down upon the upper horizontal seat 4^b of the ring 4 and to clamp the ring and turret against relative movement. Contraction of the ring members is preferably effected by a right and left threaded screw c^5 having its opposite ends threaded into ears c^6 projecting from said ring members. The screw c^5 is rotated, to open and close the clamp c , in timed relation with the turret indexing mechanism. To that end a cam groove c^7 , formed in a drum c^8 fixed to the turret indexing shaft 96, is tracked by a roller c^9 , carried by one end of a lever c^{10} , fulcrumed at c^{11} in a bracket c^{12} , supported by the main frame. The other end of the lever c^{10} is connected to one end of a link c^{13} whose other end is connected with an arm c^{14} fixed to the screw c^5 .

Traverse, feed and index control mechanism

As hereinbefore pointed out, the turret indexing train and tool-feed train are alternately rendered effective by shifting of the clutch spool 56 alternately to engage the clutch teeth 56^b—85^a and 56^a—54^a. Each of these two trains actuates mechanism which in turn shifts the clutch-spool to discontinue the drive to the then operative mechanism and to further shift the clutch-spool to render effective the other train. For example, the index mechanism causes the clutch-spool to be shifted to disconnect the index clutch-teeth 56^b and 85^a and to engage the clutch-teeth 56^a and 54^a of the feed drive train.

Likewise, rotation of the feed shaft Q at station M shifts the clutch-spool 56 to discontinue the drive to the feed train and to connect the index drive.

Rotatably journaled on the index shaft 96 beneath the worm-wheel 95 is an arm 102 normally held in contact with a stud 102^a, carried by the turret clamp cam drum c⁸, by a coil spring 103 connecting the hub of the lever with said cam drum (see Fig. 14). During the rotation of the index disk 84, the rounded outer end of the arm 102 engages a stud 104 carried by one arm of a two-armed lever 105 fulcrumed at 105^a in a bracket 105^b secured to the main frame. A detent 119, later to be referred to, temporarily holds the lever 105 against oscillation whereupon the shaft 96 and cam drum c⁸ continue to rotate independent of the arm 102, the spring 103 being extended and put under tension. Continued rotation of the cam drum c⁸ brings a stud 102^b into contact with the rear wall of the lever 102, as shown in Fig. 14. A further slight rotation of the drum, and pin 102^b carried thereby, swings the lever 102 counter-clockwise causing its rounded outer end to exert a cam action on the stud 104, thereby overcoming the action of the detent hereinbefore referred to and causing the lever 105 also to be swung counter-clockwise. The other arm of the lever 105 is connected by a link 106 to an arm 107 secured upon one end of a shaft 108 journaled in bearings provided by the gear-box. To the other end of the shaft 108 is secured an arm 109 to which is connected one end of a link 110 which, at its other end, is connected to a swinging arm 111 journaled on a stud 112 fixed in the gear-box. A second link 113 connects the arm 111 with one arm 114^a of a two armed lever 114 rotatably mounted upon a shaft 115 journaled in the gear-box, which shaft has secured to it a fork 116 engaging the clutch-spool 56.

Fixed upon the outer end of the shaft 115 is an arm 117 having its free end arranged between lugs 114^c and 114^d projecting from the lever 114. The lever 114 is also formed with a bevelled nose 118 engaging the bevelled end of a spring pressed plunger 119 slidably mounted in a casing supported by the gear-box. This plunger 119 comprises the detent means which temporarily holds the lever 105 against swinging when the stud 104 thereof is first engaged by the arm 102. As shown in Fig. 7, the lever 114 is in an intermediate position through which it passes in shifting the clutch-spool from feed to index position and vice versa. During the feeding of the tool heads the plunger 119 engages the upper inclined wall of the nose 118 and during the index of the turret it engages the lower inclined wall thereof. Due to the lost motion between the lugs 114^c and 114^d and the arm 117 and the action of the spring plunger on the nose 118 of the lever 114, those elements constitute a carry-over mechanism for completing the shifting of the clutch-spool 56. As the rounded outer end of the arm 102, acting on the stud 104, cams the lever 105 counter-clockwise, the lever 114 is rotated clockwise, causing the lower inclined wall of the nose 118 to wipe past the nose of the plunger 119 depressing it in opposition to its spring 119' until the apex of the nose has reached the apex of the plunger, as shown in Fig. 7. This initial movement of the lever 114 has no effect upon the arm 117 or the shaft 115 and fork 116 connected therewith. Instantly upon the passing of the apex of the nose beyond the apex of the plunger, the spring 119'

forces outwardly on the plunger and its lower bevelled edge acts upon the upper bevelled edge of the nose 118, thereby giving the lever 114^a quick rotation in a clockwise direction. This movement causes the lug 114^c to engage the arm 117 and give it and the shaft 115, and fork 116 connected therewith, a similar clockwise movement thereby shifting the clutch-spool 56 to disengage the index clutch-teeth 56^b and 85^a and to engage the feed clutch-teeth 56^a and 54^a. The parts are shifted in the opposite directions to disengage the feed drive and to re-engage the index drive by mechanism later to be described. The final clockwise movement of the lever 114, under the influence of the plunger, pulls the links 113 and 110 and thereby through arm 109, shaft 108, arm 107, and link 106 causes the lever 105 to be swung clockwise to move the stud 104 out of contact with and out of the path of the arm 102. Immediately upon this final movement of the stud, the spring 103 swings the lever 102 about the shaft 96, bringing the forward wall of lever into contact with the stop stud 102^a.

The clutch-spool 56, fork 116, shaft 115, arm 117, and lever 114 are swung counter-clockwise to disengage the feed clutch-teeth and to engage the index clutch-teeth by mechanism actuated from the feed shaft Q of the station M as now will be described. Rotatably mounted on the shaft Q is the hub of an arm 120 which projects outwardly through apertures in the cam drum 38^x and in one of the cam sections secured thereto. A spring 120^a connected with the hub of the arm and the cam drum 38^x normally tends to swing the arm clockwise about the shaft but permits it to be moved in the opposite direction. The arm 120 passes through a U-shaped guide 121 secured to the cam drum, which guide prevents movement of the arm axially of the shaft Q. The outer end of the arm carries a cam 120^b which, during rotation of the shaft Q, and after the tool slides have been advanced and subsequently substantially retracted, engages a stud 122 carried by an arm 123 fixed upon one end of a rock shaft V journaled in the gear-box transverse to the axis of the shaft Q. Upon the other end of the shaft V, there is secured an arm 124 connected by a link 125 with an arm 114^b of the lever 114. When, during rotation of the feed shaft Q, the cam 120^b engages the stud 122, the arm 120 is temporarily held against rotation with the shaft due to the fact that the arm 123 and parts connected therewith are impositively held against movement by the plunger 119. The arm 120 remains stationary, thereby placing the spring 120^a under tension until the wall 121^a of the U shaped guide 121 engages the arm and moves it against the resistance offered by the spring-pressed plunger 119. Movement of the arm 120 causes the cam 120^b thereof to shift the arm 123 counter-clockwise as viewed in Fig. 12. This movement of the arm 123 effects, through the connection previously described, counter-clockwise movement of the lever 114, shaft 115 and fork 116, thereby shifting the clutch spool 56 to disengage the feed clutch-teeth 56^a and 54^a and (unless further movement of the fork is prevented by interference means herein-after to be described) to engage the index clutch-teeth 56^b and 85^a to initiate a new cycle. In throwing out the feed, the lever 114, arm 117, and plunger 119 act as a carry-over device as hereinbefore described, but in the reverse direction. After the apex of the nose 118 has passed the apex of the plunger and as the lever 114 is moved by the plunger, the arm 123 is swung to the

position shown in dotted lines in Fig. 12, thereby moving the stud 122 out of the path of the cam 120^b and permitting the arm 120 to be swung to its normal position by the spring 120^a. Final counter-clockwise movement of the lever 114 under the action of the plunger causes, through the links 113, 119, 106, etc., the stud 104 again to be placed in the path of the rounded end of the lever 102 for a subsequent operation. Likewise, final clockwise movement of the lever 114 under the influence of the plunger again places the stud 122 in the path of the cam 120^b.

To prevent breakage of the parts should, for any reason, the arm 120 or cam 120^b interfere with the return movement of the arm 123, the link 125 is preferably made of two sections held in their normal position by a heavy coil spring 125^a which permits relative movement of the sections in the event of interference.

Tool slide rate control

The clutch-spool 57, which determines whether the drive to the tool slides shall be at a rapid traverse rate or a slow feeding rate, is shifted by means similar to that which shifts clutch-spool 56. Adjustably secured, in any desired position, upon a disk 126 carried by the feed worm-wheel 64 at station M are a rapid traverse dog 127 and a slow feed dog 128 which, during rotation of the cam drum, alternately engage a stud 129 (Fig. 11) carried by an arm 130 fixed upon one end of a shaft U, journaled in the gear-box parallel with the shaft V. To the other end of the shaft U (Fig. 7) there is fixed an arm 131, connected by a link 132, with an arm 133 rotatably mounted upon a shaft 134, to which is secured a fork 135 engaging the clutch-spool 57. The arm 133 is provided with lugs 133^a and 133^b and a bevelled nose 133^c similar to those of the lever 114 previously referred to. A spring pressed plunger 136 co-operates with the nose 133^c similarly to the plunger 119. Fixed to the outer end of the shaft 134 is an arm 137 having its free end arranged between the lugs 133^a and 133^b. When, during the rotation of the feed shaft Q, the dog 127 engages the stud 129, the arms 130 and 131 are rotated clockwise, thereby rotating the arm 133 counter-clockwise and causing the fork 135 to shift the clutch-spool 57 to the left (Fig. 7) engaging the clutch-teeth 57^a and 55^a to effect rapid rotation of the feed cams. The dog 128 shifts the parts in the opposite direction and causes the clutch-teeth 57^b and 82 to be engaged to render effective the slow drive to the feed cams.

Index interference and throw-in mechanism

As hereinbefore stated, the spring plunger 119 would, upon shifting the clutch spool 56 to disconnect the feed drive, (unless prevented) immediately connect the index drive to initiate a new cycle. This is, in most instances, undesirable inasmuch as it gives the operator only a limited amount of time to remove the finished work-piece from the work-holder and place a new piece therein. To prevent this automatic starting of the index and to place the starting of a new cycle under the control of the operator, this invention provides an interference device which, when the feed is discontinued, limits the automatic movement of the clutch-spool 56 to an intermediate neutral position. Slidingly mounted in bearings g³ and g⁴ provided in the gear-box beneath and transversely of the shaft Q is a rod 138 adapted during the rotation of the cam drum 38^x to be moved axially toward the left, as viewed in

Fig. 9, to project the end 138^a thereof into the path of movement of an arm 139 secured upon the shaft 115. Movement of the rod in that direction is effected by a lever 140, fulcrumed at 140^a, and having one arm adapted, during the rotation of the feed cam, to be engaged by a stud 141 carried by the cam drum and turned counter-clockwise (Fig. 9). Another arm of the lever 140 carries a pin 140^b engaging, at one side, a collar 142 fixed to the rod 138 and at the other side a collar 143 slidingly mounted on the rod but normally held against relative movement with respect to the rod by a coil spring 144 surrounding the rod and interposed between the sliding collar 143 and a collar 145 also fixed to the rod. Thus, during the rotation of the feed cam 38, the end 138^a is projected into the path of the arm 139 which thereby limits the return movement of the clutch shifting fork 116 to a neutral position. The spring 144 serves to prevent breakage of the parts should, for any reason the rod 138 be prevented from moving axially.

Manual means is provided for retracting the rod 138 to remove its end 138^a out of the path of the arm 139, thereby to permit the clutch-fork 116, under the influence of the spring plunger 119, to engage the index clutch-teeth 56^b and 85^a to initiate a new cycle. This means comprises a control lever Z arranged at the front of the machine and secured upon one end of a shaft 146 carrying, at its other end, an arm 147 connected by a link 148 with a similar arm 149 on a shaft 150 (see Fig. 9). A second arm 151, fixed to the shaft 150, carries a stud 152 which engages a collar 153 fixed to the rod 138. Thus, by swinging the hand lever Z, the operator may move the rod 138 to the right (Fig. 9) thereby removing the end 138^a out of the path of the arm 139.

Slip coupling

To prevent damage to the machine parts should, for any reason, the turret be held against rotation when the index train is rendered effective, there is embodied in the index train, preferably between the shaft I and the sleeve 89, a slip coupling SC (see Figs. 14, 19, 20 and 24). This coupling is adapted to transmit a predetermined torque sufficient to effect indexing of the work turret and to slip should the load thereon be materially increased, such as might be caused by a work-piece, carried by one of the work-holders, coming into contact with one of the tool slides. As shown in Figs. 19 and 20, this coupling comprises a disk 154, formed integral with the sleeve 89, and provided with a plurality of tapered cavities 155 into which are seated the rounded end of pins 156 slidingly fitted in bores 157 formed in a collar 158 keyed to the shaft I. A heavy coil spring 159 interposed between a collar 160, threaded on the shaft I, and a washer 161, slidingly mounted on the shaft and engaging rear ends of the pins 156, serves to hold the rounded ends of the pins in the cavities 155 with a force sufficient normally to effect a driving connection between the collar 158 and the flange 154 of the sleeve 89. Should the turret or any part of the turret driving train beyond the sleeve 89 be held against rotation, the pins 156 will cam themselves out of the cavities 155, forcing backwardly on the washer 161 and compressing the spring 159, thereby permitting the shaft I to turn relative to the sleeve 89. To insure that each of the pins 156 will accurately fit its cavity 155, so that they will all serve as driving elements, it is essential that the end

of the pin be ground into its cavity. To the end that each of the pins need be fitted to only one cavity, each pin is preferably located at a different distance radially from the axis of the shaft I, as is also an individual cavity to receive each individual pin. Fig. 20 shows the cavities 155 arranged at different distances radially, so that only one pin may engage any one of the cavities. As shown, the difference in distance between the axis of the shaft I and the cavities are greatly exaggerated for the purpose of illustration. Actually the distances need to vary only slightly.

Timing couplings

To facilitate assembling the machine and correctly timing the feed cams 38, the shafts G and S are each formed of a plurality of sections and said sections are connected by timing couplings T (see Figs. 24 and 25). These couplings are preferably constructed, as shown in Figs. 21, 22 and 23 and comprise two flanges, t^4 and t^5 secured upon adjacent ends of aligned shaft sections. One of the flanges is provided with six holes t^7 and the other with eight holes through which are passed connecting bolts t^6 . The combination of the six and eight holes produces twenty-four different angular positions in which the two flanges may be secured together, thereby affording twenty-four angular adjustments of 15 degrees each of one shaft section relative to the other. Inasmuch as the cam drums are each driven by a speed reduction worm and worm-wheel, an adjustment of 15 degrees in one shaft section will produce a very slight angular adjustment of the cam drum which may be as low as a fraction of a degree, dependent upon the ratio between the worm and worm-wheel. It will thus be perceived that a very fine and accurate adjustment of the cam may be obtained. For convenience in effecting this adjustment, the shafts P^1 , P^2 and P^3 are preferably formed with squared outer ends p^2 , accessible from the outside of the machine, as shown in Figs. 8 and 18 to which a suitable crank may be applied.

The timing couplings 45 for the cross-slide cam-drives afford means for similarly timing the cross-slide cams and these couplings may be similar in construction to the couplings hereinbefore described.

Operation

Assuming now that the work turret is at rest with the turret-clamp set and the lock-bolt advanced, engaging one of the notches 97^c, that the spindle driving motor 6 and the feed and index motor 47 are running and that the necessary tools have been secured to the main and cross-slides, the cycle of operation of the machine is as follows, referring particularly to Figs. 1, 4, 14, 15, 16, 26 and 27:—The operator, stationed at the front of the machine, places a work-piece in the work-holder. He then grasps the lever 35, pushes it from him to connect the friction drive for the work spindle. As soon as the work chuck has attained a substantial speed of rotation, which is almost instantly, the operator pulls the lever 35 toward him to connect the positive drive clutch elements. Next, he moves the control lever Z clockwise, thereby to remove the end 138^a of the rod 138 out of the path of the arm 139, whereupon the spring plunger 119 causes the clutch-teeth 56^b of the clutch element 56 to engage the clutch-teeth 85^a on the index drive gear 85. This starts the index train. Initial rotation of the shaft 96 and Geneva disk

84, of 30 degrees, as indicated at o^1 Fig. 26, causes the cam portion 101^a to shift the air valve w^{12} outwardly which, in turn, effects retraction of the lock-bolt 97. At substantially the same time the bolt is being retracted, the cam c^7 rocks the lever c^{10} which effects release of the turret clamp c as indicated at o^2 in Fig. 26.

The turret is now unclamped and unlocked and ready to receive its 90 degree indexing movement to carry the work-piece from the loading station to tooling station L. This index is effected by a two-stage movement of 45 degrees each, the rollers 84^a and 84^b successively engaging the slots 83^a in the disk 83 and rotating said disk. The indexing movement of the turret requires rotation of the shaft 96 approximately 270 degrees as indicated at o^3 . During the latter part of the index movement and within the next 10 degree rotation of the shaft 96, as shown at o^4 the roller 101, on the stem of the air valve w^{12} rides down the incline 101^b causing the lock-bolt 97 to be advanced and forced into one of the notches 97^c, thereby definitely locating the turret and locking it against rotation. Further rotation of 32 degrees of the shaft 96 and cam drum c^8 , as indicated at o^5 , causes the turret clamp again to be set.

The indexing is now completed, the work-piece is at station L and the shaft 96 and the parts rotated thereby still have a further rotation of 18 degrees. During the final rotation of the shaft 96, the arm 102, carried by said shaft, engages the stud 104 on lever 105 and through the connections hereinbefore described causes the clutch-spool 56 to be shifted to disengage the index clutch-teeth and to engage the feed clutch-teeth 56^a and 54^a. Inasmuch as the machine had previously come to rest with the clutch-spool 56 shifted to engage the clutch-teeth 57^a with the rapid traverse clutch-teeth 54^a, the tool slide feeds, including the shafts P, P^1 and P^2 , and the tool feed cams rotated thereby are rotated at a rapid rate. This effects traverse movement of the tool-slides rapidly to advance the tools toward the adjacent work piece. At a predetermined point, the dog 128, (see Figs. 11, 12 and 27) adjustably secured upon the disk 126 rotated with the feed shaft Q at station M, engages the stud 129 on the arm 130 which, through the connections hereinbefore described, shifts the clutch-spool 57 to disengage the rapid traverse clutch-teeth 57^a and 55^a and to engage the slow feed clutch-teeth 57^b and 82. The speed of rotation of the feed cams is thus reduced and the tool slides are advanced at a relatively slow rate during the tooling operations. At another predetermined point, as determined by the setting of the dog 127, the arm 130 is shifted in the opposite direction to throw out the slow feed and to throw in the rapid traverse for the purpose of rapidly retracting the tool slides after the machining operations have been completed.

The final rotation of the shaft Q, station M, causes the cam 120^b, carried by the arm 120, to engage the stud 122 on arm 123 thereby, through the connections hereinbefore described, to shift the clutch-spool 56 to disconnect the clutch-teeth 56^a and 54^a thereby to stop rotation of the feed train. This movement also tends to again engage the index clutch-teeth to initiate a new cycle, which, however, is presented by the interference member 138^a lying in the path of the arm 139 as previously described. This completes the cycle of the machine, which cycle is repeated for each operation on the work-piece.

Without further analysis, the foregoing will so fully reveal the gist of this invention that others can, by applying current knowledge, readily adapt it for various utilizations by retaining one or more of the features that, from the standpoint of the prior art, fairly constitute essential characteristics of either the generic or specific aspects of this invention and, therefore, such adaptations should be, and are intended to be, comprehended within the meaning and range of equivalency of the following claims.

Having thus revealed this invention, I claim as new and desire to secure the following combinations and elements, or equivalents thereof, by Letters Patent of United States:—

1. A radial spindle chucking machine combining a frame; a work turret rotatably mounted thereon; work-holders carried by said turret; means to index said turret to deliver a work-piece carried by a work-holder successively to a plurality of tooling stations located about said turret; a pair of tool slides adapted to be removably supported by said frame at each of said stations; individual means for reciprocating each of said slides, the slides of each pair being movable in transverse planes; and means permitting the removal of any of said tool slides.

2. A radial spindle chucking machine combining a frame providing a plurality of tooling stations each affording a horizontally disposed guideway and a horizontally disposed seat; a main tool slide translatably mounted on one of said guideways; a rotary tool spindle journaled in said main slide; an electric motor mounted on said tool slide and operatively connected to rotate said tool spindle; an upright standard mounted upon one of said seats; a cross slide translatably mounted on said standard and movable in a plane transverse to the axis of said tool spindle; a tool carried by said cross slide; a rotating cam mounted beneath said main slide and operatively connected therewith to reciprocate said main slide; a rotating cam mounted in said standard and operatively connected to reciprocate said cross slide; and a rotatable work turret rotatably mounted on said frame and adapted to present work-pieces successively to said tooling stations.

3. A radial spindle chucking machine combining a frame providing a plurality of tooling stations; a work turret rotatably mounted on said frame and adapted to present work-pieces successively to said tooling stations; a tool located at each of said tooling stations and adapted to operate on said work-piece; an additional tool located at one of said tooling stations, the two tools at said one of the tooling stations being adapted to perform, respectively, internal and external operations on the work-piece; and means to cause all of said tools simultaneously to perform their tooling operations.

4. A radial spindle chucking machine combining a frame providing a plurality of tooling stations one of which affords a horizontally disposed guideway; a main tool slide translatably mounted on said guideway, said tool slide being provided with a motor supporting seat, tool supporting seat, and a spindle bore; a rotary tool spindle journaled in said bore; a non-rotary tool secured upon said tool seat; an electric motor mounted on said tool slide and operatively connected to rotate said tool spindle; a tool located at each of the other tooling stations; and a rotatable work turret rotatably mounted on said

frame and adapted to present work-pieces successively to said tooling stations.

5. A radial spindle chucking machine combining a frame providing a plurality of tooling stations each affording a horizontally disposed guideway and a horizontally disposed seat; a work turret adapted to present a work-piece successively to said tooling stations; a main tool slide translatably mounted on each of said guideways; an upright standard mounted on each of said seats; a cross slide translatably mounted on each standard; a shaft arranged vertically in each standard; a cross slide actuating cam on each of said shafts; a main slide actuating cam located adjacent each of said main slides; a feed shaft extending to each of said tooling stations; means for driving a main slide cam and a cross slide cam from each of said feed shafts; and a common driver for all of said feed shafts.

6. A chucking machine of the work-rotating type combining a frame; a rotatable work turret supported on said frame; a plurality of rotatable work spindles journaled in said turret; means to rotate all of said tool spindles at a common rate; means to vary the rate of rotation of all of said spindles; a plurality of tools mounted on said frame and adapted successively to operate on work-pieces carried by said spindles, one of said tools being rotatable; a prime mover connected with said rotatable tool; and means to vary the rate of rotation of said rotatable tool under the action of said prime mover, thereby to vary the rate of relative rotation between the tool and an adjacent work spindle.

7. A chucking machine of the work-rotating type combining a frame; a rotatable work turret supported on said frame; a plurality of rotatable work spindles journaled in said turret; means to rotate all of said tool spindles at a common rate; means to vary the rate of rotation of all of said spindles; a plurality of tools mounted on said frame and adapted successively to operate on work-pieces carried by said spindles, one of said tools being rotatable; a prime mover connected with said rotatable tool; and means to vary the direction of rotation of said rotatable tool under the action of said prime mover, thereby to vary the rate of relative rotation between the tool and an adjacent work spindle.

8. A chucking machine of the work-rotating type combining a frame; a rotatable work turret supported on said frame; a plurality of rotatable work spindles journaled in said turret; means to rotate all of said tool spindles at a common rate; means to vary the rate of rotation of all of said spindles; a plurality of tools mounted on said frame and adapted successively to operate on work-pieces carried by said spindles, one of said tools being rotatable; a prime mover connected with said rotatable tool; and means to vary the rate and direction of rotation of said rotatable tool under the action of said prime mover, thereby to vary the rate of relative rotation between the tool and an adjacent work spindle.

9. A chucking machine of the work-rotating type combining a frame; a rotatable work turret supported on said frame; means including a motor and mechanism actuated thereby for indexing said turret; a plurality of rotatable work spindles journaled in said turret; means including a motor and a power transmission actuated thereby to rotate all of said tool spindles at a common rate; manually actuated speed change gearing embodied in said transmission to vary the rate of rotation of all of said spindles; a

plurality of tools mounted on said frame and adapted successively to operate on work-pieces carried by said spindles, one of said tools being rotatable; a motor connected with said rotatable tool; and means to vary the rate of rotation of said rotatable tool under the action of said motor, thereby to vary the rate of relative rotation between the tool and an adjacent work spindle.

10. A chucking machine combining a frame providing a plurality of tooling stations; a translatable tool slide supported by said frame at each of said stations; a rotary cam operatively connected with each of said tool slides; a transmission having a branch line extending to each of said stations to rotate said cams thereby to effect translation of said tool slides; and means actuated from one of said branch lines for varying the rate of rotation of all of said cams.

11. A chucking machine combining a frame providing a plurality of tooling stations; a translatable tool slide supported by said frame at each of said stations; a rotary cam operatively connected to reciprocate each of said tool slides; a high speed transmission for rotating said cams; a slow speed transmission for rotating said cams; a single clutch means for rendering either of said transmissions effective; and means actuated in timed relation with one of said cams for actuating said clutch means thereby to vary the rate of rotation of all of said cams.

12. A chucking machine combining a frame; a plurality of tooling stations provided by said frame; a translatable tool slide supported by said frame at each of said stations; a rotary cam operatively connected to reciprocate each of said tool slides; a high speed transmission for rotating said cams to effect rapid traverse of said tool slides; a slow speed transmission to rotate said cams to effect slow feeding movement of said tool slides; a single clutch element controlling both of said transmissions; means to shift said clutch element; a dog rotatable with one of said cams and adapted to actuate said clutch shifting means to render effective said high speed transmission; and a second dog rotatable with said one of said cams for actuating said clutch shifting means for rendering effective said slow speed transmission.

13. In a chucking machine, a rotatable turret; a plurality of reciprocable tools located about said turret; individual cams adapted to reciprocate said tools; a prime mover; means actuated from said prime mover to index said turret; power transmission mechanism connecting said prime mover with all of said cams to rotate the latter, thereby to effect feeding movements of said tools; a clutch element interposed between the turret indexing means and the tool feed transmission, alternately to render them effective; detent means acting to hold said clutch element in either its indexing or feed positions; a delayed action mechanism actuated by said index means to shift said clutch element to feed position; and a delayed action mechanism actuated by the tool feed transmission to shift said clutch to index position.

14. In a chucking machine, a plurality of tooling stations; a reciprocatory tool at each station; a rotatable work turret; indexing means for said turret; reciprocating means for each of said tools; a prime mover; a main power transmission actuated from said prime mover and having a branch line extending to each tooling station for actuating said tool-reciprocating means at one rate; a supplemental transmission adapted to be con-

nected with said main transmission to actuate said branch lines and thereby the tool reciprocating means at another rate; and automatically actuated means for rendering the main transmission ineffective and for rendering effective said supplemental transmission.

15. In a chucking machine, a plurality of tooling stations; a reciprocatory tool at each station; a rotatable work turret; indexing means for said turret; reciprocating means for each of said tools; a prime mover; a main power transmission actuated from said prime mover and having a branch line extending to each tooling station for actuating said tool-reciprocating means at one rate; a supplemental transmission adapted to be connected with said main transmission to actuate said branch lines and thereby the tool reciprocating means at another rate; speed change mechanism embodied in said supplemental transmission to vary the rate of reciprocation of said tools through said supplemental transmission; and automatically actuated means for rendering the main transmission ineffective and for rendering effective said supplemental transmission.

16. A chucking machine combining a frame affording a plurality of tooling stations; a reciprocatory tool at each station; a rotatable work turret; indexing means for said turret; reciprocating means for each of said tools; a prime mover; a main power transmission actuated from said prime mover and having a branch line extending to each tooling station for actuating said tool reciprocating means at one rate; a supplemental transmission located partly within said frame and having shaft ends projecting outwardly therefrom, said supplemental transmission being adapted to be connected with said main transmission to actuate said branch lines and thereby the tool reciprocating means at another rate; pick-off gears removably secured to the projecting ends of said shafts and adapted to be interchanged, thereby to vary the rate of reciprocation of said tools through said supplemental transmission; and automatically actuated means for rendering the main transmission ineffective and for rendering effective said supplemental transmission.

17. In a chucking machine, a plurality of tooling stations; a reciprocatory tool at each station; a rotatable work turret; indexing means for said turret; reciprocating means for each of said tools; a prime mover; a main power transmission actuated from said prime mover and having a branch line extending to each tooling station for actuating said tool reciprocating means at one rate; a supplemental transmission adapted to be connected with said main transmission to actuate the tool reciprocating means at another rate; automatically actuated means for rendering the main transmission ineffective and for rendering effective said supplemental transmission; means for disconnecting both of said transmissions from said prime mover; and manual means for actuating said transmissions.

18. A chucking machine combining a frame; a work turret rotatably mounted thereon; a plurality of tool slides translatable mounted on said frame about said turret; means to index said turret; means to feed said tool slides; means actuated by the tool feed tending to render the index means effective; and interference means to prevent said indexing means being rendered effective by said feed means.

19. A chucking machine combining a frame; a work turret mounted thereon; a plurality of

tool slides translatably mounted on said frame about said turret; mechanism to index said turret; means to feed said tool slides; a single clutch element shiftable to two positions selectively to
 5 render effective said turret index mechanism and tool feed means; means actuated by the index mechanism to shift said clutch element to render effective the tool feed means; a member movable with said clutch element; an interference member
 10 moved by said feed means into the path of said member; and means actuated by said feed means to shift said clutch element to render ineffective the tool feed means and tending to engage the clutch element with said index mechanism, said
 15 interference member engaging said member to limit the movement of said clutch element to a neutral position.

20. A chucking machine combining a frame; a work turret mounted thereon; a plurality of
 20 tool slides translatably mounted on said frame about said turret; means to index said turret; means to feed said tool slides; means actuated by the tool feed tending to render the index means effective; interference means positioned by said
 25 feed means to prevent said index means being rendered effective by said feed means; and manual means to render said interference means ineffective.

21. A machine tool, combining a frame affording a plurality of tooling stations; an actuated element at each of said stations; individual means at each of said stations for actuating said elements; a prime mover; a transmission extending from said prime mover to all of said element
 30 actuating means; and a timing coupling embodied in said transmission adjacent each of said stations for permitting individual timing of each of said element actuating means.

22. A machine tool combining a frame affording a plurality of tooling stations, a translatable tool at each of said stations; a rotary cam at each of said stations for translating said tool carriers; a prime mover, a power transmission extending from said prime mover to all of said stations for
 40 rotating all of said cams; a timing coupling embodied in said transmission adjacent each of said stations for permitting individual rotation of said cams relative to and independently of said prime mover, thereby to permit individual adjustment
 45 of said tool carriers and individual timing of said cams.

23. A machine tool, as set forth in claim 22, in which the power transmission includes a plurality of shafts each comprising a plurality of sections arranged end to end and in which timing couplings connect the adjacent ends of said shaft sections, said timing couplings each comprising flange elements fixed to the adjacent ends of said shaft sections, said flanges being provided with
 50 unequal numbers of pairs of bolt holes, whereby said sections may be secured together in a plurality of angular positions by bolts passed through complementary pairs of said holes, the number of angular positions obtainable being greater than the number of holes in either flange.

24. In a machine tool, a rotatable turret; mechanism to index said turret; means to lock said turret in predetermined positions, said locking means comprising a lock-bolt adapted to enter apertures formed in said turret; a differential pneumatic motor connected with said lock-bolt; an air pressure line permanently connected with the least effective end of said motor and tending constantly to retract said lock-bolt; a
 75 valve connecting said air pressure line with the

most effective end of said motor; and means actuated by said indexing mechanism to actuate said valve to admit air pressure into the most effective end of the motor, thereby to advance said lock-bolt in opposition to the air pressure in the
 80 least effective end thereof.

25. A chucking machine combining a substantially inverted T-shaped frame as viewed from the front; a tooling station provided at the left, rear and right extremities of said frame; a reciprocatory tool at each tooling station; means adjacent each tool to give it reciprocatory movements; a rotatable work turret mounted on said frame intermediate its extremities; means to index said turret successively to present to the
 85 tools at said left, rear and right tooling stations work-pieces carried thereby; a driving motor; a power transmission actuated by said motor; a first feed shaft P¹ connecting said power transmission with the rear tool feeding means; a shaft
 90 G extending toward the front of its machine; a shaft S journaled in said frame substantially parallel with the front thereof and actuated from the shaft G; second and third feed shafts P² and P³ journaled in said frame adjacent the right and
 100 left tooling stations and actuated from the shaft S, said shafts P² and P³ serving to transmit power to the right and left tool feeds.

26. A chucking machine as specified in claim 25, in which the turret is indexed by the motor
 105 which actuates the tool feeds and in which index and feed control mechanism is mounted on the rearward extremity of the frame and is automatically actuated.

27. In a machine tool a fixed member; a vertically translatable tool slide, formed with a vertically arranged cylindrical bore, supported by said member; a rotating cam journaled in said fixed member; an operative connection between said cam and said tool slide for reciprocating the
 110 latter by rotation of the former; a piston fitted in said cylindrical bore; a rigid connection between said piston and said fixed member; and means to admit fluid pressure into said bore above said piston to transmit to said piston and thereby to
 115 said fixed member a substantial portion of the weight of said tool slide.

28. In a chucking machine, a standard; a tool slide vertically movable on said standard and provided with a vertically arranged cylindrical
 120 bore; a cam connected with said tool slide to give it vertical reciprocations on said standard; and fluid pressure actuated means, including a piston fitted in said bore, a rigid connection between said piston and said standard and means
 125 to admit fluid pressure into said cylindrical bore above said piston, to support a substantial portion of the weight of said tool slide, whereby the load required to be lifted by said cam is materially reduced.

29. A chucking machine combining a frame providing a plurality of tooling stations; a tool translatably mounted at each of said stations; a work turret; work holders carried thereby; means to index said turret successively to present work pieces carried by said work holders to the action of said tools; means to reciprocate said tools toward and from the work pieces; power transmission means for said reciprocating means; a clutch element interposed between the turret indexing means and the tool feed transmission whereby when the clutch element is shifted in one direction the turret indexing means is rendered effective and when the clutch element is shifted in the opposite direction the tool re-
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reciprocating means is rendered effective; means actuated by the turret indexing means to move said clutch element in the last named direction; and means actuated by the tool reciprocating means to shift said element in the first mentioned direction.

30. In a machine tool, a rotatable turret; indexing means for said turret; means to lock said turret in predetermined positions, said locking means comprising a lock-bolt adapted to enter apertures formed in said turret; a pneumatic

motor connected to actuate said lock-bolt; an air pressure line; a reciprocating valve associated with said motor for admitting and releasing air pressure thereto; a rotatable cam driven in timed relation with said indexing means and directly cooperating with said valve for controlling the latter; a spring normally urging said valve into engagement with said cam; and means for manually moving said valve against the pressure of said spring for controlling said motor at will.

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