W. LE R. BRYANT.

MULTISPINDLE METAL GRINDING MACHINE.

APPLICATION FILED OCT. 26, 1907.

925,867.

Patented June 22, 1909.

19 SHEETS—SHEET 1.

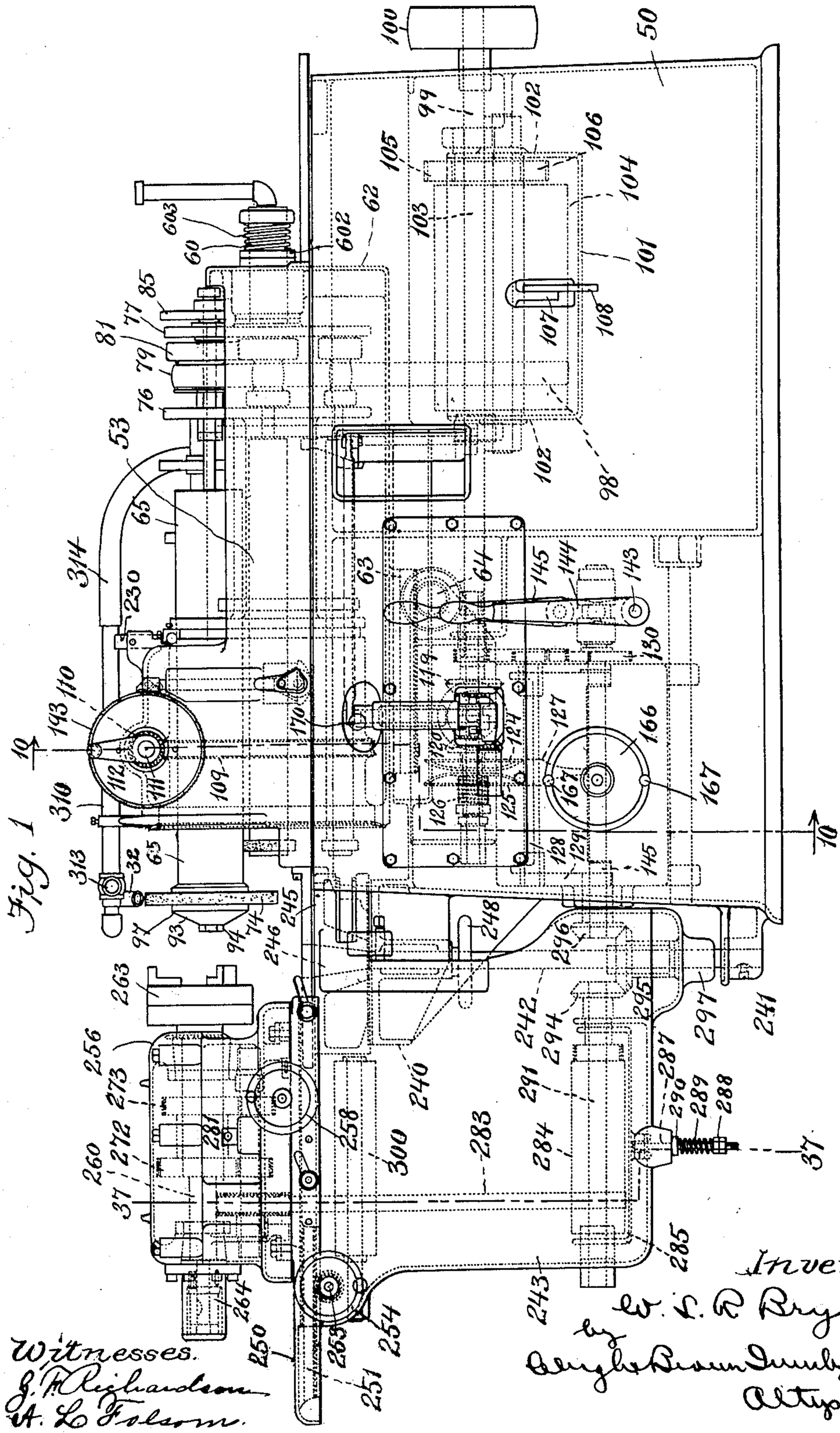

Fig. 1

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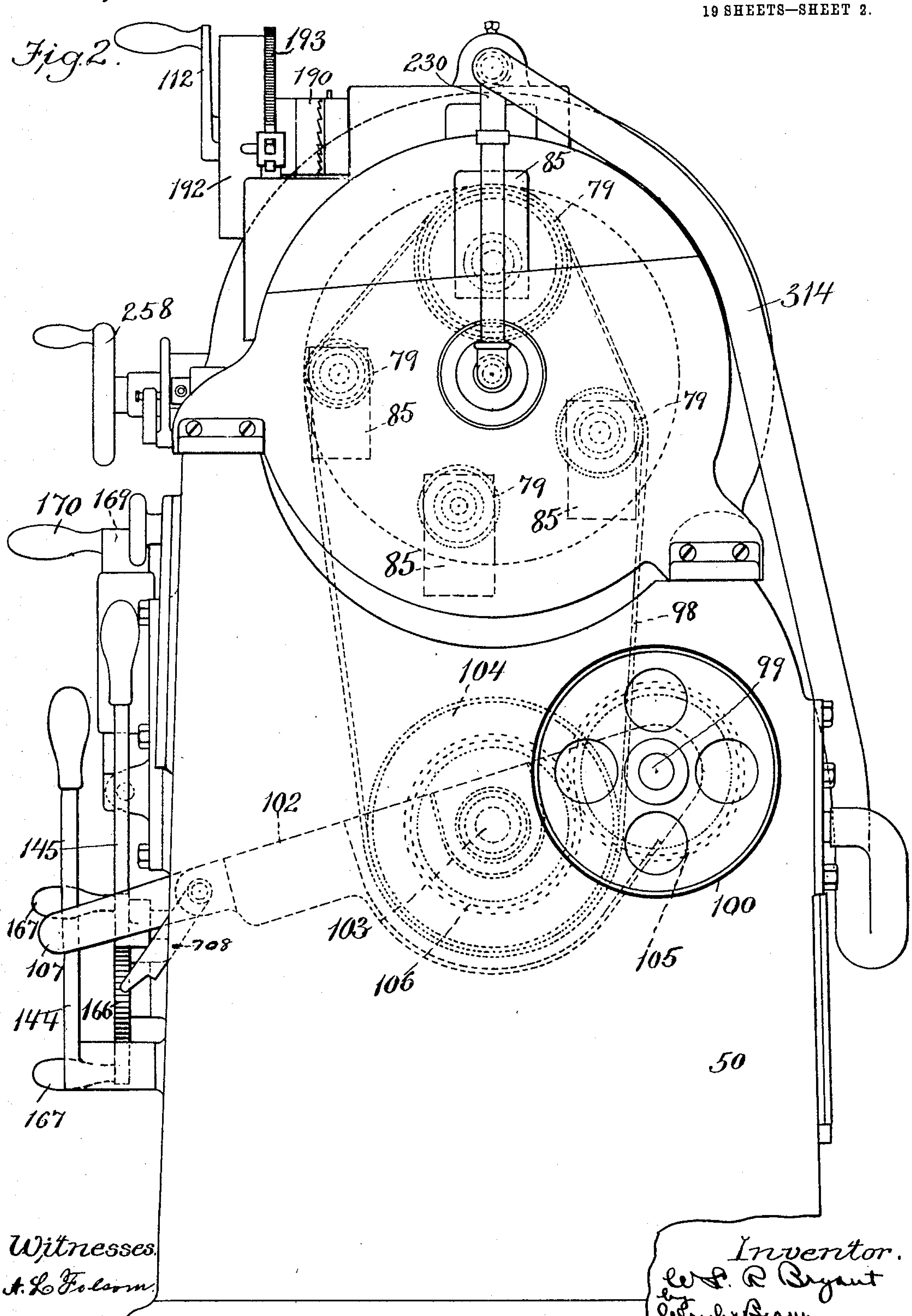
19 SHEETS—SHEET 2.

Fig. 2.



Witnesses.

A. L. Folsom.

J. F. Richardson

Inventor.

W. Le R. Bryant

by Wright, Brown, Quinby & May Atty's.

W. LE R. BRYANT.

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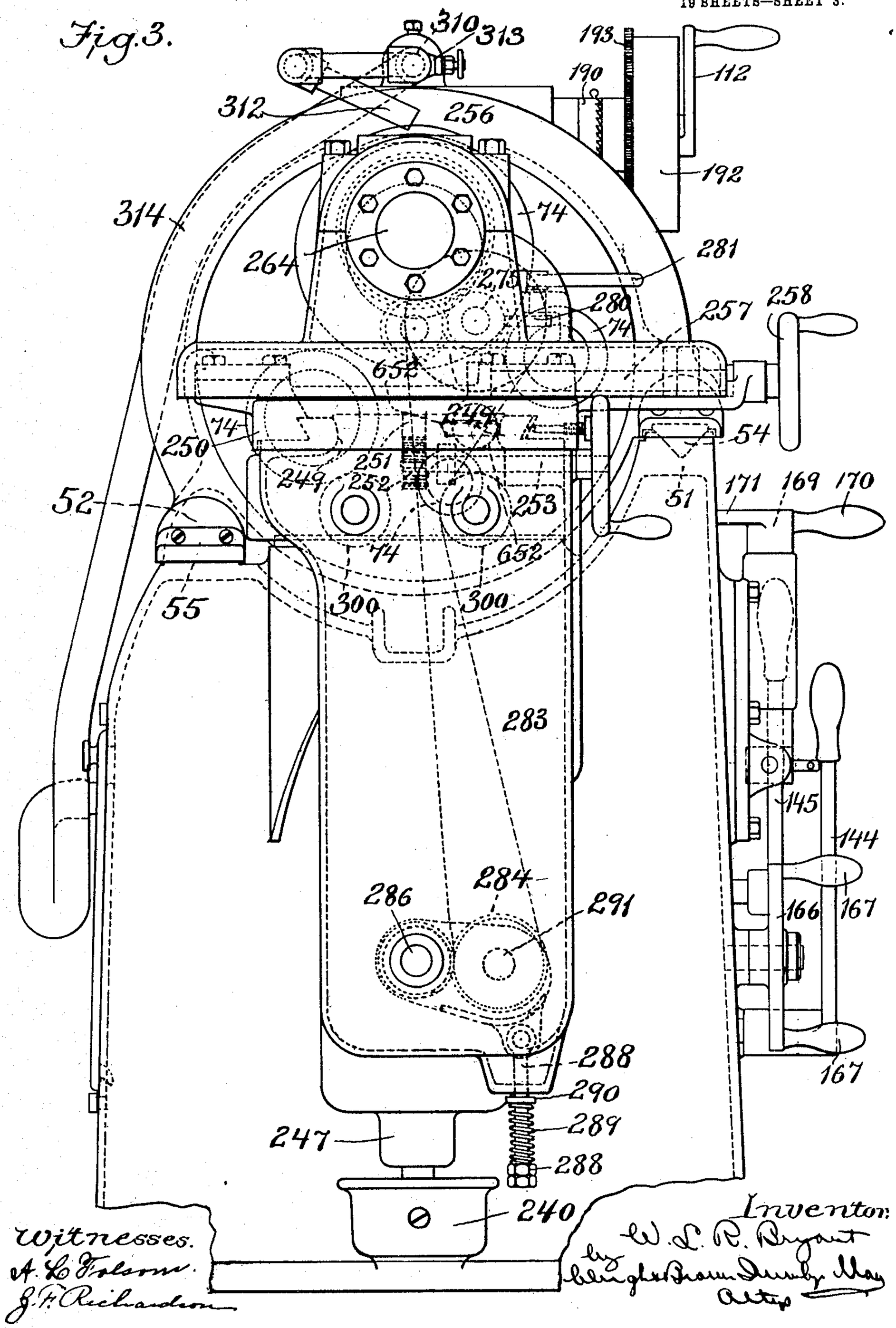
19 SHEETS—SHEET 3.

Fig. 3.



Witnesses.
A. L. Folsom.
J. F. Richardson.

Inventor:
W. L. R. Bryant
by Wright Brown Quinby & May
Attys

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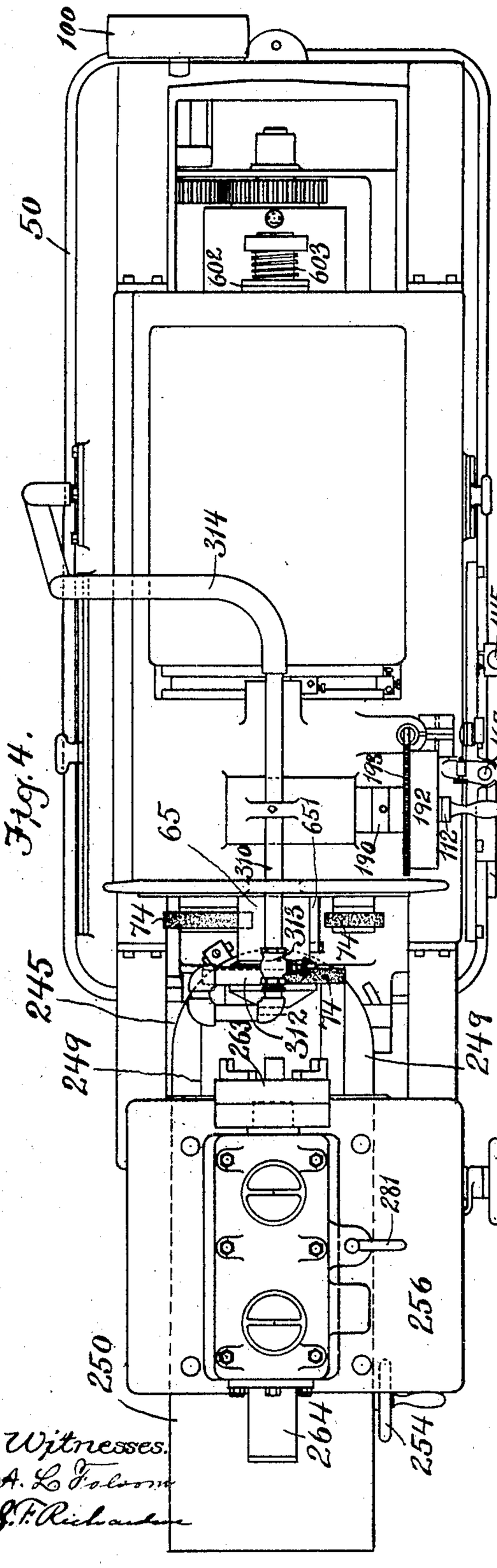

Fig. 4.

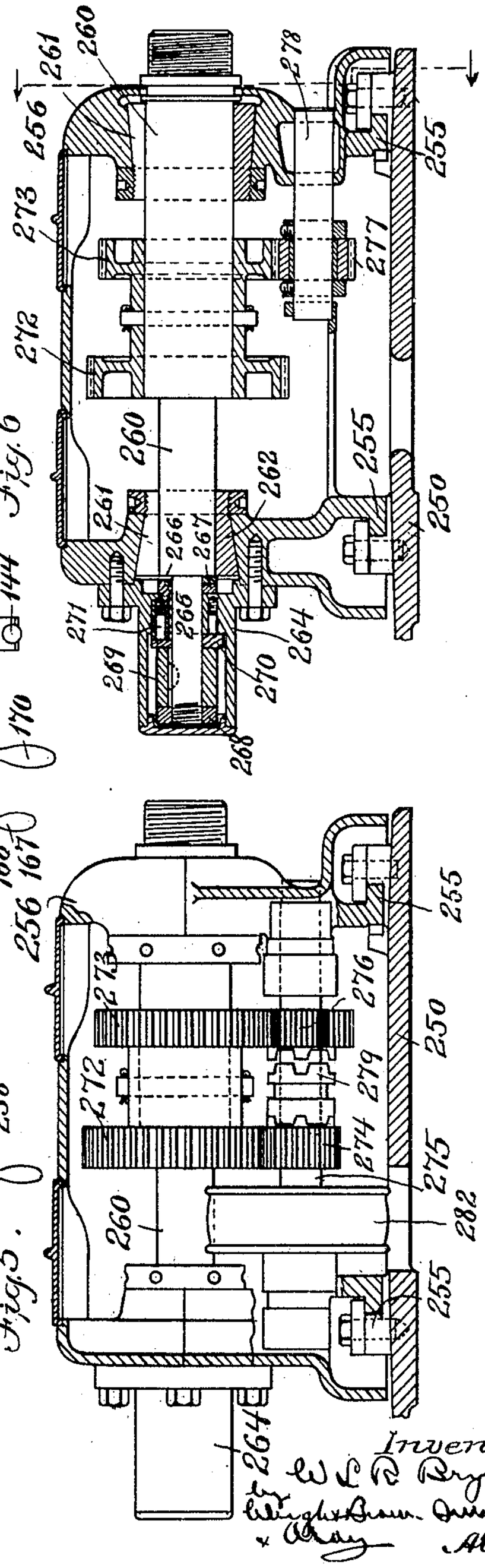

Fig. 6.

Fig. 5.

Witnesses.
A. L. Folsom
J. F. Richardson

Inventor
W. LE R. Bryant
by Wright Brown Quinby & Otray
Attys.

W. LE R. BRYANT.

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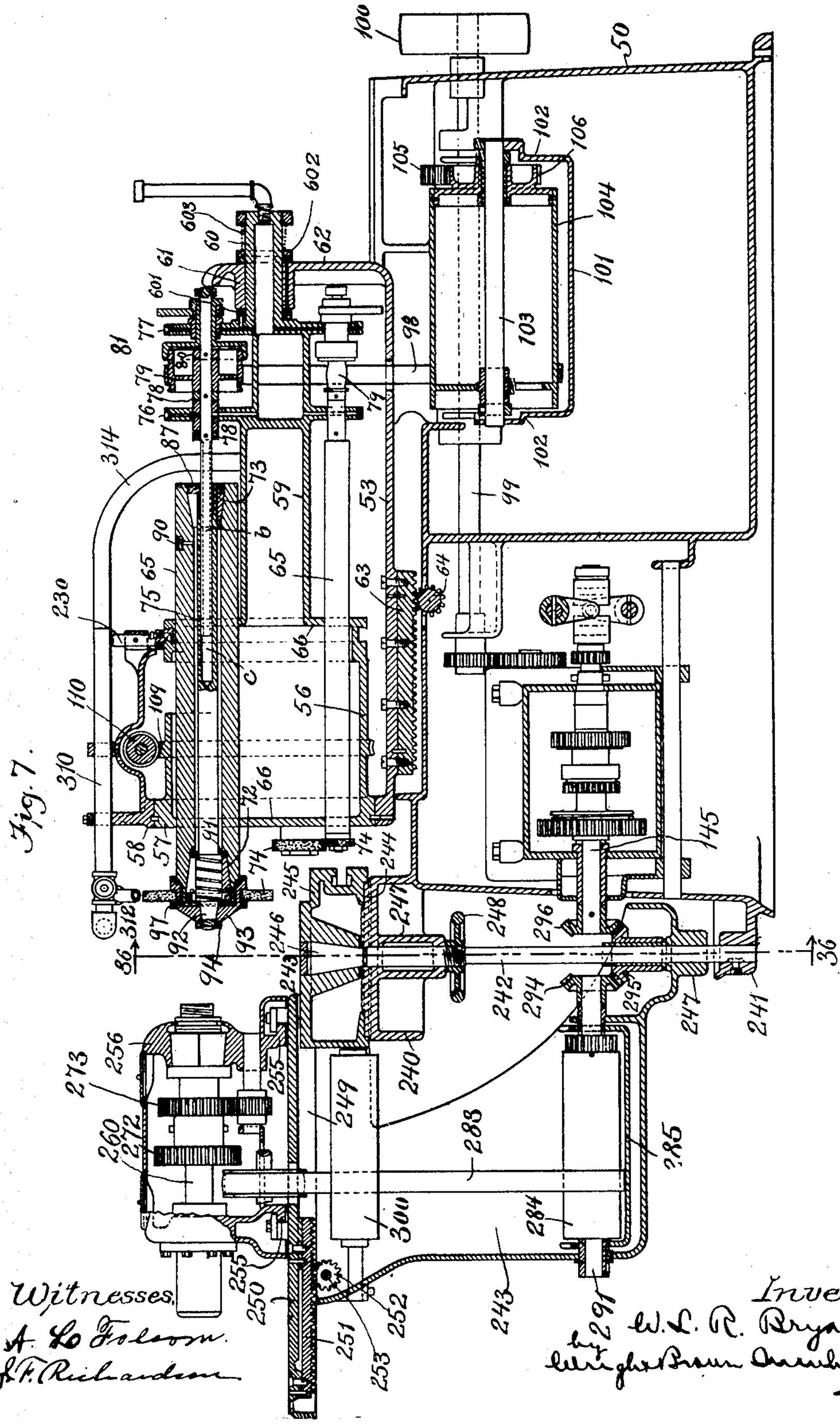

Fig. 7.

Witnesses.
A. L. Folsom.
S. F. Richardson.

Inventor.
W. L. R. Bryant
by Wright Brown Quinby & May
Attys.

W. LE R. BRYANT.

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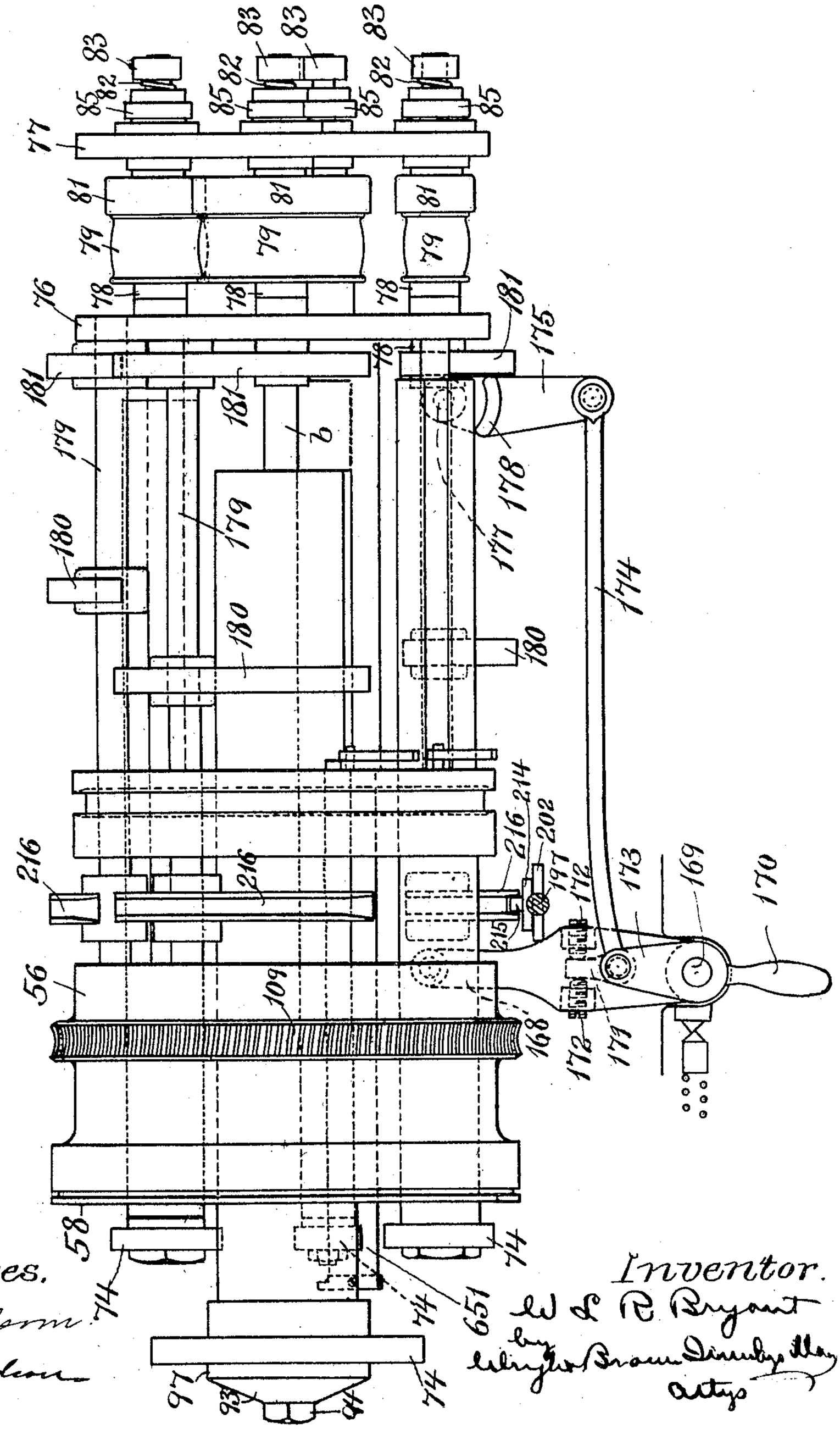
19 SHEETS—SHEET 6.

Fig. 8



Witnesses.

A. L. Folsom

J. F. Richardson

Inventor.

W. LE R. Bryant

by Albright Brown Dinsmore & May

Attys

W. LE R. BRYANT.

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19 SHEETS—SHEET 7.

Fig. 9

Witnesses.
A. L. Folsom
J. F. Richardson

Inventor.
W. LE R. Bryant
by Wright Brown Quinby & May
Attys

W. LE R. BRYANT.

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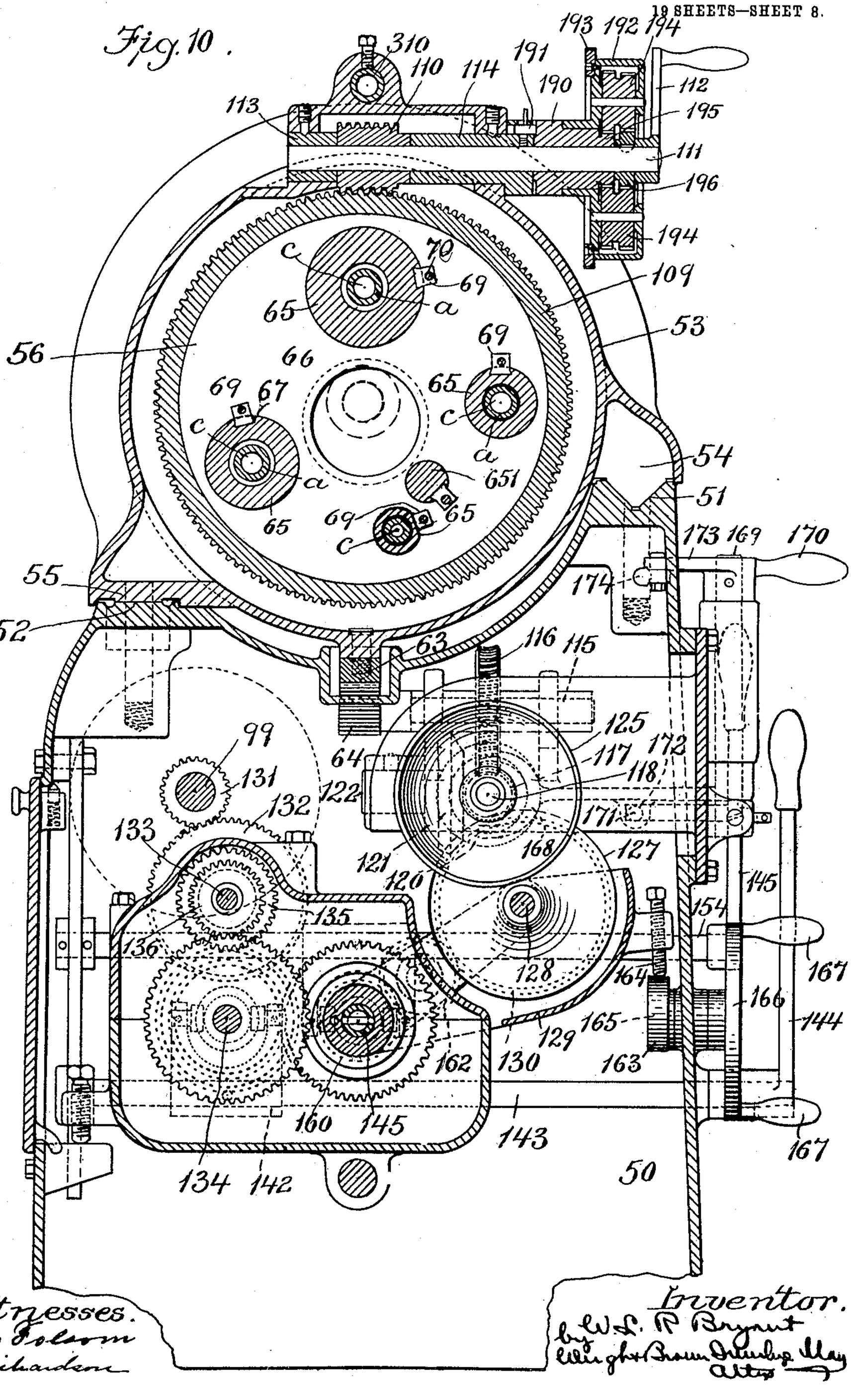
19 SHEETS—SHEET 8.

Fig. 10.



Witnesses.
A. H. Folsom
J. F. Richardson

Inventor.
by W. LeR. Bryant
Albright & Brown Schenck & May
Attys

W. LE R. BRYANT.

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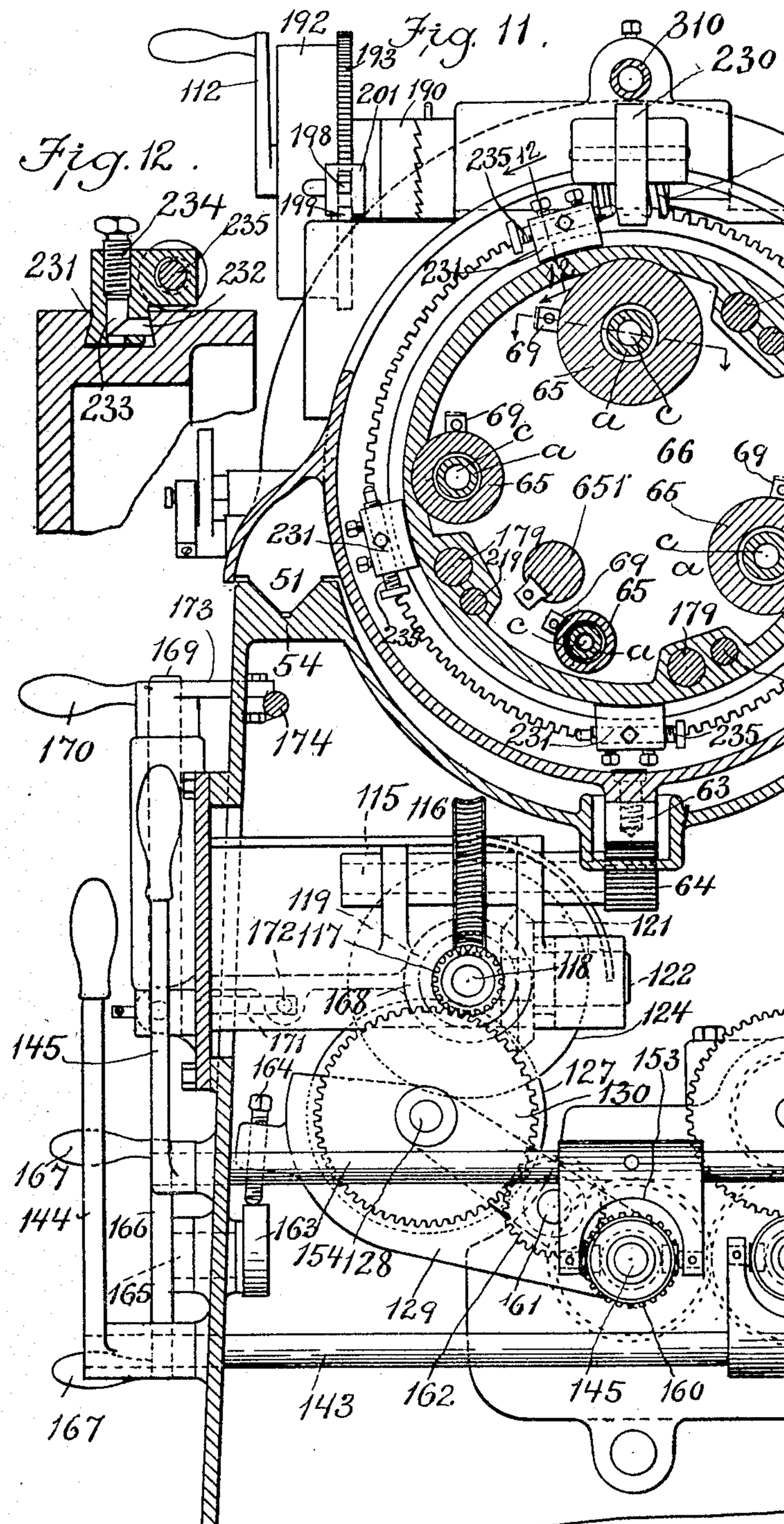
19 SHEETS—SHEET 9.

Fig. 11.



Witnesses.

A. L. Folsom.

J. F. Richardson

Inventor:

W. LeR. Bryant

by Wright Brown Quinby & May

Attys

W. LE R. BRYANT.

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19 SHEETS—SHEET 10.

Fig. 13.

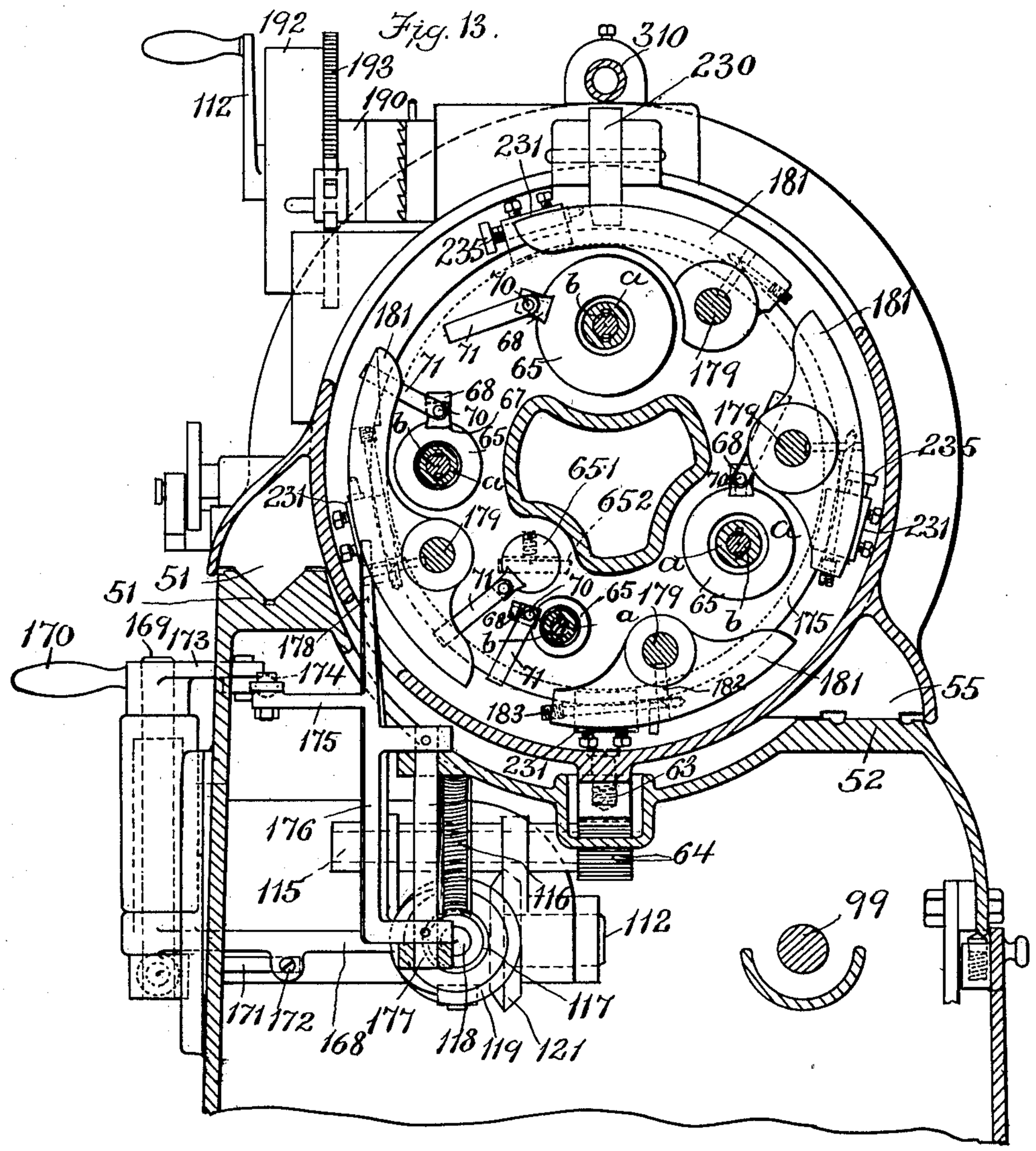
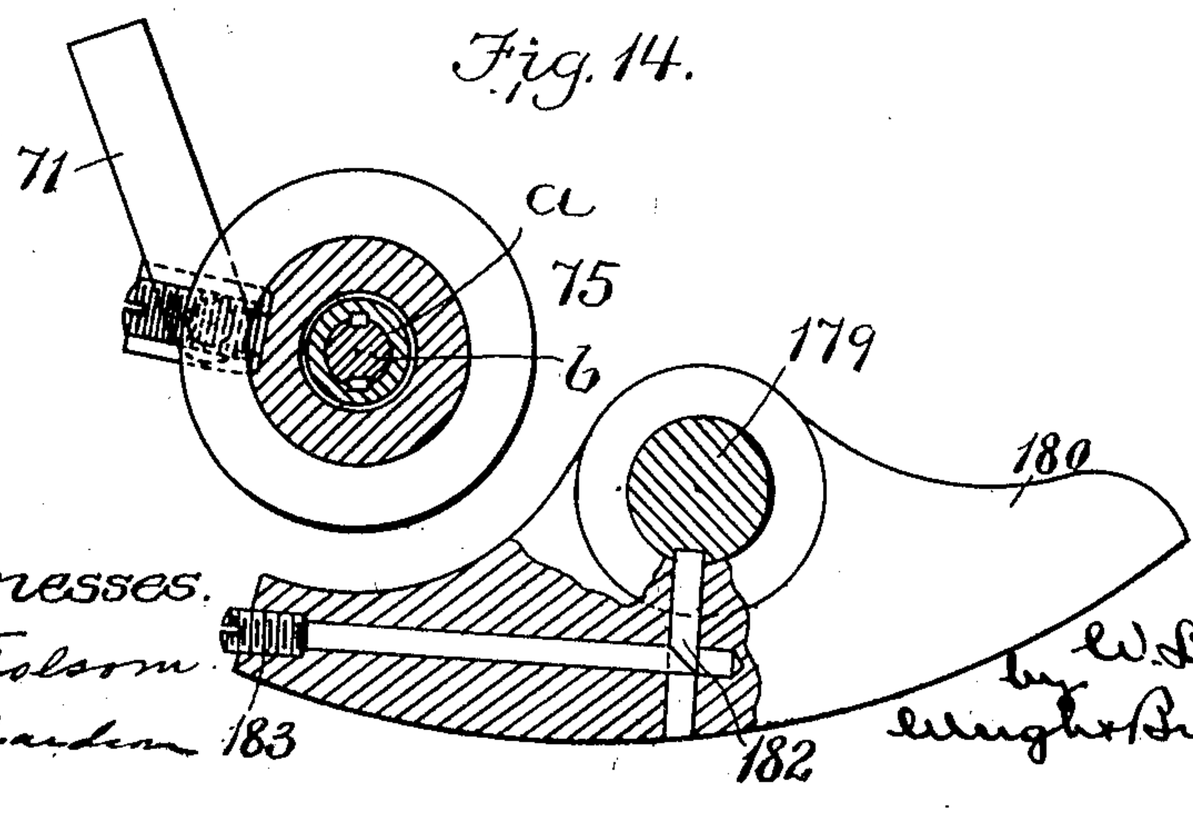


Fig. 14.



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A. L. Folsom.
J. F. Richardson

Inventor.
W. L. R. Bryant
by Wright Brown Quinby & May
Attys

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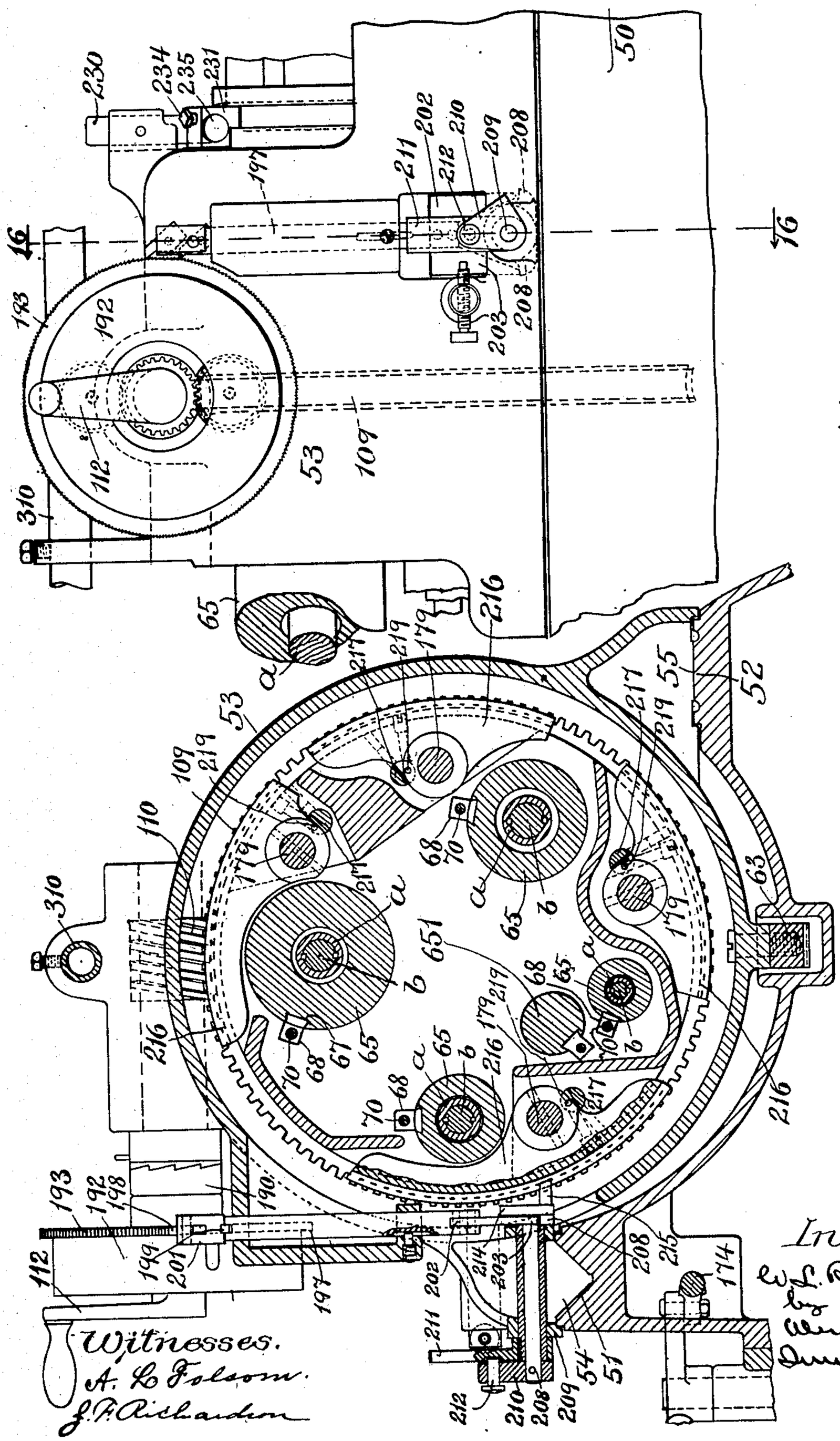

Fig. 15.

Fig. 16.

Witnesses.
A. L. Folsom.
J. F. Richardson

Inventor:
W. L. R. Bryant
by Wright Brown
Quinby & May.
Atty

W. LE R. BRYANT.

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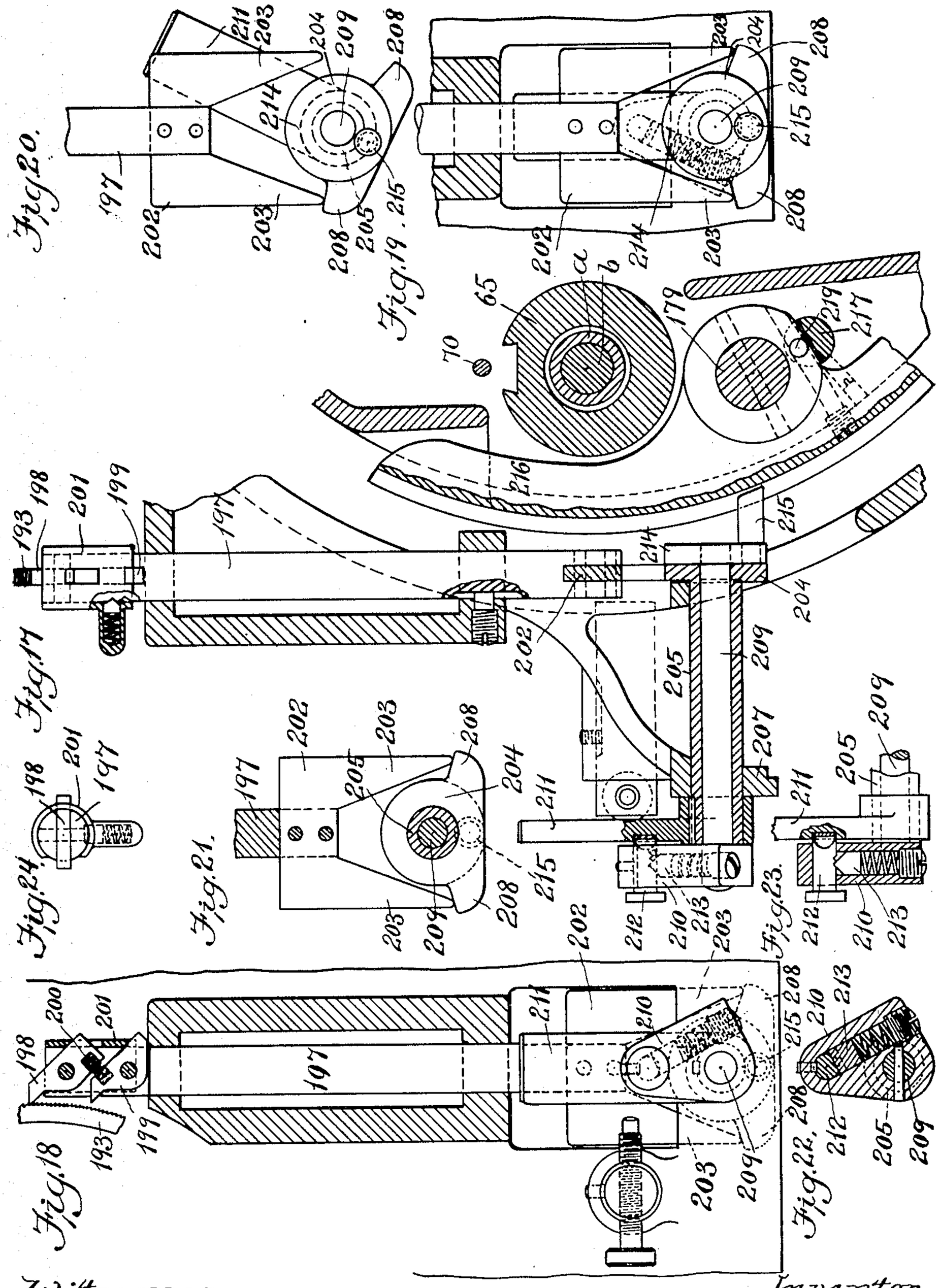

Witnesses.
A. L. Folsom
J. F. Richardson

Inventor.
W. LE R. Bryant
by Wright Brown Quinby & May

W. LE R. BRYANT.

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19 SHEETS—SHEET 13.

Fig. 25.

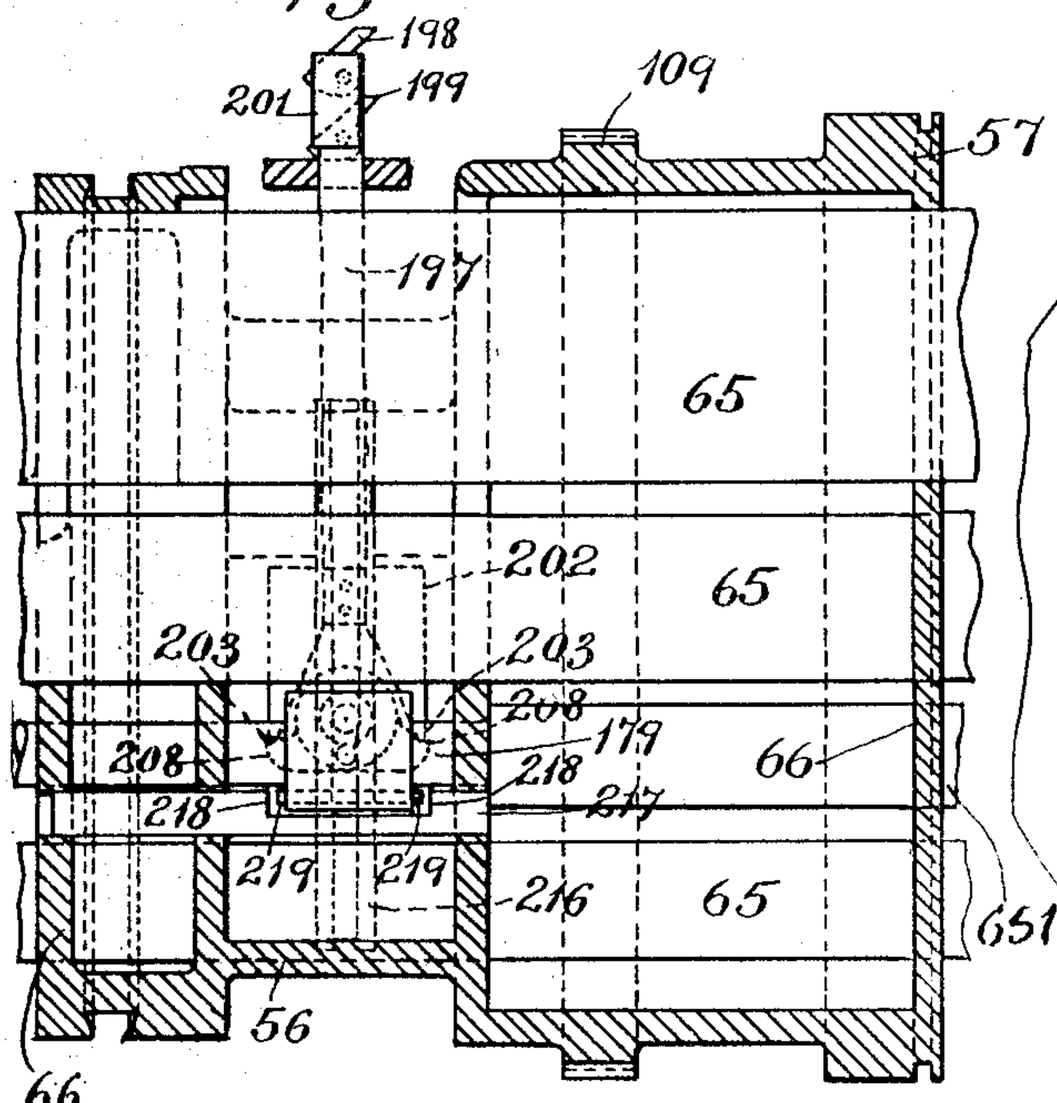

Fig. 29.

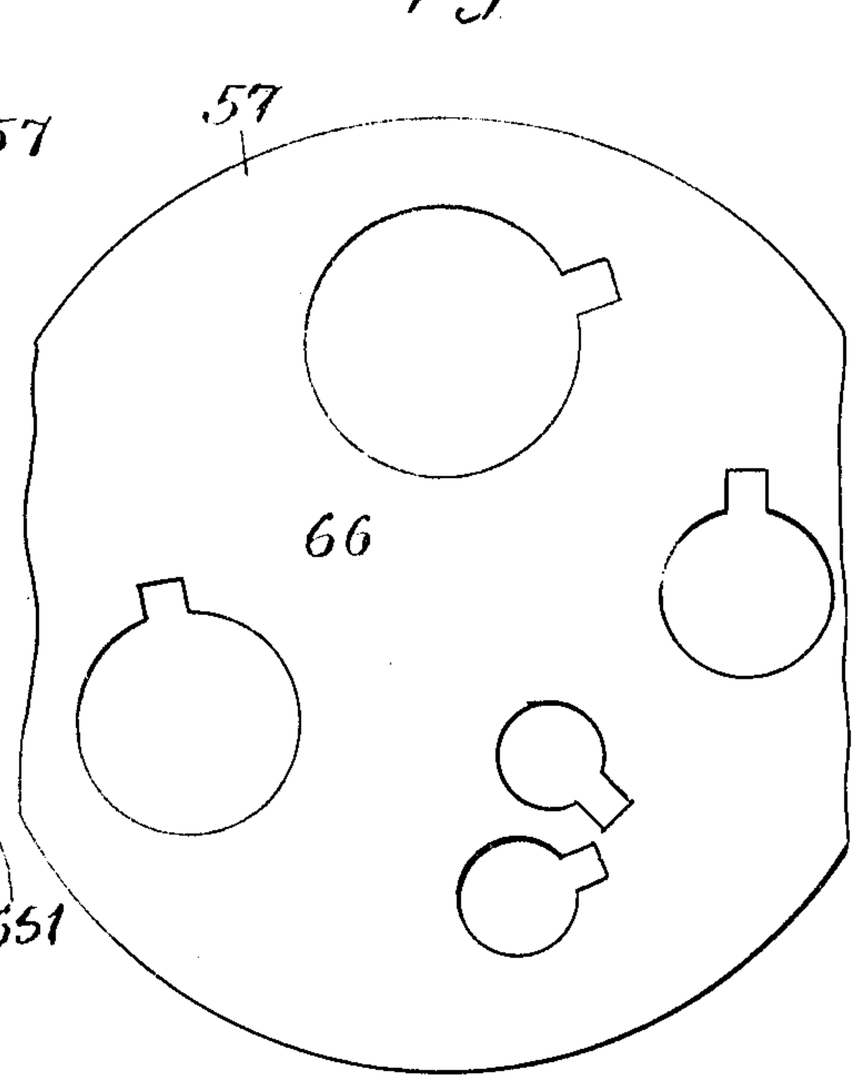

Fig. 26.

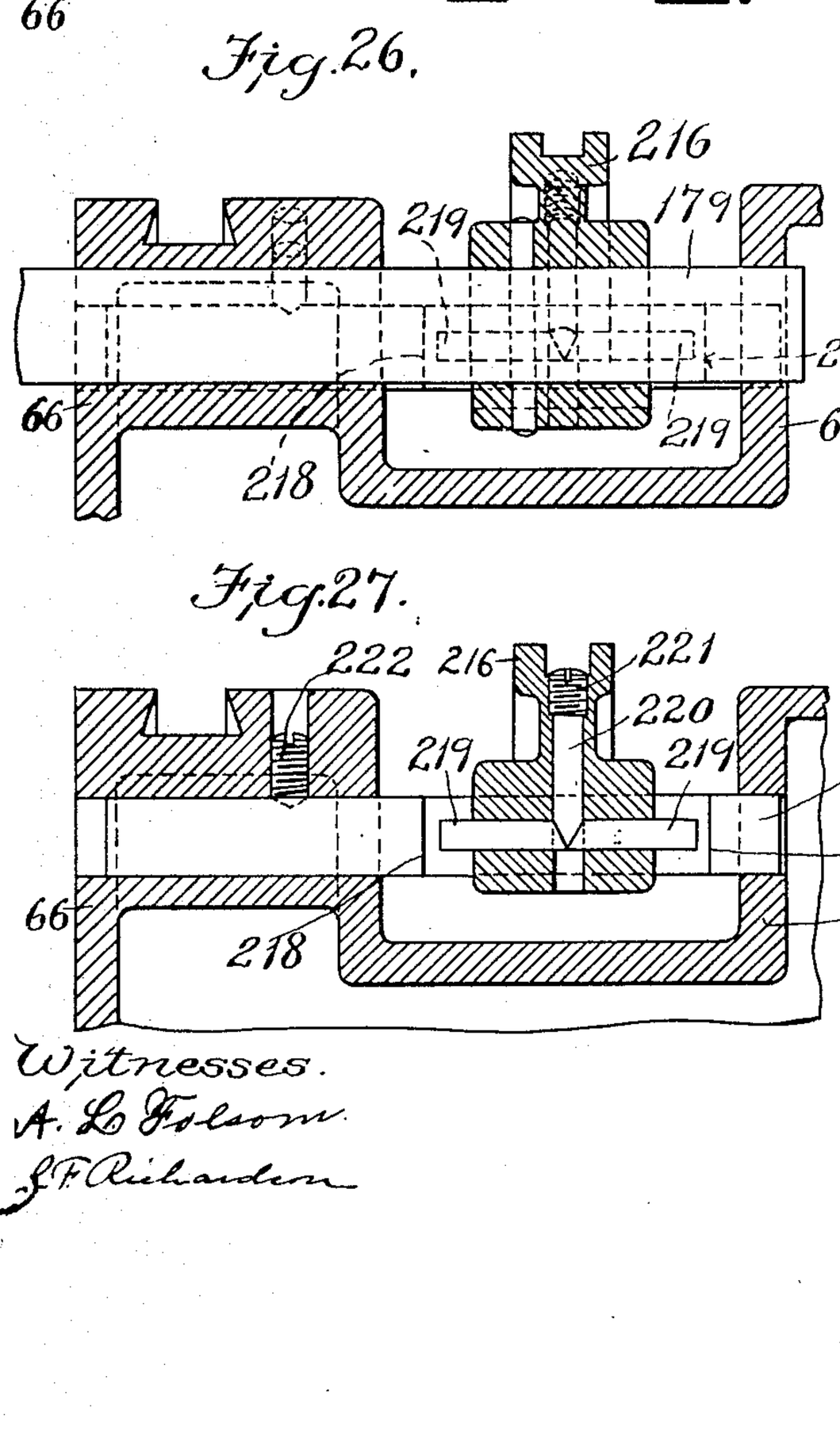

Fig. 28.

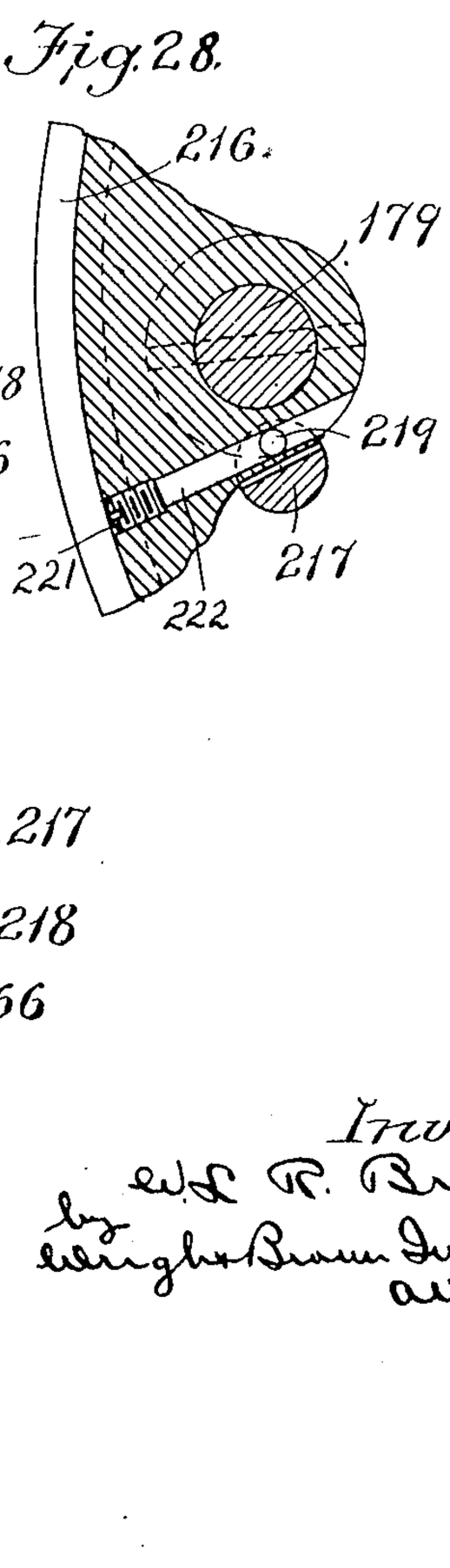

Fig. 27.

Witnesses.
A. L. Folsom.
F. F. Richardson

Inventor.
W. LE R. Bryant
by Wright Brown Quinby & Ult
Attys

W. LE R. BRYANT.

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19 SHEETS—SHEET 14.

Fig. 30.

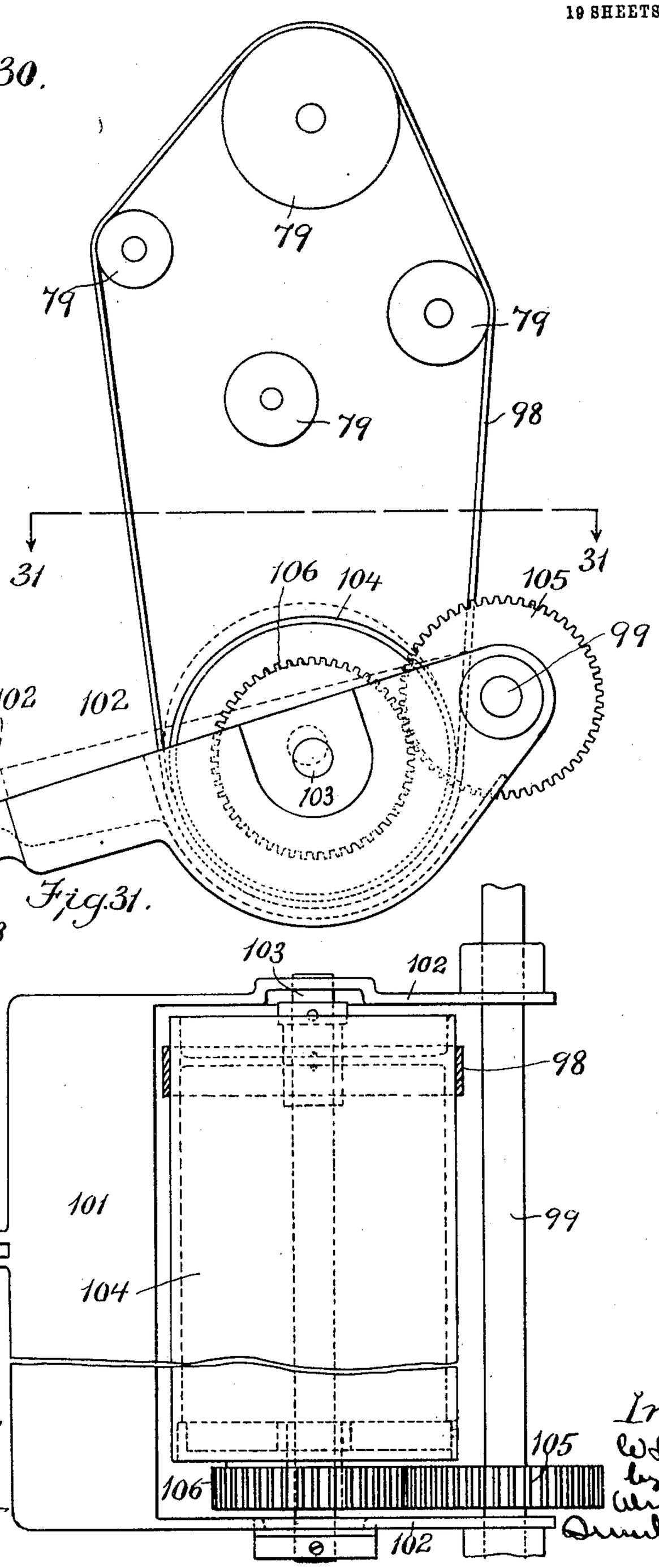

Fig. 31.

Witnesses.
A. L. Folsom
J. F. Richardson

Inventor
W. LE R. Bryant
by
Wright Brown
Quinby & May
atty's

W. LE R. BRYANT.

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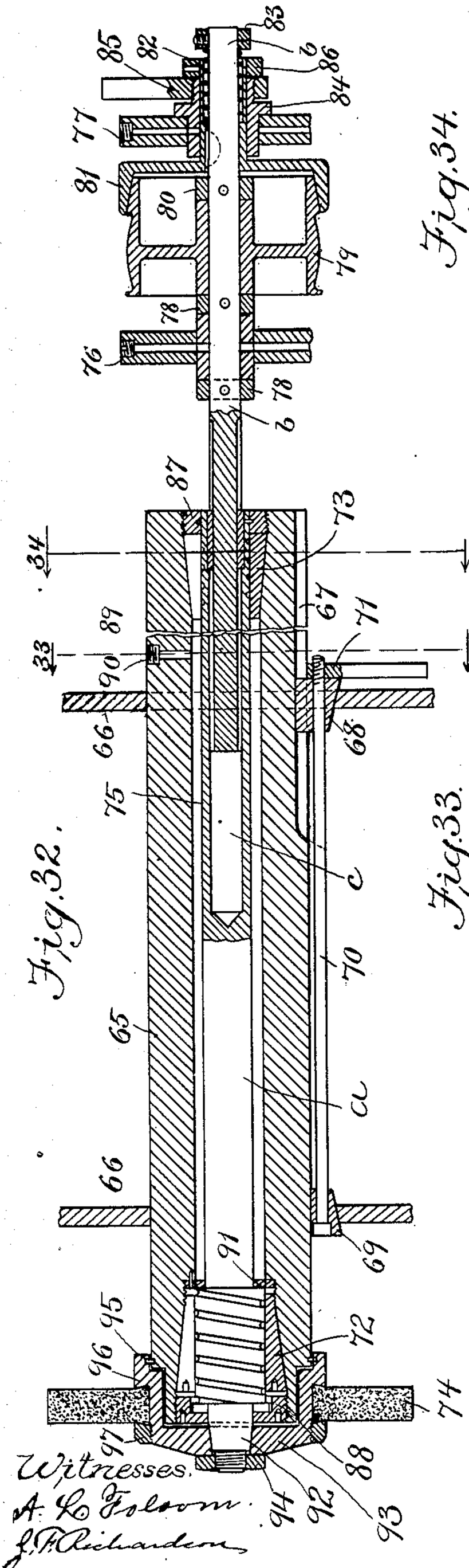

Fig. 32.

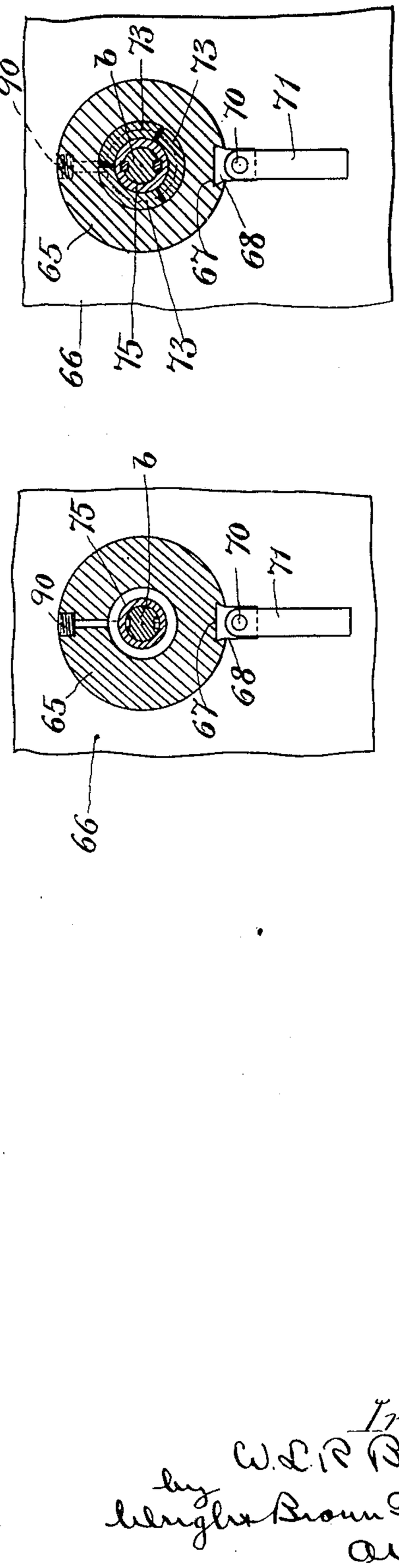

Fig. 34.

Fig. 33.

Witnesses.
A. L. Folsom.
J. F. Richardson

Inventor.
W. LE R. Bryant
by Wright Brown Quinby & May
Attys

W. LE R. BRYANT.

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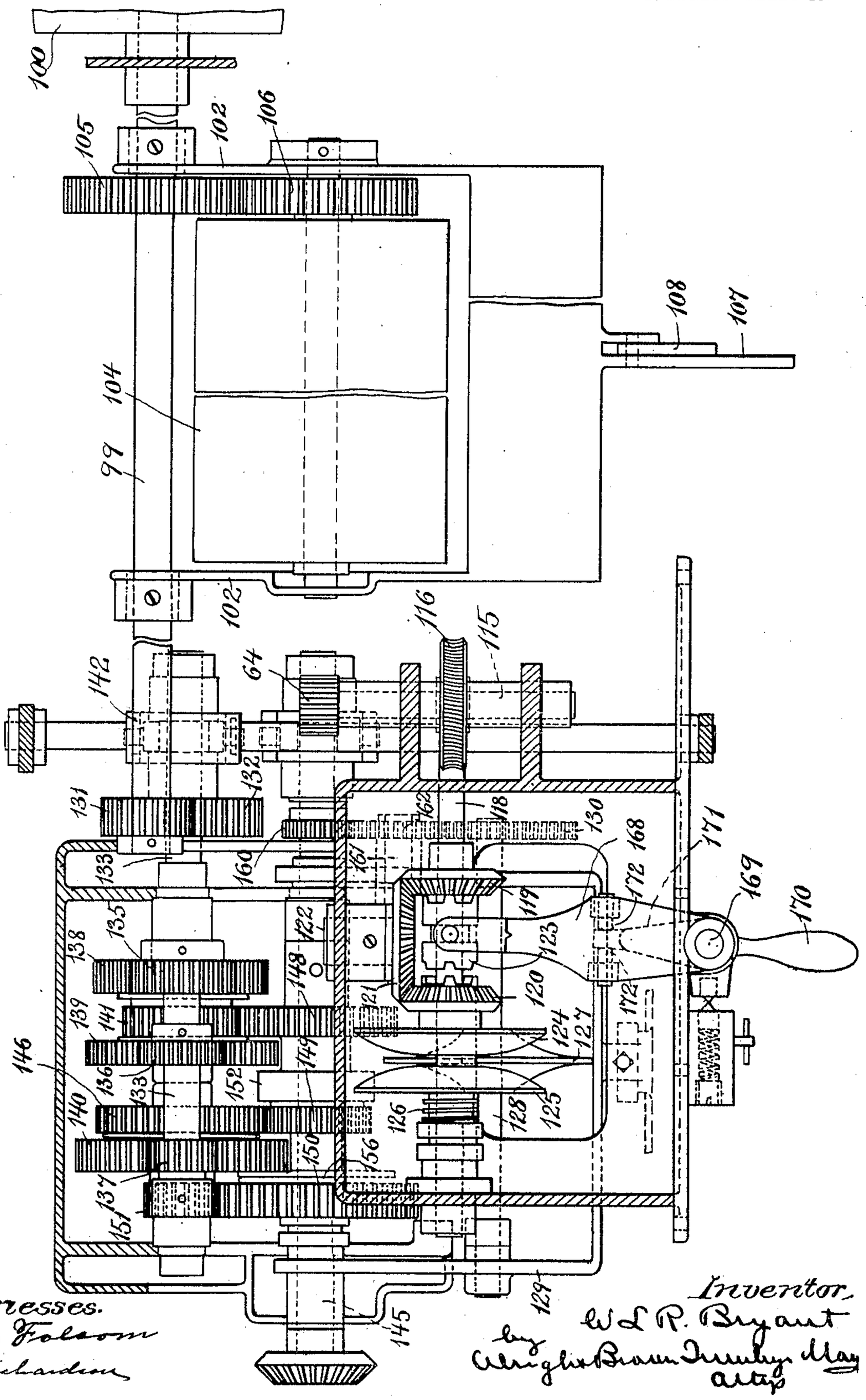
19 SHEETS—SHEET 16.

Fig. 35.



Witnesses.
A. L. Folsom
F. P. Richardson

Inventor.
W. LE R. Bryant
by Wright Brown Quinby & May
Attys

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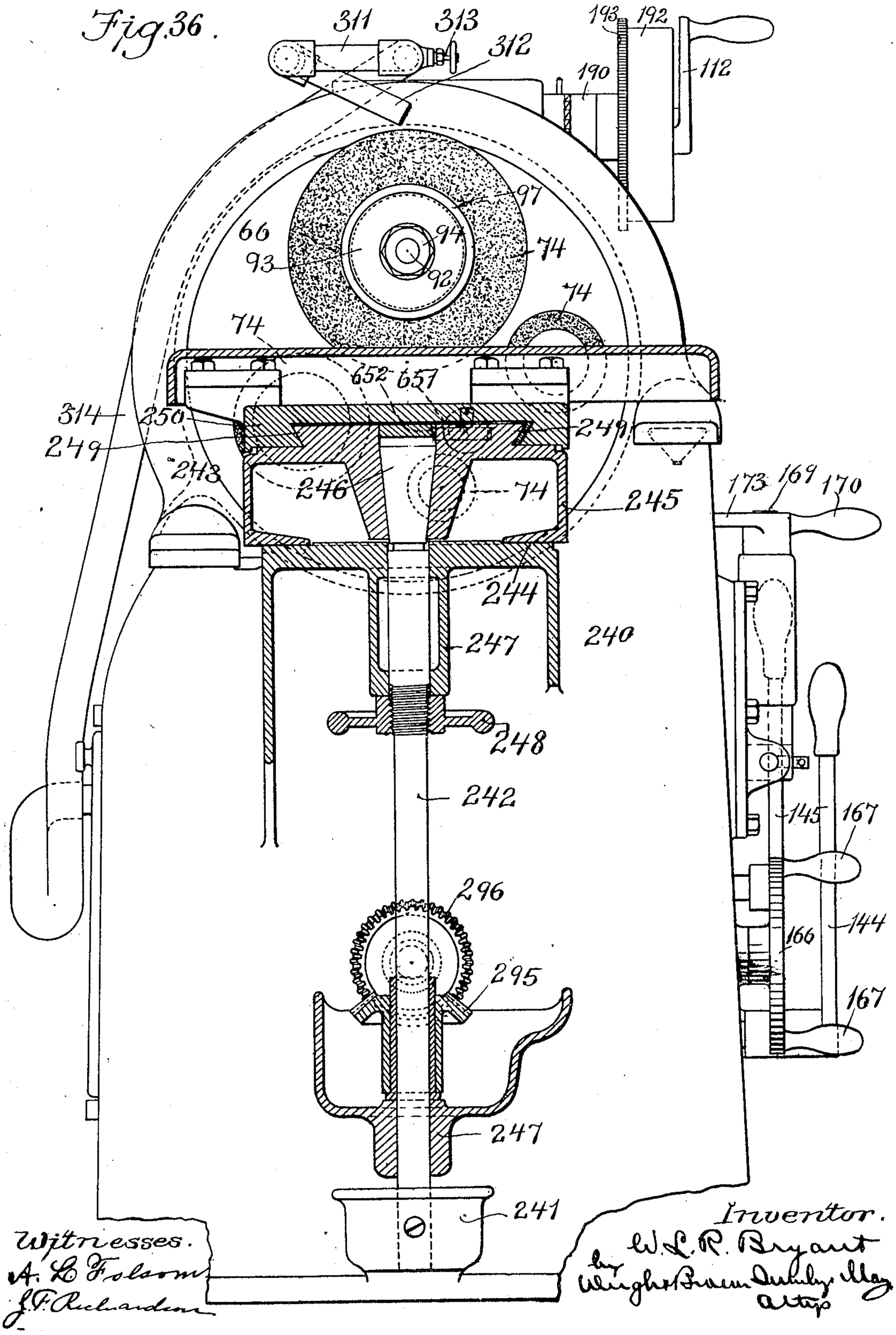
19 SHEETS—SHEET 17

Fig. 36.



Witnesses.
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J. F. Richardson

Inventor.
W. L. R. Bryant
by Wright Brown Quinby & May
Attys

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19 SHEETS—SHEET 18.

Fig. 37.

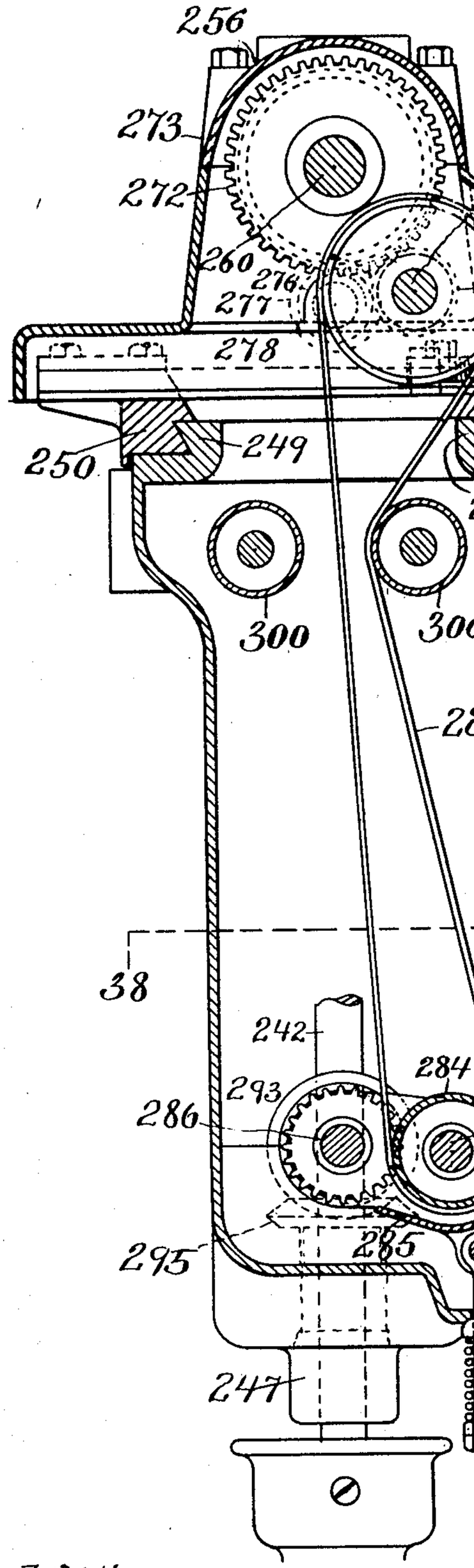
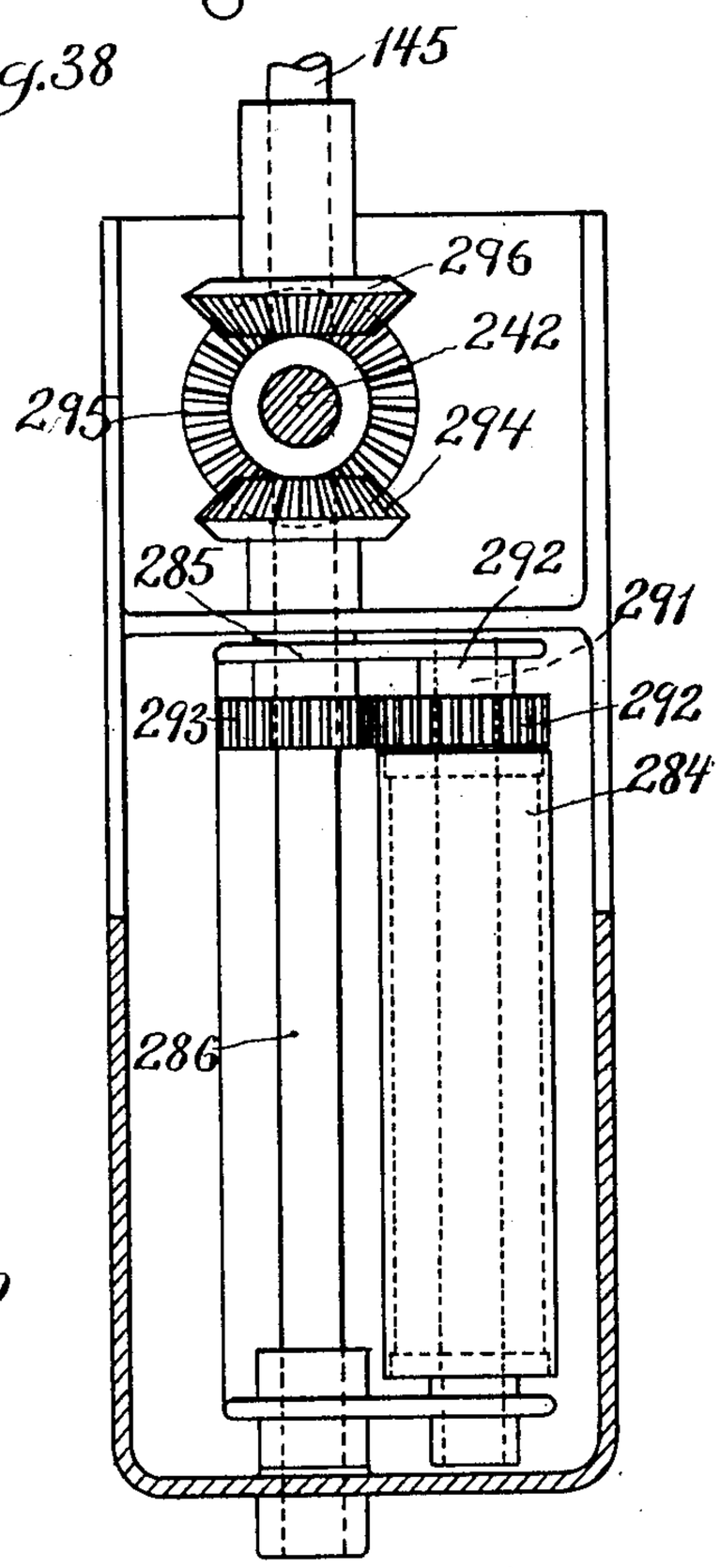


Fig. 38



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F. F. Richardson

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19 SHEETS—SHEET 19.

Fig. 39.

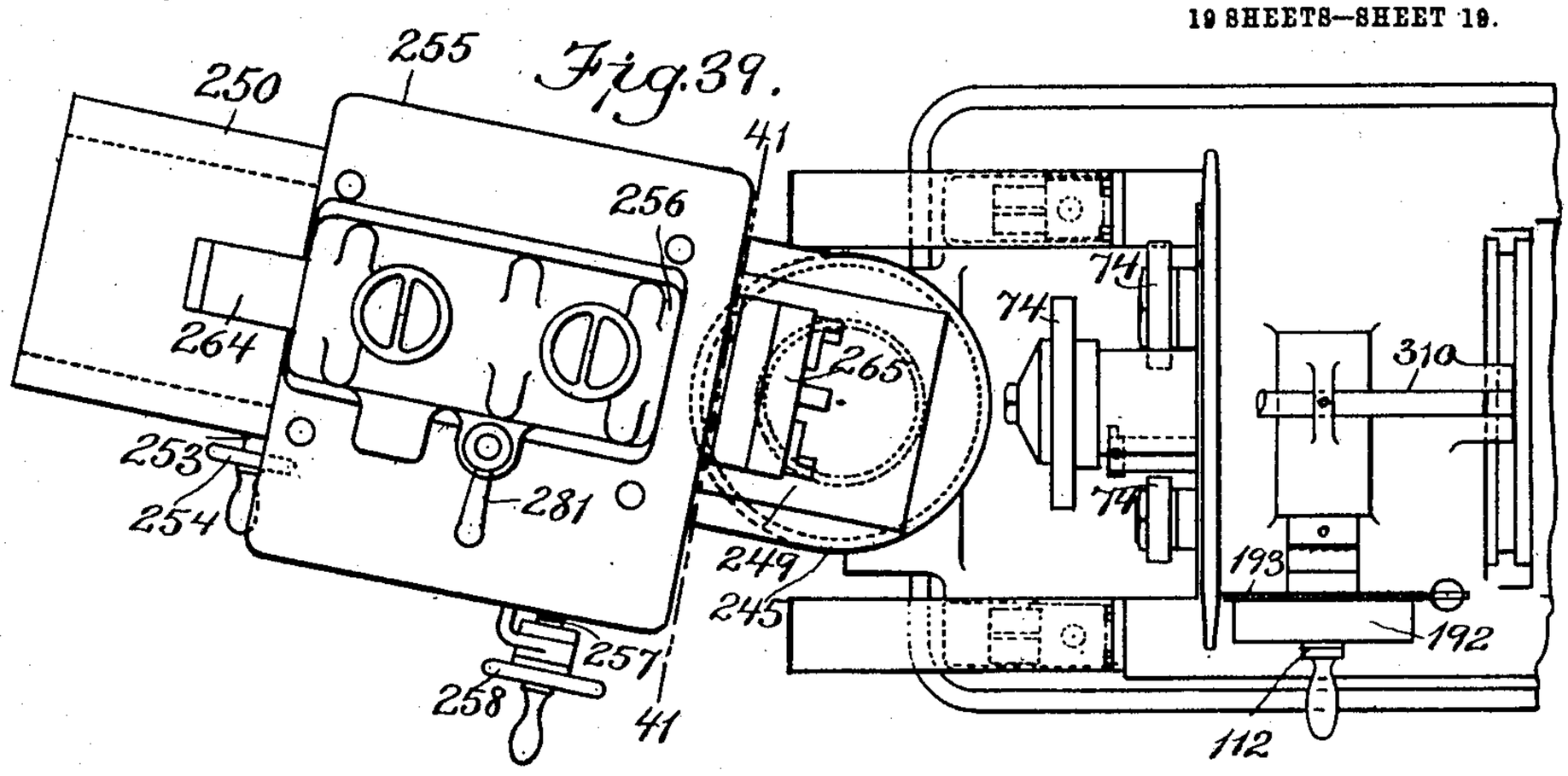


Fig. 40.

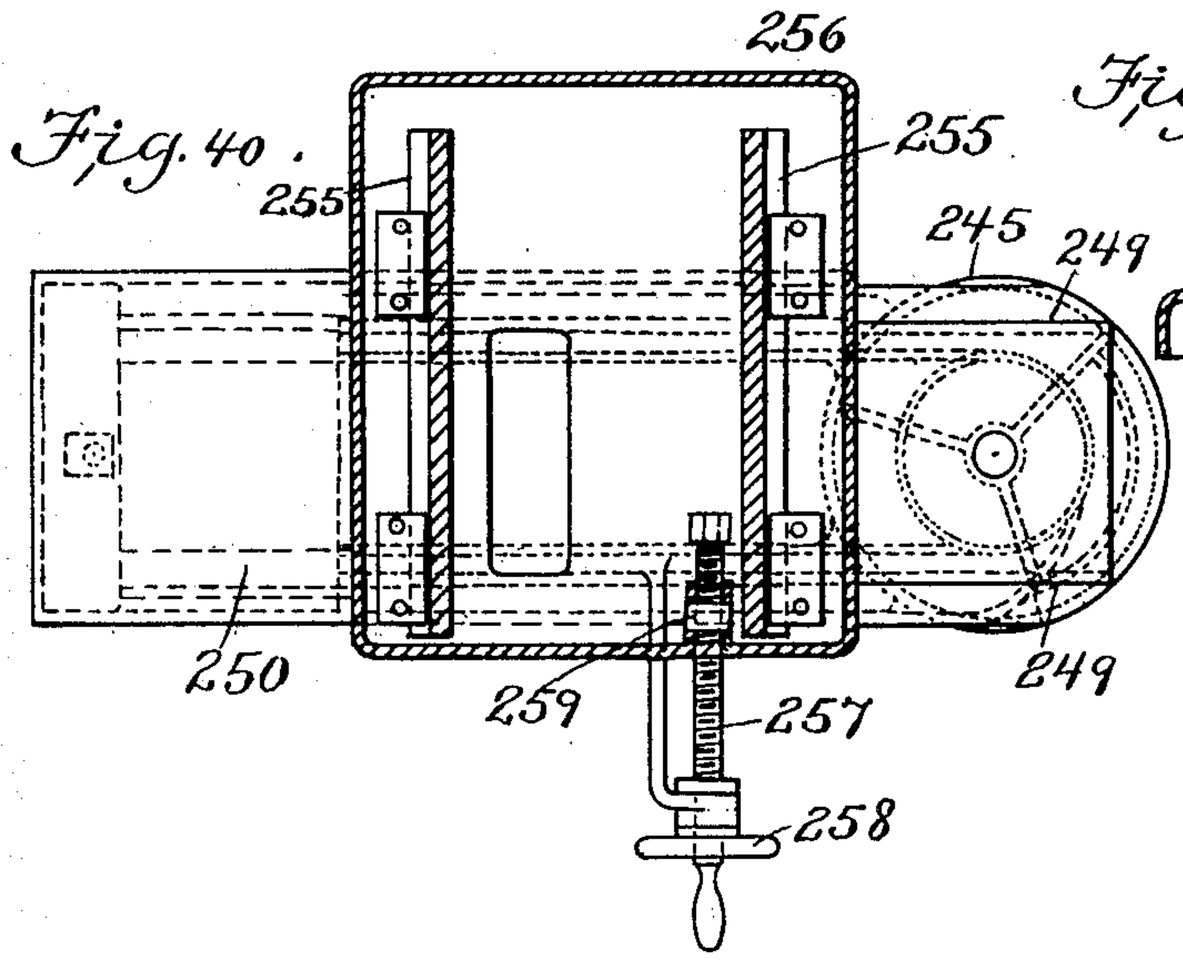


Fig. 41.

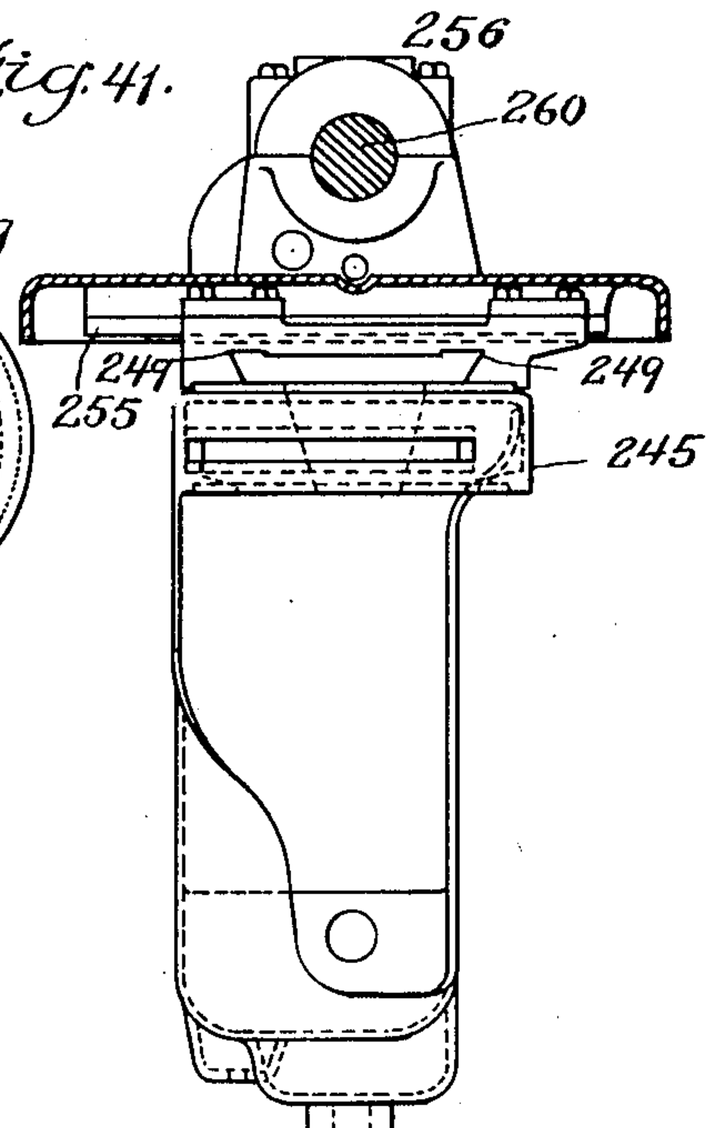


Fig. 42.

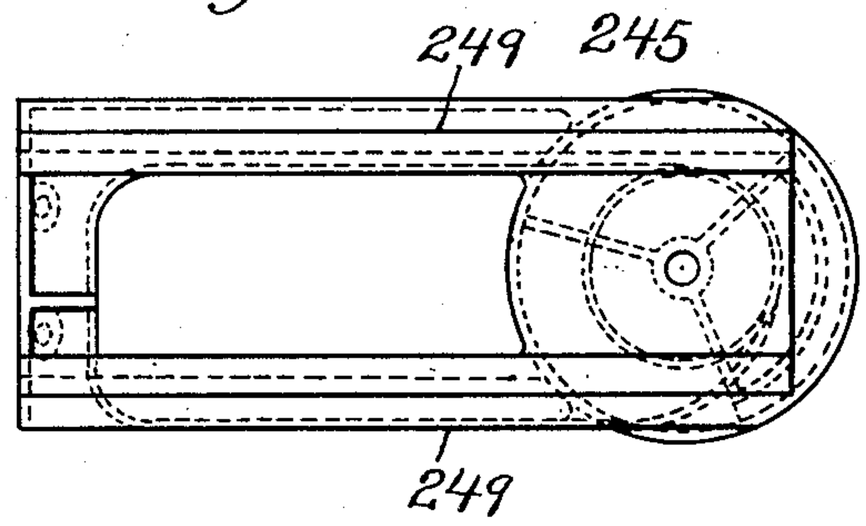
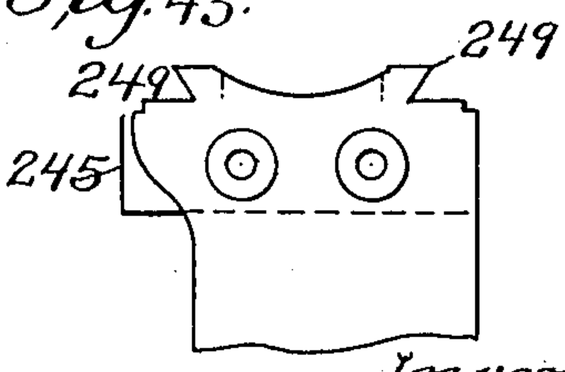


Fig. 43.



Witnesses.
A. L. Folsom
J. F. Richardson

Inventor
W. L. R. Bryant
by Wright Brown Quinby & May
Attys.

UNITED STATES PATENT OFFICE.

WILLIAM LE ROY BRYANT, OF SPRINGFIELD, VERMONT.

MULTISPINDLE METAL-GRINDING MACHINE.

No. 925,867. Specification of Letters Patent. Patented June 22, 1909.

Application filed October 26, 1907. Serial No. 399,334.

To all whom it may concern:

Be it known that I, WILLIAM LE ROY BRYANT, of Springfield, in the county of Windsor and State of Vermont, have invented certain new and useful Improvements in Multispindle Metal-Grinding Machines, of which the following is a specification.

In modern machine shop practice, the best results are secured in the production of turned work by roughing out the work with a lathe or special machine, and then finishing it by means of a grinding tool. Where the finishing operation necessitates the removal of a small amount of stock, a grinding tool is particularly desirable for accomplishing that result, since the removal of the small amount of stock may be done accurately and speedily.

The object of the present invention is to provide a machine for grinding and finishing turned work and for forming thereon external or internal tapers or shoulders as the character of the work may require.

Generally speaking, the invention comprises a plurality of grinding tools of different shapes, sizes and abrading qualities which may be successively brought into operative relation to the work without necessitating a change or removal of the piece of work. The various grinding tools are mounted upon spindles which may be driven at the particular speed it is desirable to rotate the grinding tools thereon. These spindles are mounted upon a rotatable turret located upon a carriage, so that the turret may be rotated to bring any desired grinding tool into operative relation to the work, and the carriage may be advanced and retracted to feed the tool relatively to the work. The work holder consists preferably of a spindle having thereon a chuck or other device for receiving the work. The work holder is rotated and is mounted on slides, in consequence of which it may be moved in lines parallel to its axis and also in lines transverse to its axis. These slides are preferably located upon a support or table which may be swung about an axis perpendicular to the axis of the chuck so as to hold the work either in parallelism with the grinder, or at an angle thereto for the production of a taper. The machine, as illustrated, is of the semi-automatic type, in that the rotation of the turret for the grinder spindles to present the grinding tools to the work is effected manually, although I have contemplated the provision of automatic mechanism for securing this result.

In addition to the grinding tools, I employ a turning tool which is not rotated, but which is mounted in the turret so that it may be brought into proper relation to the work.

In the grinding of a piece of shouldered work, it is necessary to first "neck" the work (*i. e.* form a groove therein) to provide the proper clearance for the grinding tool. Heretofore this has been accomplished by a separate lathe, but this I regard as bad practice, for the reason that the groove or clearance thus formed may not be concentric with the finished ground surface. To prevent this possible error, I provide the turning or necking tool mounted upon the turret, so that after the work has been secured in the work spindle, it may be first necked and then ground.

Referring to the accompanying drawings, which illustrate one embodiment of the invention, to the details of construction of which the invention is not limited however—Figure 1 illustrates the machine in side elevation. Fig. 2 represents an elevation of one end of the machine. Fig. 3 represents an elevation of the other end of the machine. Fig. 4 represents the machine in plan view. Fig. 5 is a longitudinal vertical section on the line *x*—*x* of Fig. 4. Fig. 6 is a longitudinal vertical section on the line *y*—*y* of Fig. 4. Fig. 7 represents a longitudinal vertical section through the machine. Fig. 8 illustrates in plan view the grinder spindles and the turret. Fig. 9 illustrates substantially the same mechanism in front elevation, partially in section. Fig. 10 represents a section on the line 10—10 of Fig. 1. Fig. 11 illustrates a section on the line 11—11 of Fig. 9. Fig. 12 represents a section on the line 12—12 of Fig. 11 and illustrates one of the adjustable stops. Fig. 13 represents a section on the line 13—13 of Fig. 9. Fig. 14 illustrates a section through one of the spindles and one of the knock-off bars. Fig. 15 illustrates in front view a portion of the automatic turret-rotating mechanism by which the grinding tools are fed transversely with relation to the work. Fig. 16 represents a section on the line 16—16 of Fig. 15. Fig. 17 represents in vertical transverse section a portion of the mechanism for effecting the operation of the turret-rotating mechanism. Figs. 18 to 24 inclusive illustrate details of the construction thereof. Figs. 25 to 28 inclusive illustrate the longitudinally movable bars which form a part of the devices which cause the opera-

tion of the turret-rotating mechanism and also which control the slide-moving mechanism. Fig. 29 illustrates one of the disks forming a part of the turret. Fig. 30 illustrates the means for rotating the grinder spindles. Fig. 31 represents a section on the line 31—31 of Fig. 30. Fig. 32 represents in section one of the grinder spindles with the parts thereon. Figs. 33 and 34 respectively represent sections on the lines 33—33, and 34—34 of Fig. 32. Fig. 35 represents the power-transmitting mechanism forming a part of the machine. Fig. 36 represents a section on the line 36—36 of Fig. 7. Fig. 37 represents a section on the line 37—37 of Fig. 1. Fig. 38 represents a section on the line 38—38 of Fig. 37. Fig. 39 represents in plan view the work-holding and rotating devices. Fig. 40 represents a horizontal section through the same. Fig. 41 represents a section on the line 41—41 of Fig. 39. Figs. 42 and 43 illustrate the guides for one of the slides forming a part of the work-holding and rotating mechanism.

Before proceeding to describe the machine which I have selected as best embodying my invention, I desire to have it understood that said machine is not the only embodiment of which the invention is capable, that a wide range of equivalents may be employed for the parts which I have illustrated and will hereinafter describe, and that the phraseology which I have adopted is for the purpose of description and not of limitation except where the sense absolutely requires it.

The machine is provided with a box-like bed or main frame 50, which is substantially oblong. This bed is hollow to receive the power-transmitting mechanism, and it has upon its upper surface guides to receive what may be termed the tool-slide or carriage. The carriage is moved longitudinally of the bed by a power-transmitting mechanism, and it is provided with a turret in which are mounted the carriers or spindles for the grinder tool. As the tool-carriers are brought to operative position with relation to the work, they are rotated by suitable power-transmitting mechanism at the proper or desired speed. The rotation of the turret to bring the proper tool into position to operate upon the work is effected by manually-actuated devices. In addition thereto, the turret is rotated a short distance one step for each longitudinal reciprocation of the tool-slide to effect a transverse feed of the grinder relatively to the work. At the end of the bed, there is pivoted a support or table which carries slides upon which is journaled the work-carrier.

Proceeding to a detailed description, the bed 50 is provided with guides or guideways 51 52 to receive and support the carriage 53 which is provided with complemental guides or guideways 54 55 to engage those at 51 52 on the bed. The left end of the carriage is in the form of a hollow cylinder, as shown in Figs. 7 and 10, to receive the barrel-shaped turret which is indicated at 56, said turret having a peripheral flange 57 which is journaled in a bearing 58 formed at the left end of the tool-slide. The turret has an extension 59, the end 60 of which is journaled in a bearing 61 in the end wall 62 of the tool-slide. The turret end 60 has thrust collars 601, 602, there being a spring 603 between the collars 602, and a head 604 on the end 60 to hold the turret firmly against the collar 601. Secured to the under side of the carriage, there is a rack 63 with which is engaged a pinion 64 for effecting its movement and thereby causing the reciprocation of the carriage. In the turret are mounted a plurality of sleeves or bolsters 65, of which there may be any desired number, as four for instance. These sleeves or bolsters are longitudinally movable relatively to the turret and may be locked in position after such movement, as will be subsequently explained. Each sleeve serves as an elongated bearing for one of the spindles which carries a grinding tool, as illustrated in Fig. 32. In addition to the grinder spindles, I provide a bar or cylindrical carrier 651 which is provided at its front end with a transversely adjustable necking or turning cutter 652 as shown in Fig. 13. Each sleeve 65, and the bar 651 are mounted in the end walls 66 of the turret which are apertured to receive them. Said members are each provided with a longitudinal exterior groove at one end, as indicated at 67, to receive a combined spline and wedge 68 which is inserted in a notch in one of the end walls 66. In the aperture in the other of the end walls 66 is a wedge 69. A rod 70 is passed through the two wedges, its head engaging the wedge 69, and a nut 71 on its other end engaging the wedge 68. The nut 71 has a handle so that, by rotating it in one direction or the other, the wedges may be drawn closer together to clamp the sleeve or the bar 651 against movement or else may be released to permit the sleeve or the bar 651 to be moved manually longitudinally. Each sleeve is provided at its ends with bearings 72 73 to receive the spindles for carrying the grinding tools 74. Each spindle, which is indicated as a whole at 75, is extensible, consisting of two telescoping parts *a* and *b*. The extensible part *a* of the spindle is journaled in bearings 72 and 73 and is provided with a socket *c* to receive the part *b* which is splined therein, as shown in Fig. 32. The extremity of the part *b* of the spindle is journaled in peripheral flanges 76 77 of the extension 59 of the turret, these flanges being separated from each other a distance for the purpose to be explained. The part *b* is held against axial movement with relation to the turret by collars 78 and has mounted loosely

upon it a pulley 79 located between the flanges 76 and 77 of the turret. This pulley is loose, being held between one of the collars 78 and a collar 80 pinned on the part *b* of the spindle 75. Splined upon the said part *b* is a friction clutch member 81 having an internally-tapering portion on the pulley 79. This clutch member has a hub which is journaled in the peripheral flange 77 of the turret and it also forms a bearing for the part *b* of the spindle 75. A spring 82 encircles the end of the part *b*, one end bearing against an internal shoulder in the hub of the clutch and the other bearing against a collar 83 on the end of the part *b* so as to normally hold the clutch member yieldingly in engagement with the pulley so that the spindle will be yieldingly driven. A sleeve or bushing 84 encircles the hub of the clutch member and has a threaded end upon which there is a handle nut 85. This nut may be adjusted to serve as a stop for a collar 86 on the end of the hub of the clutch member so as to limit the longitudinal movement of the clutch or so as to withdraw the clutch from engagement with the pulley.

Returning now to the part *a* of the spindle 75, it will be observed that the bushing 73 is beveled and split, and is crowded into the beveled end of the sleeve 65 by a ring 87. The bushing 72 is likewise split and beveled and is forced into place by a flanged ring 88. Oil is introduced into the interior of the sleeve 65 through a duct 89 normally closed by a screw plug 90. The ends of the part *a* of the spindle are helically grooved to carry oil into the bearing bushings 72 73. The outer end of the part *a* is somewhat enlarged to provide a shoulder which may abut against a thrust-resisting washer 91. The outer extremity of the spindle is tapered as at 92 to receive the metallic hub 93 of the grinding wheel, there being a nut as at 94 to hold said hub in place. The said hub overlaps the sleeve and is provided with a packing ring 95 to prevent the entrance of water into the space between them. The hub is formed with an undercut peripheral flange 96, against which the grinding disk 74 may be clamped by an undercut screw-collar 97. It will be observed from the drawings, that the grinding disks 74 are of different sizes so that they may be used for various purposes to grind the work interiorly or exteriorly as circumstances may require. Said disks will preferably be formed of materials differing as to their abrading qualities, as the character of the work to be accomplished may demand.

The grinding disks and their sleeves and the cutter bar 651 are normally withdrawn to the positions in which the lower grinding tools are illustrated in Fig. 7. After the turret has been rotated to bring the desired tool in proper relation to the work, the sleeve or bolster therefor (or the bar 651) is moved outward by hand and clamped as previously described, as illustrated by the upper grinding tool in the last-mentioned figure, so that the tool may engage the work.

The pulleys 79 for the various grinder spindles are of different sizes so as to drive each grinding tool at the desired speed. They are arranged equi-distant from the axis of rotation of the turret and they are all adapted to be engaged by a single belt as illustrated in Figs. 2, 7, 30 and 31. This belt, which is indicated at 98, is driven by mechanism which I will now explain. The bed or frame 50 of the machine is provided with a front to rear partition in which and in the right end wall of the bed is journaled a prime power-shaft 99. This shaft is equipped with the usual driving pulley 100 by which it is rotated. Hung upon the shaft 99 is a yoke 101, in the arms 102 of which is loosely journaled a shaft 103 parallel to that at 99. Upon this shaft is secured an elongated drum 104, around which the belt 98 passes. The yoke extends forwardly from the shaft 99 so that its weight is sustained by the driving belt 98, the gravity of the yoke serving to maintain the belt in proper frictional engagement in the upper belt pulley 79 and the two adjacent pulleys. Upon the shaft 99 and the shaft 103 are the intermeshing gears 105 106, by which rotation is imparted to the drum 104. The yoke is provided with a forwardly-extending handle 107 which projects through an aperture in the front of the bed, as shown in Fig. 1. The yoke hangs normally upon the belt but it may be raised and held in a raised position while the turret is being rotated. To this end, there is pivoted to the handle 107 a finger 108 having a shoulder adapted to engage the lower end wall of the slot in the front wall of the bed of the machine, as illustrated by the dotted lines in Fig. 30. When the yoke is so raised and locked in its raised position, tension is removed from the belt 98 and the turret may be rotated with ease. The yoke constitutes an automatic belt-tightener and it automatically compensates for the differences in the diameter of the driven pulleys 79.

The mechanism, by which the turret may be rotated by hand, is illustrated in Figs. 7 and 10 to which reference may now be had It will be observed that the turret is formed with worm-teeth 109 on its periphery, with which a worm 110 is engaged. This worm is secured to a shaft 111 which is journaled in suitable bearings in the upper portion of the tool-slide, and upon its forwardly projecting end, it has a crank 112 by which it may be rotated. As an incidental matter of construction, the shaft 111 is illustrated as being journaled in bushings or sleeves 113 114.

The longitudinal reciprocation of the carriage through the rack and pinion 63 64 is effected by the following mechanism: The pin-

ion 64 is mounted upon a shaft 115 which is journaled in suitable bearings and extends toward the front of the bed as shown in Figs. 9, 10, 11 and 35. The shaft 115 has a worm-wheel 116 which is engaged with and driven by a worm 117 on a shaft 118 extending longitudinally of the bed. Upon this shaft are loosely journaled two beveled gears 119 120 which engage a bevel gear 121 upon a stud shaft 122 mounted in stationary bearings. The two bevel gears 119 120, which are rotated in opposite directions, are provided with clutch teeth, as shown in Fig. 35, with which a clutch member 123 splined to slide upon said shaft 118 may be engaged. By shifting the clutch member in one direction or the other, the shaft 118 may be rotated first in one direction and then in the other, so that, through the gearing previously described, the carriage may be advanced and retracted on the bed toward and from the work.

I desire to have it understood that the particular mechanism, which I have described thus far for the purpose of feeding the carriage, is simply one which has commended itself to me, but which is not at all necessary, since other feeding mechanism may be utilized in lieu thereof; and the mechanism, which I shall now explain for transmitting power from the main power-shaft to the bevel gear 120, may have substituted for it any other power-transmitting mechanism which will recommend itself to the builder of the machine. I may here state, however, that I prefer to employ a variable speed gearing for the reason that I find it desirable to feed the carriage at different speeds in accordance with the character of the operation being performed by the particular tool which is then operating on the work. For one grinding disk it is desirable to feed the carriage at a high speed, for another tool it is desirable to feed the carriage at a lower speed, and for other tools the carriage may be fed at other speeds as may seem meet for them. I also prefer to drive the carriage-feeding mechanism yieldingly or frictionally, although this is not necessarily essential.

The bevel gear 120 is formed on or secured to a beveled friction disk 124 and confronting said disk is a similar one as at 125 which is pressed toward it by a spring 126. With these two disks is engaged a driving disk 127 (see Figs. 11 and 35), which is concavely beveled as shown. This disk is secured upon a shaft 128 journaled in a yoke 129. Upon the shaft is secured a gear 130 by which rotation is imparted to it.

I will now explain the variable speed mechanism by which the gear 130 is rotated. On the prime power shaft 99 is a gear 131 which intermeshes with and drives a gear 132 on a shaft 133 located within the end of the bed of the machine. Immediately below the shaft 133 there is another shaft 134, as shown in Figs. 9, 11 and 35, said shaft being provided with three pairs of gears for effecting the rotation of the shaft 134 at any one of three different speeds. The gears on the shaft 133 are indicated at 135, 136 and 137; those on the shaft 134 being indicated at 138, 139 and 140. Between the gears 138 and 139 on the shaft 134 there is a sliding gear 141 which may be moved by a yoke 142 into clutched engagement with either of said two gears so as to cause the shaft 134 to be driven by either of them. When the gear 141 is in its neutral unclutched position, the shaft 134 will be driven from the gear 140 by a ratchet-clutch mechanism, which I have not illustrated as it is well known. This ratchet-clutch mechanism is introduced between the gear 140 and a gear 146 fast upon the shaft 133. Such a clutch as may be used is illustrated in the patent to Hartness No. 703,411 dated July 1, 1902. A yoke 142 is mounted upon a rock-shaft 143 which extends through the front wall of the bed and is provided with a handle 144 by which it may be rocked. This yoke is connected by any suitable means with the sliding gear 141 for the purpose of moving it into clutched engagement with either of the gears 138 139. In front of the shaft 134, there is another shaft 145, upon which there are three gears 148 149 and 150. These gears intermesh respectively with the gears 141 146, previously referred to, and a gear 151, all on the shaft 134. The gear 151 is fast on or formed upon the shaft 134. The gears 148 and 149 are loose upon the shaft 145, and either may be clutched thereto by a clutch member 152 with which is connected a yoke 153 on a rock-shaft 154 extending through the front portion of the bed and having connected to it a lever 155. The gear 150 is loose upon the shaft 145, but drives the same through the ratchet clutch 156, the details of construction of which are not illustrated. Through the medium of the variable speed gearing, thus briefly described, it will be understood that the shaft 145 may be driven at any one of nine different speeds. The variable speed mechanism thus described, is preferably located within a casing especially adapted for it.

The gearing which connects the shaft 145 with the shaft 128, hereinbefore referred to, may be constructed conventionally as follows: Upon the shaft 145 is a gear 160. The shaft 128, which carries the gear 130, is mounted in a yoke 129 as previously described. This yoke is hung upon the shaft 145 and projecting out from one side of the yoke, there is a stud shaft 161 carrying an idler-gear 162 which intermeshes with the two gears 130 and 160. The friction disk 127, which is carried by the yoke, may be adjusted with reference to its complemental disks 124 125 by swinging the yoke about the

axis of the shaft 145. This may be conveniently accomplished by means of an eccentric as indicated at 163, upon the periphery of which rests the end of the screw 164 passed through a lug on the front of the yoke This eccentric is located inside of the front wall of the bed, and is mounted upon a shaft 165 journaled in the bearing in the bed wall and having on its forwardly projecting end a disk 166 with handles 167 by which it may be rotated.

From the foregoing description, it will now be apparent that the friction disk 127 may be employed to drive the shaft 118 at any one of nine different speeds so that the carriage may be fed back and forth at the speed which is desirable. The direction of rotation of the shaft 118 is varied by shifting the clutch member 123 so as to cause said shaft to be driven either by the bevel gear 120 or by the bevel gear 119. The clutch may be shifted manually but is also adapted to be shifted automatically.

168 is a yoke which is journaled upon an upright rock-shaft 169 mounted in suitable bearings in the front wall of the bed. To the upper end of said shaft is attached a handle 170 projecting forwardly from the bed, and attached to the lower end of the shaft there is an arm 171 which extends between two set screws 172 172 passed through lugs on the under side of the yoke 168, so that, when the shaft 169 is rocked, it will oscillate the yoke 168 and effect shifting of the clutch member 123.

Any suitable mechanism may be employed to rock the shaft 169 at the end of the travel of the tool-slide or carriage. Projecting forwardly from the handle 170 there is an arm 173 which is connected by a rod 174 located inside the bed and extending longitudinally thereof, with an arm 175 (see Figs. 8, 9 and 13). The arm 175 projects outwardly from a yoke 176 which is hung upon a vertical rock-shaft 177 mounted in suitable supports. The front part of the yoke is extended upwardly to form a lever or member as at 178, in proximity to the turret, so that it may be engaged by devices thereon and rocked to effect the shifting of the clutch member 123 through the connections last described. The turret is provided with a plurality of stops, one pair for each of the grinding tools, for effecting the operation of the knock-off mechanism or carriage-reversing mechanism.

Referring to Figs. 8, 9, 13 and 14, it will be observed that the turret is provided with a plurality of rods or supports 179, of which one is located in parallelism with and relatively near to each of the spindles 75. Each rod is provided with two stops 180 181. The rods themselves are mounted at their ends in the left end of the turret and in the peripheral flange 76 of the turret hereinbefore referred to, and they are, for a purpose to be described, adapted to be moved longitudinally or axially to a limited extent. The shape of the stops 180 and 181 is shown in Figs. 13 and 14, each being extended peripherally of the turret to insure the engagement of the stop with the knock-off lever 178. Each of the stops may be attached to its support or rod 179 by a locking pin 182 entering a longitudinal groove in the rod and clamped or wedged in place by a screw-pin 183, as best shown in Fig. 14. The stops 181 are all set in the same transverse vertical plane to limit the forward movement of the tool-slide, but the stops 180 are located in different vertical planes according to the desired length of travel of the tool-slide. When the slide travels rearward, one of the stops 180 engages the knock-off arm 178 and effects the shifting of the clutch 123 to effect the withdrawal of the carriage; and when the tool-slide reaches its rearward extreme of movement for that particular piece of work, the stop 180 engages the knock-off member 178 and shifts the clutch in the opposite direction to cause the carriage to be again fed forward.

It is desirable to automatically feed the tool transversely of the work at each reciprocation of the tool-slide and to accomplish this, the following mechanism is provided: Reference may now be had to Figs. 10, and 15 to 28 for an illustration of this mechanism. It has already been explained how the turret is rotated by means of the worm 116 and the shaft 111. On the shaft 111 is mounted a sleeve 190 having on its inner end ratchet teeth, as illustrated in Fig. 2, which may be engaged by a latch 191 to hold it against rotation, said latch being located in a socket in the sleeve 114 previously described. Loosely mounted upon the sleeve 190 is a casing 192 having a peripheral ratchet-toothed flange 193. By a mechanism to be explained, this ratchet-toothed casing is rotated with a step-by-step movement. The casing is provided with two planetary gears 194, each of which intermeshes with a gear 195 on the end of the sleeve 190, and a gear 196 keyed to the shaft 111. When the sleeve 190 is locked against rotation, the rotation of the casing 192 will effect the rotation of the shaft 111 through the planetary gearing thus described; but, when the latch 191 is disengaged from the sleeve 190, the shaft 111 will not be rotated by the rotation of the casing 193. For the purpose of effecting the step-by-step rotation of the ratchet 193, I mount in the tool-slide a vertical slide or carrier 197 (see Figs. 17 and 18), which is provided at its upper end with two pivoted pawls 198 199 between which is a spring 200 for the purpose of holding either of them in engagement with the ratchet 193. On the upper end of the slide or rod 197 is a sleeve 201 by which the

two pawls may be moved to an inoperative position so as to render the automatic feeding mechanism inactive. To the lower end of the slide 197 is secured a plate 202 which is in the shape of a fork or yoke with two diverging fingers 203, as shown in Fig. 21. The fingers straddle a disk 204 on the end of a sleeve 205. This sleeve is journaled in suitable bearings 206 and is rocked to oscillate it so that either of the lugs 208 on the disk 204 will engage and lift the fingers 203 and move the slide 197 upward. The sleeve is rocked by a shaft 209 which has upon its forward end a crank-arm 210. There is on the end of the rock-sleeve 205 a similar arm 211. Splined in the end of the arm 210, is a headed pin 212, the beveled end of which enters a notch in the face of the arm 211. This pin is held yieldingly inward by a spring-pressed latch 213 having a beveled end which engages beveled notches in said pin 212. When the shaft 209 is rocked in one direction or the other, it rocks the sleeve 205 so as to cause the disk 204 to lift the yoke 202 from the position shown in Figs. 19 and 21 to the position shown in Fig. 20. On the inner end of the shaft 209 is a disk 214 carrying a crank pin 215. This crank pin is engaged successively by cams or members 216 (see Figs. 8 and 17) which are secured upon the rods 179 hereinbefore described. Each cam 216 is provided with a peripheral groove into which the crank pin 215 may enter as best shown in the last-mentioned figures. It has been stated previously that the rods 179 have a slight axial or longitudinal movement. This movement is controlled by the devices shown in Figs. 25 to 28 inclusive. Located adjacent each of the rods 179 is a short rod 217 which is cut away to provide two shoulders 218 219. In the hub of each cam 216 are placed two oppositely and axially extending pins 219 which are adjusted by a wedge pin 220 and a screw 221. The rods 217 are secured against axial movement by screws 222, and hence the pins 219, engaging the shoulders 218 218, limit the axial movement of the rods 179.

It has already been explained that the cams 180 and 181 engage the knock-off lever or arm 178 to reverse the direction of movement of the tool-slide. The rods 179 are mounted in their bearings so that, when the stops 180 and 181 engage the knock-off lever or arm 178, the stops and rods will first yield and remain stationary momentarily while the slide continues its movement, until the said rods are engaged by the pins 219 and caused to resume their movement. This momentary checking of the rods 179 effects a relative movement of the rods and the tool-slide, and consequently a relative movement of the cams 216 and the shaft 209 to effect the movement or oscillation of the crank 215 and the rocking of the shaft 209. The rocking of the shaft 209 in either direction causes the reciprocation of the pawl-carrier or slide 197, and therefore causes the ratchet 193 to be advanced one step and the turret to be slightly rotated for the purpose of feeding the working tool transversely of the work.

It will be understood that any other mechanism may be utilized in lieu of that which I have described for the purpose of effecting the transverse feeding of the tool relatively to the work. A variation in the feed is accomplished by adjusting the pins 220 so as to vary the relative movement of the rods 179 to the rods 217. While this feeding mechanism is positive, in a sense, nevertheless it is adapted to yield to prevent breakage and it is for this purpose that the pin 212 has a beveled end extending into a beveled notch in the arm 211. I further provide stops for limiting the transverse feeding movement of the grinder-tools, which may conveniently take the form illustrated in Fig. 13. The carriage is provided with a stationary stop 230 which is pivoted to the top of the turret bearing to hang down in the path of adjustable stops attached to the turret. These stops on the turret, as shown in Fig. 12, are indicated at 231 and they are located in a dovetailed peripheral groove in the turret. They are adjustably secured in place by locking pins 232, 233, the latter being engaged by a set screw 234. The pins 232 and 233 have complemental wedge-shaped or beveled ends, so that, when the pin 233 is forced inward by the screw 234, the pin 232 is crowded against one of the walls of the groove to lock the stop 231 against movement. The stop 231 is provided with an adjustable screw pin 235 which will engage the depending end of the abutment or stop 230 so as to limit the rotation of the turret and the transverse feed of the tool.

As thus far explained, it will be apparent that, after any one of the grinding tools has been brought into proper relation to the work, the turret slide or carriage will be reciprocated longitudinally of the bed to feed the tool longitudinally of the work, and that at the end of each longitudinal movement of the said slide or carriage, the turret will be slightly rotated so as to feed the tool transversely of the work.

The work-holder and the means for supporting and moving it will now be described, reference being had particularly to Figs. 4, 5, 6, 7 and 36 to 43. At the left end of the bed 50, there are two brackets which are indicated at 240 and 241, in which is secured an upright rod or shaft 242. On this shaft is pivoted a table which is indicated as a whole at 243. The upper face of the bracket 240 is substantially flat with a circular guideway 244 upon which a portion of the table

rests as indicated at 245. The table itself is hollow and is of any convenient shape, consisting of a frame which, in plan view, is substantially rectangular with a rounded inner end. The inner end 245 of the top of the table has a tapering aperture to receive the tapering end 246 of the shaft or rod 242, said table having a lower portion 247 through which the rod passes as shown in Fig. 7. The rod 242 is screw-threaded to receive a nut 248 by which the rod may be drawn downward to clamp the table firmly upon the guideway 244 of the guide, and lock the table in any position to which it may be adjusted about the axis of the rod 242. The table is provided with longitudinal guideways 249, as shown in Fig. 7, to receive a longitudinally movable slide or carriage 250. This slide or carriage is equipped with a rack 251 with which is engaged a pinion 252 on a shaft 253 projecting forwardly through the front wall of the table frame. On the said shaft is a hand wheel 254 by which it may be rotated to feed the carriage longitudinally of the table. Upon the carriage are transverse guideways 255 to receive a cross-sliding head indicated as a whole at 256. The cross-sliding head is moved relatively to the carriage by a feed-screw 257, the ends of which are journaled in bearings on the carriage, said feed-screw having on its front end a handle or wheel 258 by which it may be rotated. The head has a nut 259 in engagement with the feed-screw, as illustrated in Fig. 37. As thus explained, the table may be adjusted about a vertical axis to lie in any desired position with reference to the bed and the grinder-spindles. The carriage itself may be adjusted longitudinally of the table and the cross-sliding head may be moved transversely thereof. The head is in the form of a hollow casing to receive the work-holder or carriage and the mechanism by which it may be rotated. The work-holder or carrier consists of a spindle 260 suitably mounted at its ends in split tapering bushings 261 262 in the end walls of the cross-slide. The right hand end of the spindle 260 is equipped with a chuck 263 or other suitable device for receiving and holding a piece of work to be ground, as illustrated in Fig. 1. Any suitable means may be utilized for holding the spindle 260 against end thrust. I may, with convenience, employ a cap 264 which incloses the reduced end 265 of the spindle, as shown in Fig. 6. The spindle has a shoulder 256 between which and the cap are washers 267. On the extremity of the reduced end 265 there is a collar 268 and a sleeve 269. Against the end of the sleeve 269 is placed a collar 270 against which press spring-tensioned pins 271 set in sockets in the inner end of the cap 264. The parts just described hold the spindle 260 to the left so as to maintain the shoulder 266 in engagement with the washers 267 and thus prevent any forward as well as any rearward movement of the spindle.

The mechanism for rotating the spindle 260 comprises a gearing in the head and means for imparting rotation thereto from the power-transmitting mechanism in the bed. The spindle 260, as shown in Fig. 6, has secured upon it two gears 272 273. The former engages and may be driven by a gear 274 on a shaft 275 in the head. On the said shaft, there is a smaller gear 276 which intermeshes with and may drive a back gear 277 on a back gear shaft 278. The last-mentioned gear 277 also intermeshes with the gear 273 on the spindle 260, so that the spindle may be reversely rotated. The gears 274 276 are provided with clutch teeth with which may be engaged a clutch member 279 on the shaft 275. The clutch 279 may be shifted by an arm 280, shown in dotted lines in Fig. 3, with which is connected a handle 281 by which it may be oscillated by the operator. On the shaft 275 is a pulley 282 which is driven by a belt 283 from a drum 284 in the lower portion of the frame which constitutes the table. The drum 284 is mounted on a shaft 291 and is journaled in a yoke 285 hung upon a shaft 286 extending longitudinally of the table. The yoke is drawn downward yieldingly so as to keep the belt 283 taut by a bolt 287 which is hung upon the yoke and extends through the bottom wall of the table frame. On its end, the bolt has a nut 288 against which bears the end of a spring 289. The upper end of the spring presses against a semi-spherical collar 290 loose on the bolt and located in a curved socket in the bottom of the table frame. The shaft 291 and the shaft 286 are provided with intermeshing gears 292 293, so that the former is driven by the latter. The shaft 286 has upon its right end a bevel gear 294 which intermeshes with a bevel gear 295 loose upon the upright shaft or rod 242, as illustrated in Fig. 7. A bevel gear 296 is secured upon the end of the shaft 145 hereinbefore referred to, so that power is transmitted from the prime power-shaft through the bevel gearing to the shaft 286 and thence to the shaft 291 and the drum 284 to the shaft 275 in the cross-sliding head. With this construction and arrangement, the swinging of the table about its vertical axis interferes in no manner with the transmission of power to the work-carrier in the cross-sliding head, as for instance when the table is located in the position shown in Fig. 39. The table is apertured of course to permit the passage of the belt 283, and the carriage and the head are likewise apertured for the same purpose. The movement of the carriage and the cross-sliding head does not interfere with the transmission of power to the tool-carrier, the drum 284 being elongated to permit the

longitudinal feed of the carriage and the spring-tensioned yoke serving to maintain the belt taut as the cross-sliding head is moved. To further assist in this, there are two stationary idler drums 300 300 in the table frame with which the belt 283 may be engaged as illustrated in Fig. 37. It is desirable to supply the work, which is being ground, with a stream of water or other cooling medium. To this end, I provide a pipe 310, having on its end an adjustable coupling 311, to which is connected a nozzle 312 for delivering a stream of water upon the grinding-tool. The conduit 310 is secured in the top of the tool-slide or carriage, as shown in Figs. 2, 7 and 36. A valve 313 may be used to control the flow of water through the nozzle. The conduit 310 is connected by a flexible conduit 314 with any suitable pumping mechanism which it is desirable to employ. I have not illustrated a pump, as it is customary in many machines to employ a pump operated from the power-shaft for the purpose of delivering a stream of oil to the tool, and I may use any one of these mechanisms which are now well known.

I have not attempted to explain all of the minute details of the construction of the machine, for it will be understood by those, to whom this specification is addressed, that the parts will necessarily be of the proper size and relationship, and will be properly mounted and supported according to the tenets of machine construction; nor have I attempted to illustrate the parts in their exact sizes and dimensions as many of the parts are conventionally shown. The work spindle and the turret carriage are both actuated from the same variable speed gearing, so that the speed rotation of the work is substantially proportional to the speed of reciprocation or feed of the carriage, and hence a change in the speed of movement of one is accompanied by a proportional change in the speed of the other.

It is unnecessary to reiterate the operation of the machine, for the operation of the several parts has been described in detail. Nor does it seem necessary to burden this specification with an exposition of the advantages which the invention possesses, for they will be apparent to those skilled in the art to which this invention relates.

What I claim is:—

1. A grinding machine comprising a bed, an adjustable work holder, a rotary turret longitudinally adjustable on said bed, a plurality of rotary grinders on said turret, means for effecting the rotation of the turret to present said grinders successively to the work, means for imparting rotation to said grinders, means for adjusting said work holder in various positions to the work, and means for rotating the work-holding spindle in said work holder.

2. A grinding machine, comprising a bed, a work-holder, a slide or carriage, means for reciprocating said slide or carriage, a turret on said slide or carriage, means for rotating the turret, a plurality of extensible spindles on the turret, grinding tools on said spindles, and means for rotating said spindles.

3. A grinding machine comprising a bed, a rotary turret longitudinally adjustable on said bed, a plurality of spindles on said turret, a grinding tool on each spindle, and means for advancing a spindle and its grinding tool when it is in proper relation to the work and rotating said spindle.

4. A grinding machine comprising a bed, a rotary turret longitudinally adjustable on said bed, means for rotating said turret, a plurality of spindles journaled in the turret, a grinding tool on each spindle, a pulley on each spindle, a driving belt engaging and rotating said pulleys, and means for individually advancing a grinding tool from said turret to its proper position in relation to the work.

5. A grinding machine comprising a swinging work holder adjustable at various angles in relation to the work, a plurality of rotary grinding tools of different diameters, a rotary longitudinally adjustable turret supporting the spindles on which said tools are mounted, and means for rotating said turret to present the different tools to the work in the holder.

6. In a grinding machine, a work holder adjustable to various positions with reference to the work, a plurality of rotary spindles and grinding tools, a rotary turret longitudinally adjustable with reference to the work and supporting said spindles, and means for automatically rotating said turret to effect a transverse feeding movement of a grinding tool relatively to the work.

7. In a grinding machine, a work holder, a plurality of rotary grinding tools, means for advancing said tools simultaneously toward the work, means for presenting each of said tools successively to the work, means for adjusting a grinding tool longitudinally from its support to working position and automatic mechanism for effecting a relative transverse feed of the working grinding tool and the work holder.

8. In a grinding machine, a work-holder, a plurality of rotary grinding tools, means for presenting said tools successively to the work, automatic mechanism for effecting a relative longitudinal feeding movement of the working tool and the work-holder, and automatic mechanism controlled by the first-mentioned automatic mechanism for effecting a relative transverse feeding movement of the working tool and the work-holder.

9. In a grinding machine, a work-holder, a bed, a carriage thereon, automatic mechanism for reciprocating said carriage, a turret on said carriage, a plurality of rotary grind-

ers supported by said turret, mechanism for rotating said turret to present the grinders successively to the work, and automatic mechanism controlled by the reciprocation of the carriage for effecting a step-by-step rotation of the turret to feed the working grinder transversely of the work.

10. In a grinding machine, a turret, a plurality of extensible spindles journaled on said turret, a grinding tool on the extensible end of each spindle, and means for imparting rotation to said spindles.

11. In a grinding machine, a sleeve or bolster, a support in which said bolster is axially movable, an extensible spindle having its extensible end journaled in said sleeve or bolster and its other end journaled in said support, and a grinding tool on the extensible end of said spindle.

12. In a grinding machine, a sleeve or bolster, a support in which said bolster is axially movable, an extensible spindle having its extensible end journaled in said sleeve or bolster and its other end journaled in said support, a grinding tool on the extensible end of said spindle, and means on the other end of the spindle by which rotation may be imparted thereto.

13. In a grinding machine, a turret, a plurality of longitudinally adjustable sleeves or bolsters supported by said turret, a plurality of spindles journaled in said sleeves or bolsters, a grinding tool on the end of each spindle, and means for rotating said spindles.

14. In a grinding machine, a turret, a plurality of spindles journaled in said turret, each having an extensible end, a grinding tool on the extensible end of each spindle, and a plurality of bolsters or sleeves mounted in said turret and longitudinally adjustable relatively thereto, each bolster or sleeve serving as a bearing for the extensible end of one of the spindles.

15. In a grinding machine, a bed, a work-carrier, a carriage, a rotary turret thereon, a plurality of spindles each having a grinding tool and being journaled in said turret, means by which said spindles may be rotated, and mechanism by which the active grinding tool may be moved axially relatively to the others and to the turret to place it in and withdraw it from operative relation to the work in the work-holder.

16. In a grinding machine, a turret having a cylindrical end portion, and bearings at its other end portion, spindles journaled in said bearings, each spindle having an extensible part projecting beyond the cylindrical portion of the turret, a grinding tool on the end of the extensible part of each spindle, a plurality of elongated bolsters or sleeves supported in said cylindrical portion of the turret and projecting beyond the end thereof, said bolsters serving to receive and support the extensible parts of said spindles, and being longitudinally movable independently of each other, and means for clamping or securing each bolster in the position to which it may be moved or adjusted.

17. In a grinding machine, a bed, a carriage adapted to reciprocate thereon, a rotary grinder on said carriage, mechanism for reciprocating said carriage, a rotary work-holder, mechanism for rotating said work-holder, variable speed gearing, and power-transmitting connections between said variable speed gearing and said carriage-moving and said work-holder-rotating mechanisms, whereby the speed of rotation of the work-holder is generally proportional to the speed of reciprocation of the carriage.

18. In a grinding machine, a bed, a carriage, carriage-feeding and withdrawing mechanism, a knock-off member controlling said mechanism, a turret on said carriage, a plurality of grinding tools on said turret, and a pair of stops for each tool for operating said member.

19. In a grinding machine, a bed, a carriage, carriage-feeding and withdrawing mechanism, a knock-off member controlling said mechanism, a turret on said carriage, a plurality of grinding tools on said turret, supports on the turret, and stops adjustable on said supports for operating said member.

20. In a grinding machine, a bed, a carriage, carriage-feeding and withdrawing mechanism, a knock-off member controlling said mechanism, a turret on said carriage, a plurality of grinding tools on said turret, supports on the turret, one for each grinding tool, and stops on said each support for cooperating with said member, said stops being peripherally of the turret.

21. In a grinding machine, a bed, a carriage movable longitudinally on said bed, a rotary turret mounted on said carriage, a plurality of spindles with grinding tools mounted in said carriage, a plurality of supports on the turret, turret-rotating mechanism, and means on the supports for effecting the operation of said turret-rotating mechanism.

22. In a grinding machine, a bed, a plurality of tools, a rotary turret therefor, a plurality of supports longitudinally movable on the said turret, a reciprocatory carriage for the turret, turret-rotating mechanism mounted on said carriage, and members on said supports for successively effecting the actuation of said turret-rotating mechanism.

23. In a grinding machine, a work-holder, a bed, a carriage, a rotary turret thereon, a plurality of rotary grinding tools thereon, means for rotating the turret to present the tools successively to the work in the work-holder, yielding mechanism for actuating the turret-rotating means to effect a transverse

feeding movement of the active or working grinding tool, and stops for limiting the rotative movement of said turret.

24. In a grinding machine, a bed, a carriage, a turret thereon, rotary grinding tools on said turret, a prime power shaft, power-transmitting connections between said power shaft and the grinding tools, a carriage-feeding mechanism, and variable speed gearing between said power shaft and the carriage-feeding mechanism.

25. In a grinding machine, a bed, a tool carriage thereon, and one or more rotary grinding tools supported by the tool carriage, in combination with a work holder, a cross-sliding head in which said holder is journaled, a longitudinally slidable carriage supporting said head, and a pivoted table on which said carriage is mounted.

26. In a grinding machine, a bed, a tool carriage, and one or more rotary grinding tools, in combination with a table pivoted to the end of the bed, a work spindle supported by said table, a power shaft journaled on the bed, and power-transmitting connections between said shaft and said work spindle.

27. In a grinding machine, a bed, a tool carriage, and one or more rotary grinding tools, in combination with a table, a vertical pivot connecting said table with the bed, a work spindle supported on said table, a gear rotatable about the axis of said pivot, and power-transmitting connections between said gear and said work-spindle.

28. In a grinding machine, a bed, a tool carriage, and one or more rotary grinding tools, in combination with a table, a vertical pivot connecting said table with the bed, a driving drum on the table, a work spindle, a slide on said table for supporting the work spindle, a belt driven by said drum, and power-transmitting connections between said belt and said work-spindle.

29. In a grinding machine, a plurality of grinding tools each of which may be presented for operation upon a piece of work, mechanism for rotating said tools, a work carrier, means for rotating said carrier, adjustable means for supporting said carrier so that it may be arranged parallel with or at any desired angle relatively to the axis of the working or active grinding tool, automatic mechanism for effecting a relative longitudinal feed of the work carrier and the active or working grinding tool, and automatic mechanism for effecting a relative transverse feed of the work carrier and the active or working grinding tool.

30. In a grinding machine, a bed, a carriage thereon, one or more rotary grinding tools supported thereon, means for rotating said tools, a rotary work spindle, a head in which said spindle is journaled, spindle-driving gearing in said head, and instrumentalities by which said head may be fed both longitudinally and transversely of the axis of said work spindle.

31. In a machine for reducing metal, a work-carrying spindle, bearings in which the same is journaled, a stationary shoulder or abutment to resist the end thrust of the spindle, and spring-tensioned means for holding said spindle against said abutment.

32. In a machine for reducing metal, a work-carrying spindle having an abutment, a head in which it is journaled, said head having a stationary abutment, one or more washers placed between said abutments, a collar or shoulder on the projecting end of the spindle, and spring-tensioned means interposed between said collar or shoulder and said head, substantially for the purpose set forth.

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

WILLIAM LE ROY BRYANT.

Witnesses:
E. J. FULLAM,
HENRY B. HOLMES.