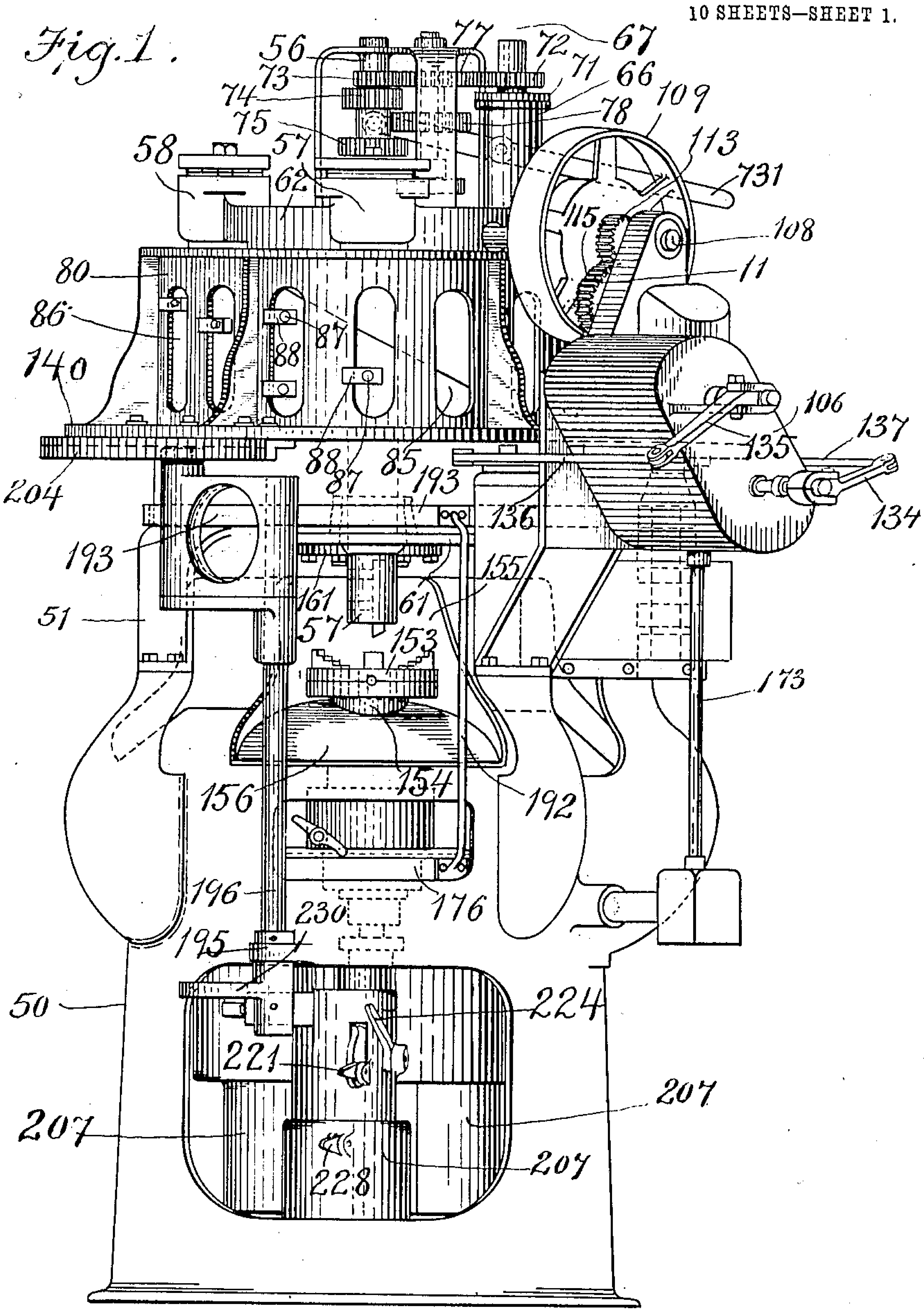
J. HARTNESS.
METAL WORKING MACHINE.
APPLICATION FILED APR. 19, 1907.

912,676. Patented Feb. 16, 1909.

10 SHEETS—SHEET 1.

Fig. 1.



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10 SHEETS—SHEET 2.

Fig. 2.

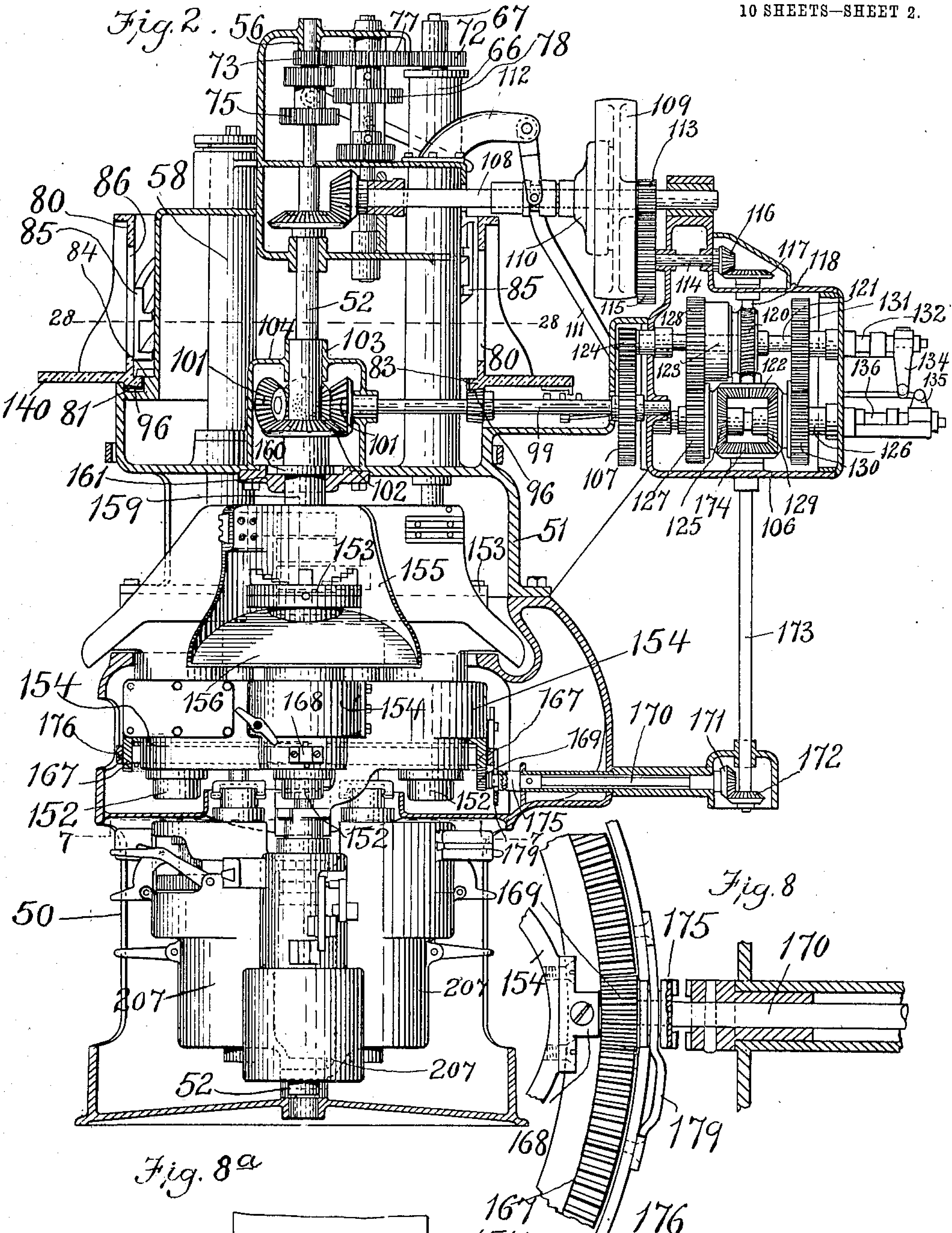
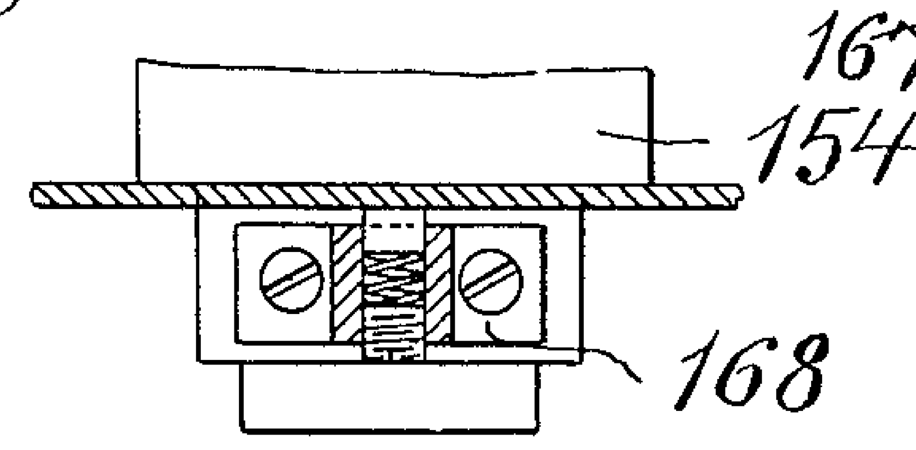


Fig. 8

Fig. 8a



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10 SHEETS—SHEET 3.

Fig. 10.

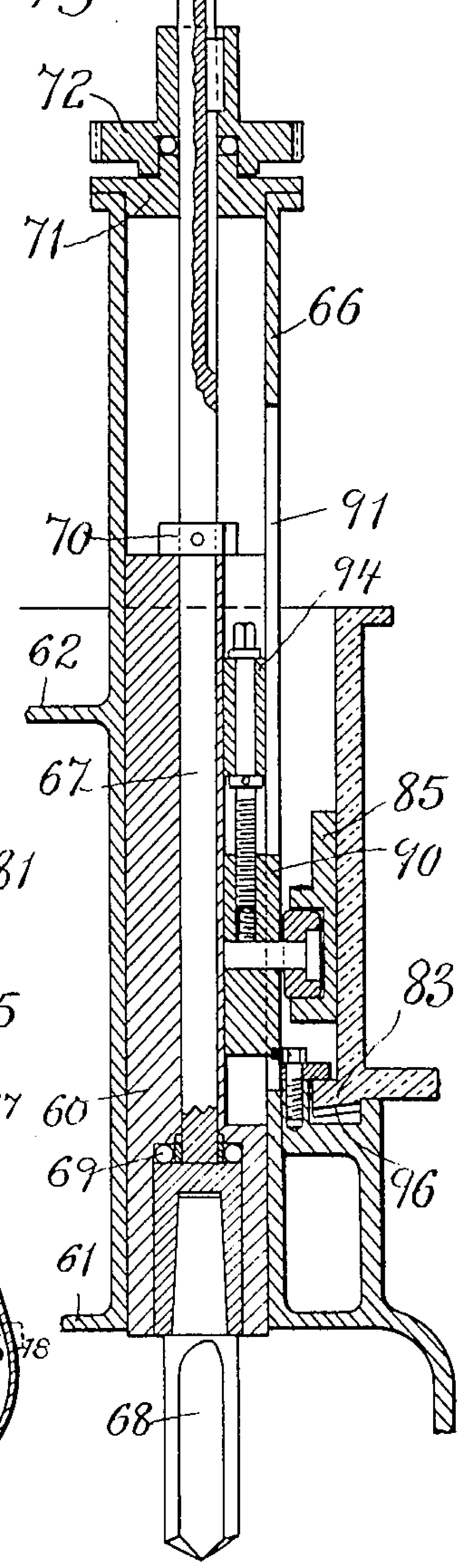


Fig. 3.

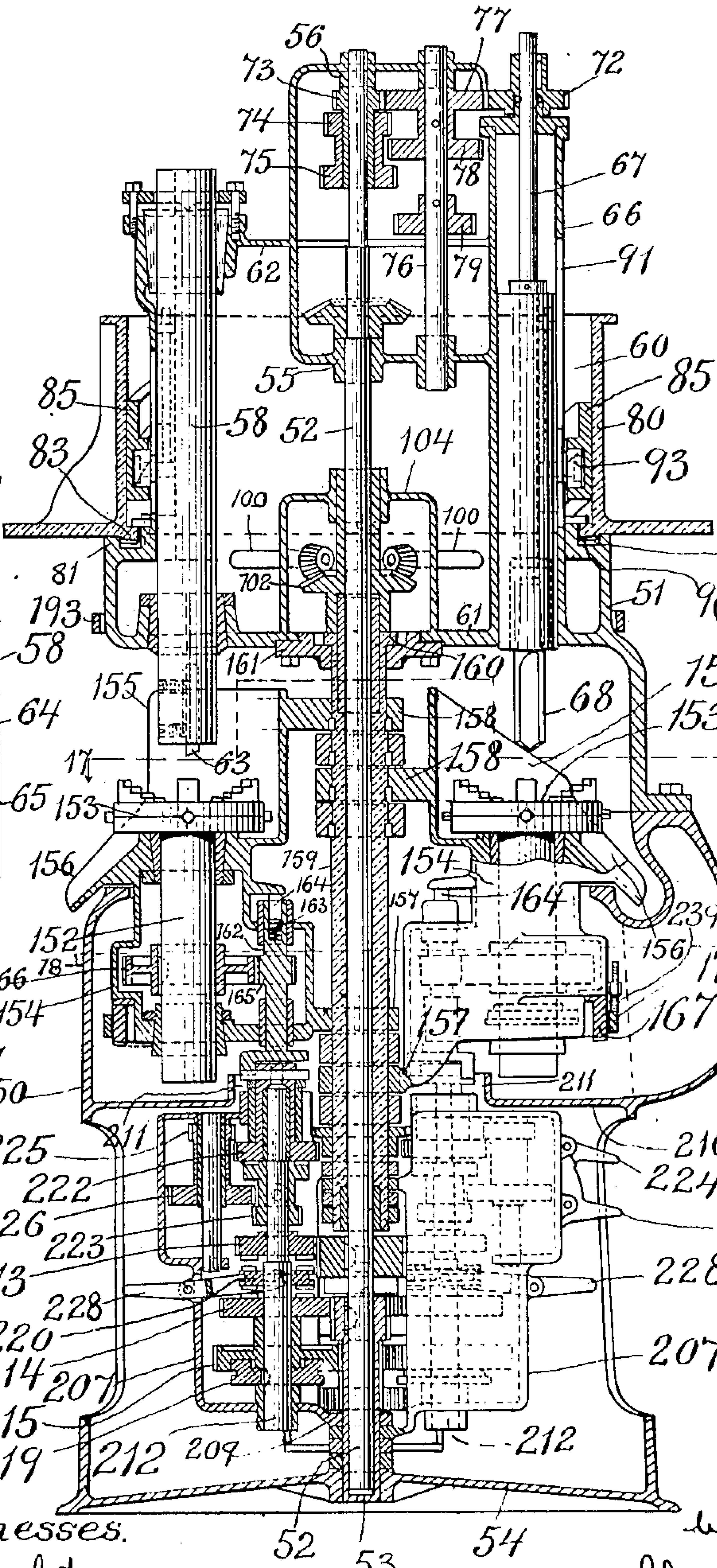
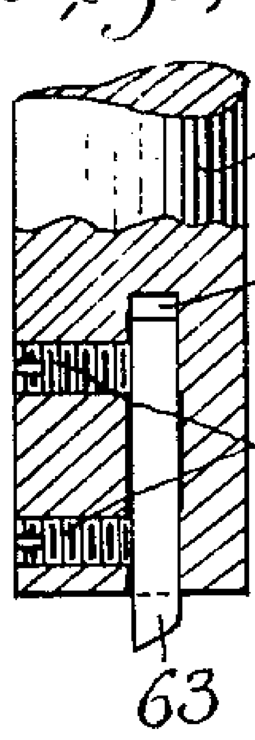


Fig. 9.



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10 SHEETS—SHEET 4.

Fig. 4.

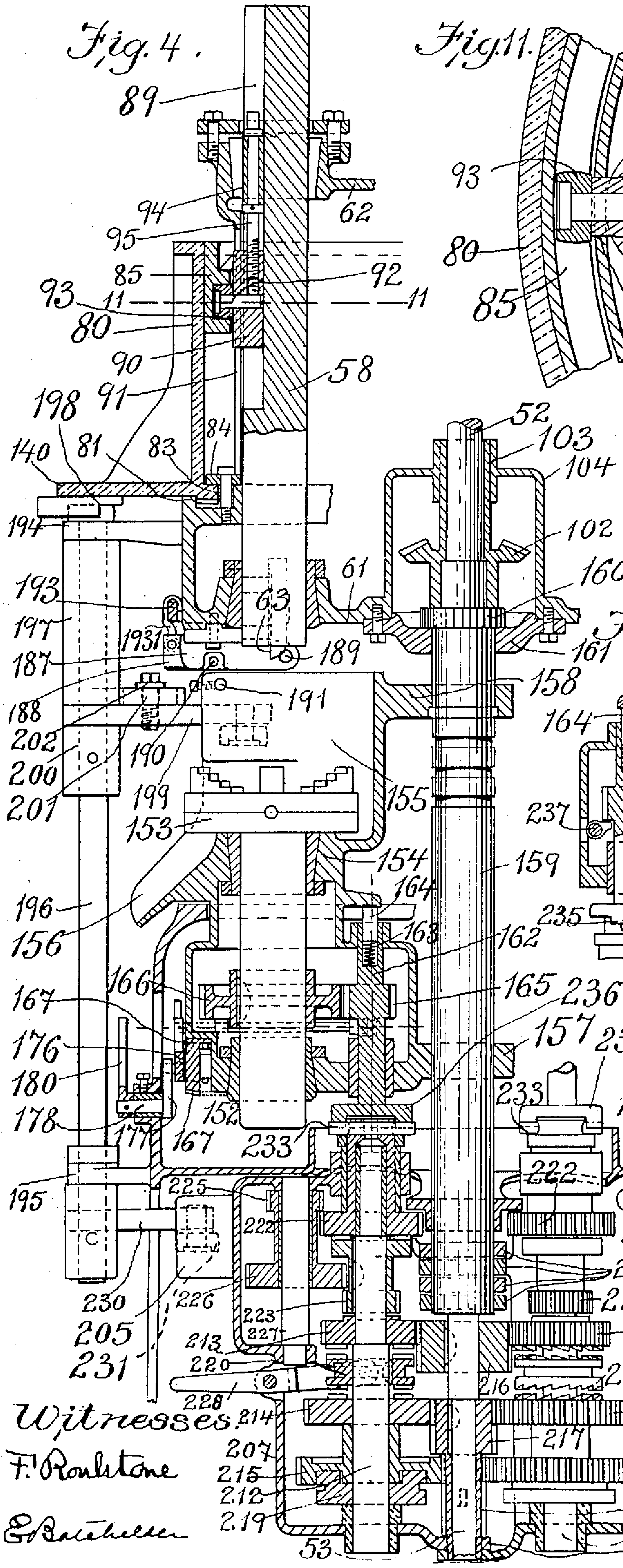


Fig. 11.

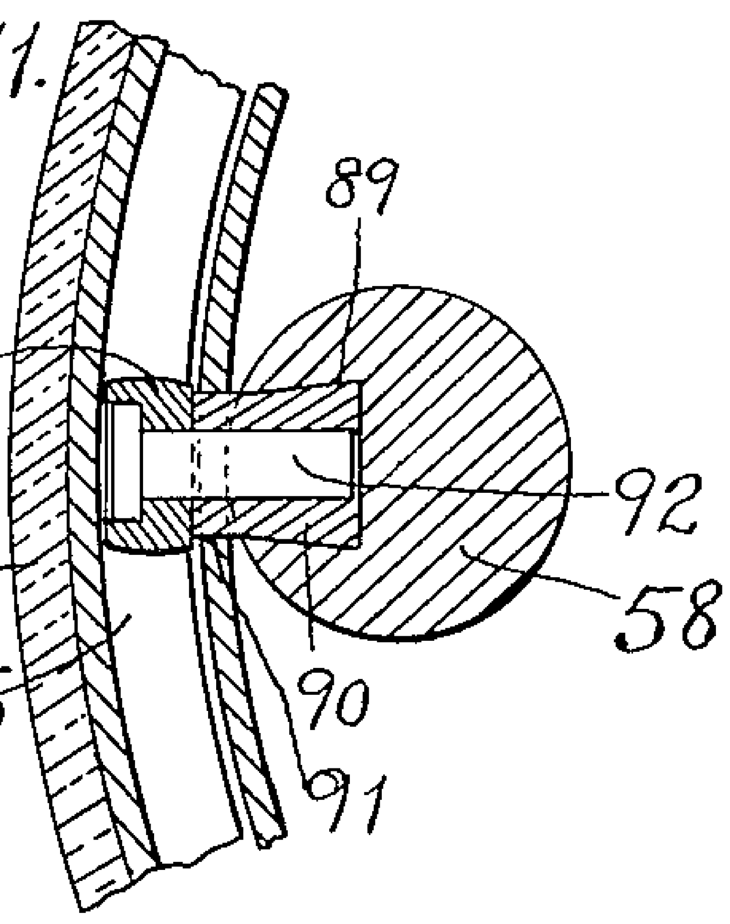


Fig. 14.

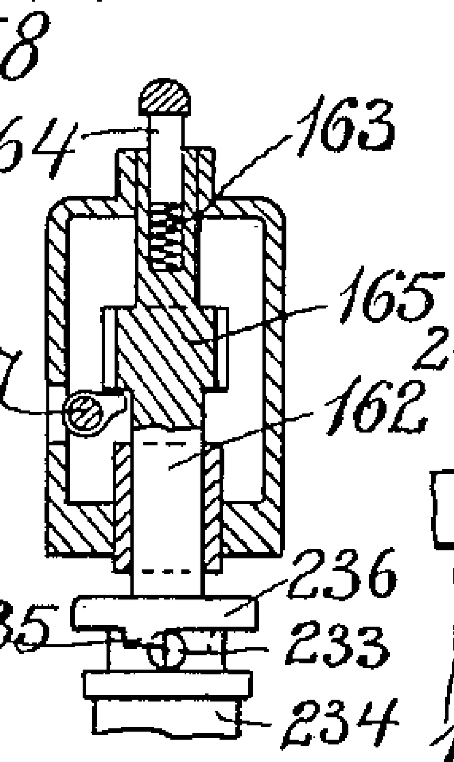


Fig. 13.

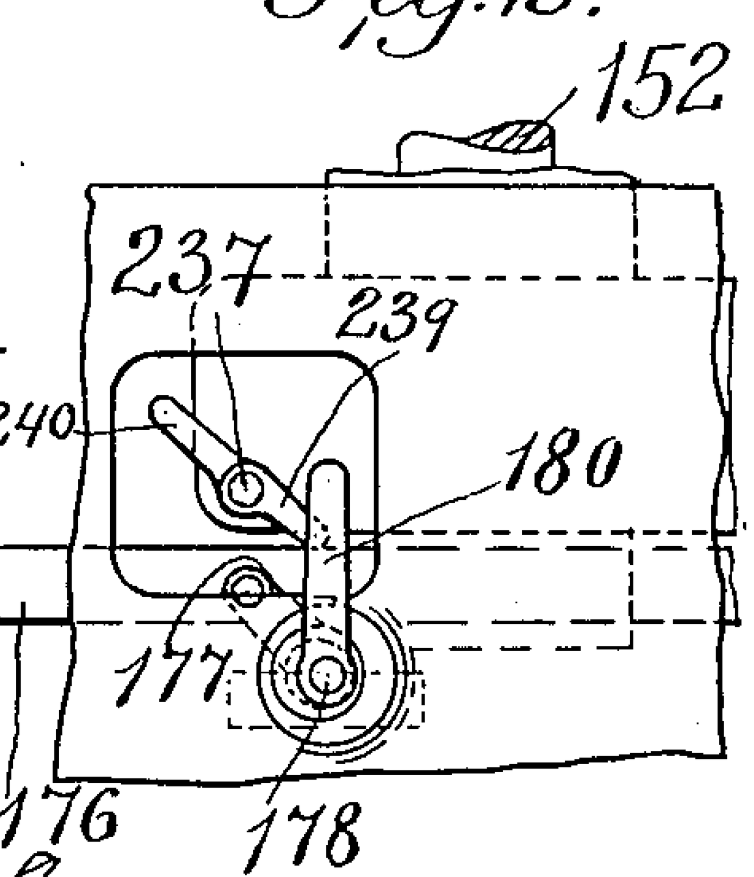
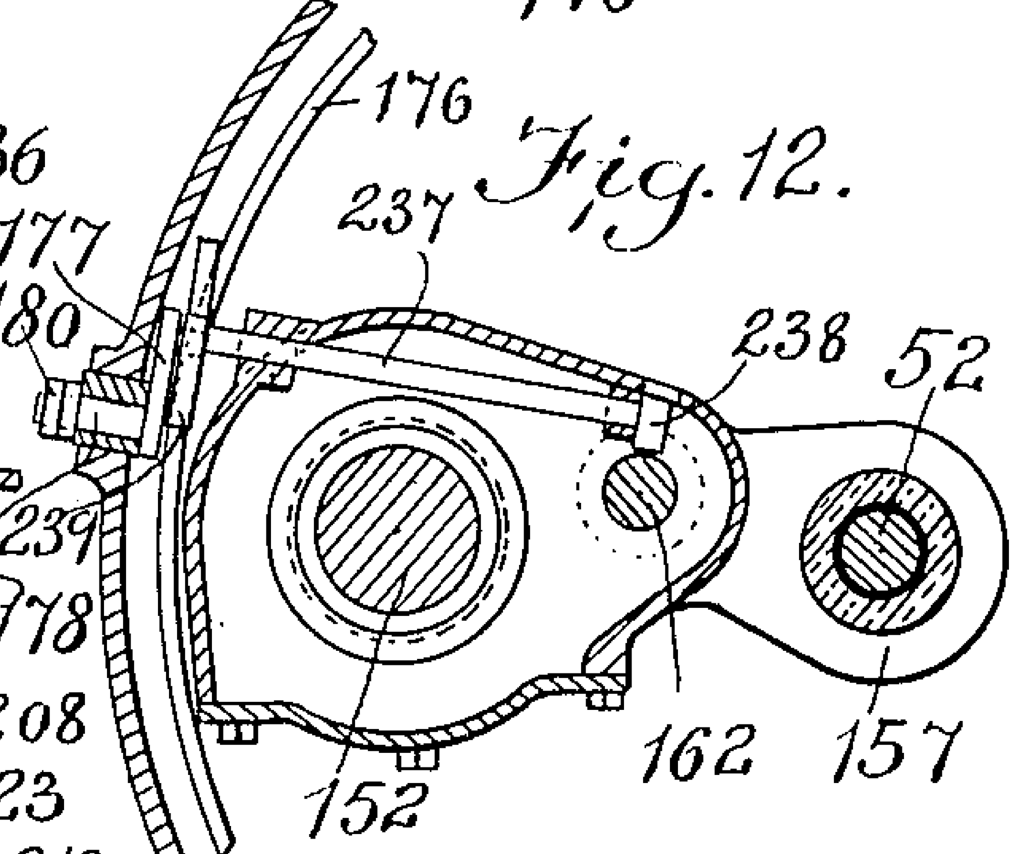


Fig. 12.



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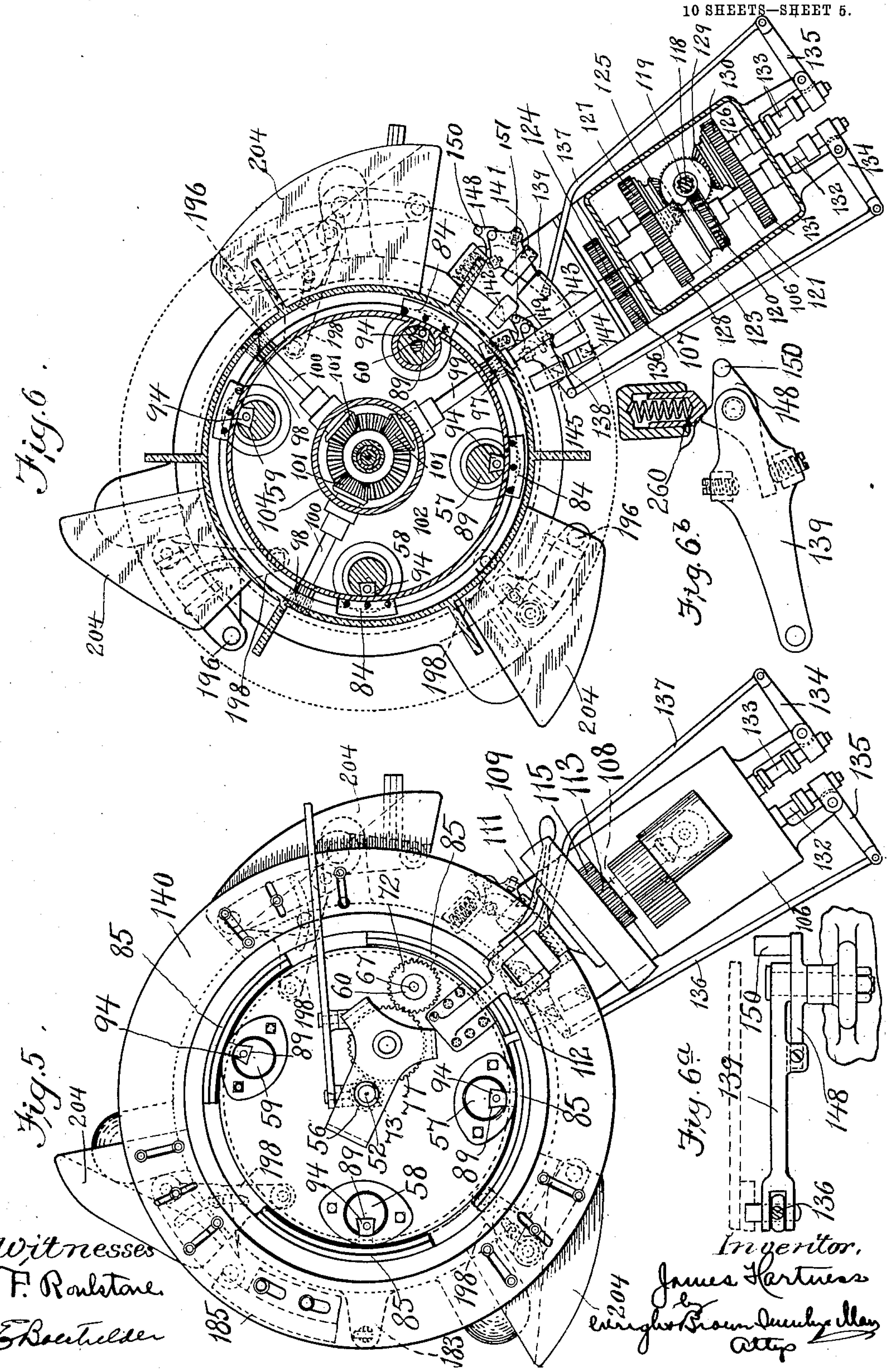

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10 SHEETS—SHEET 6.

Fig. 7.

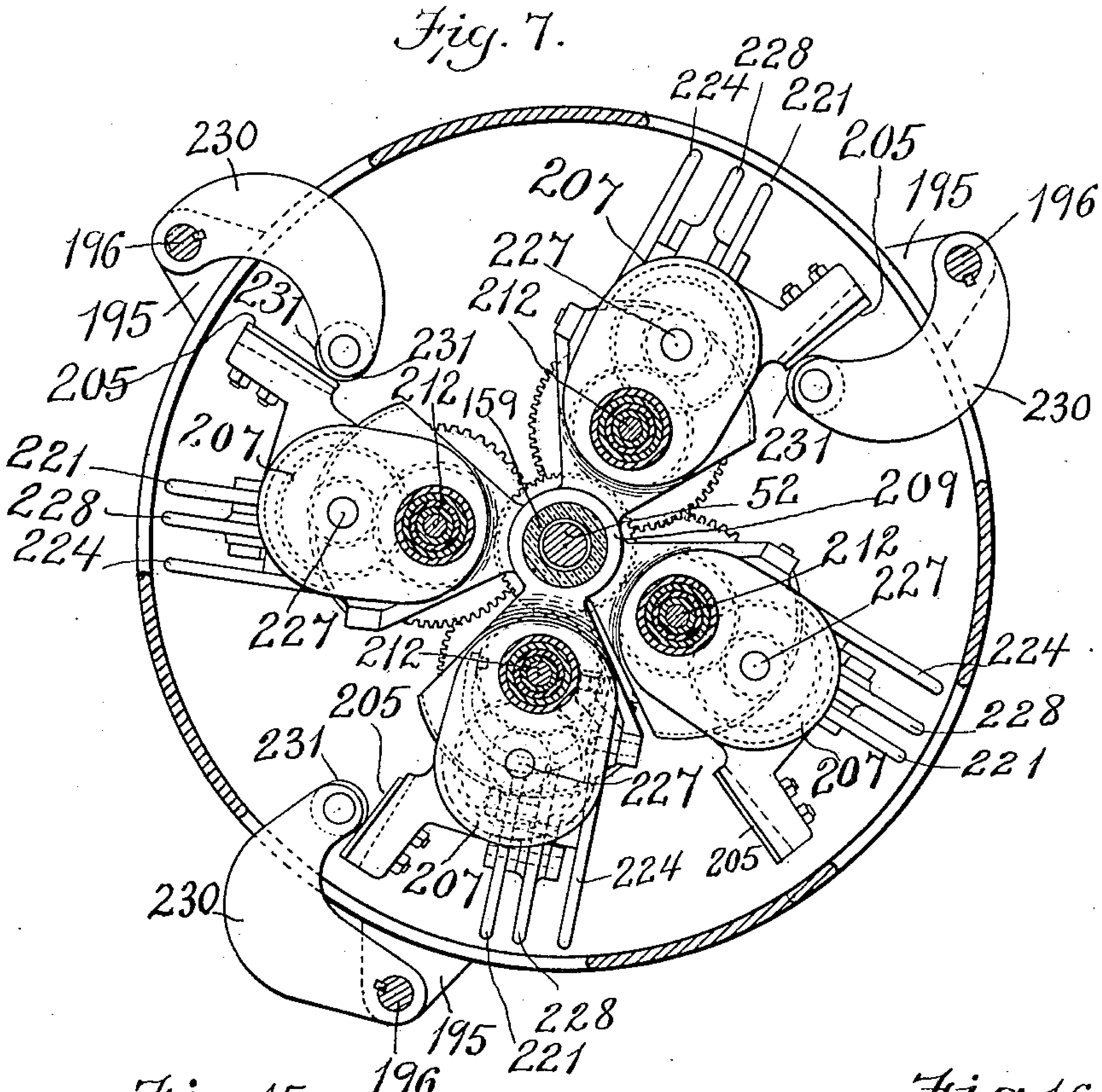


Fig. 15.

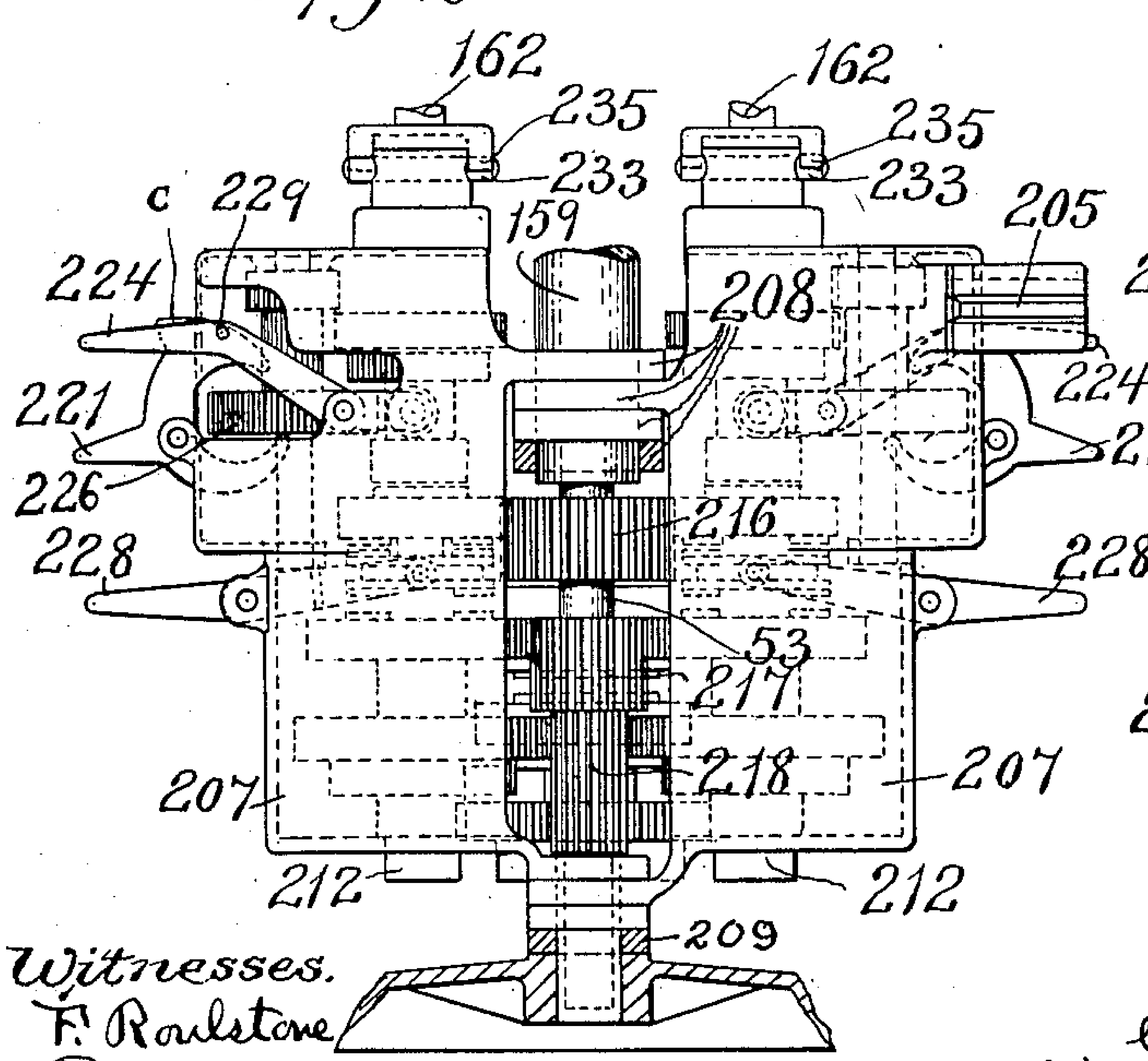
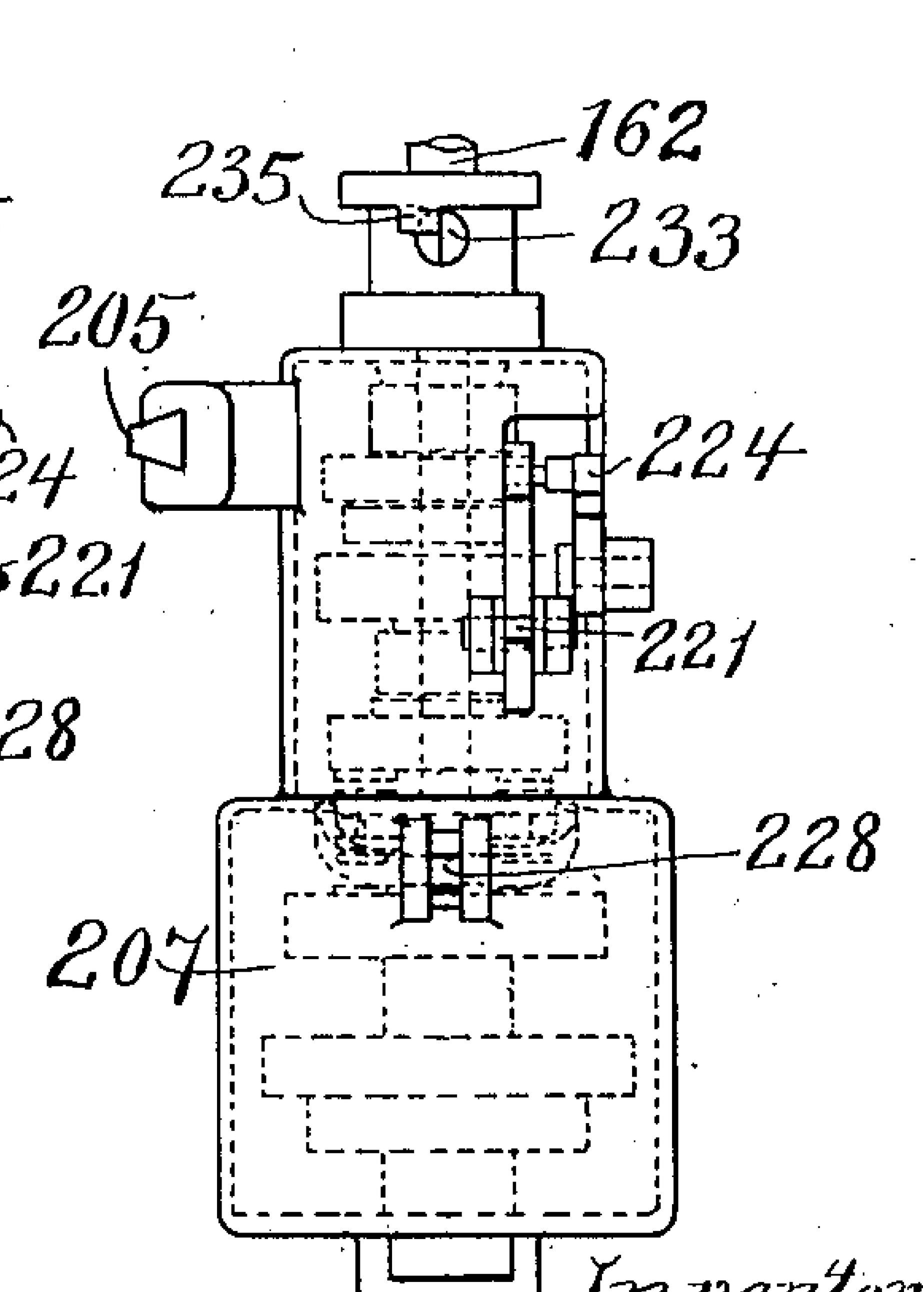


Fig. 16.



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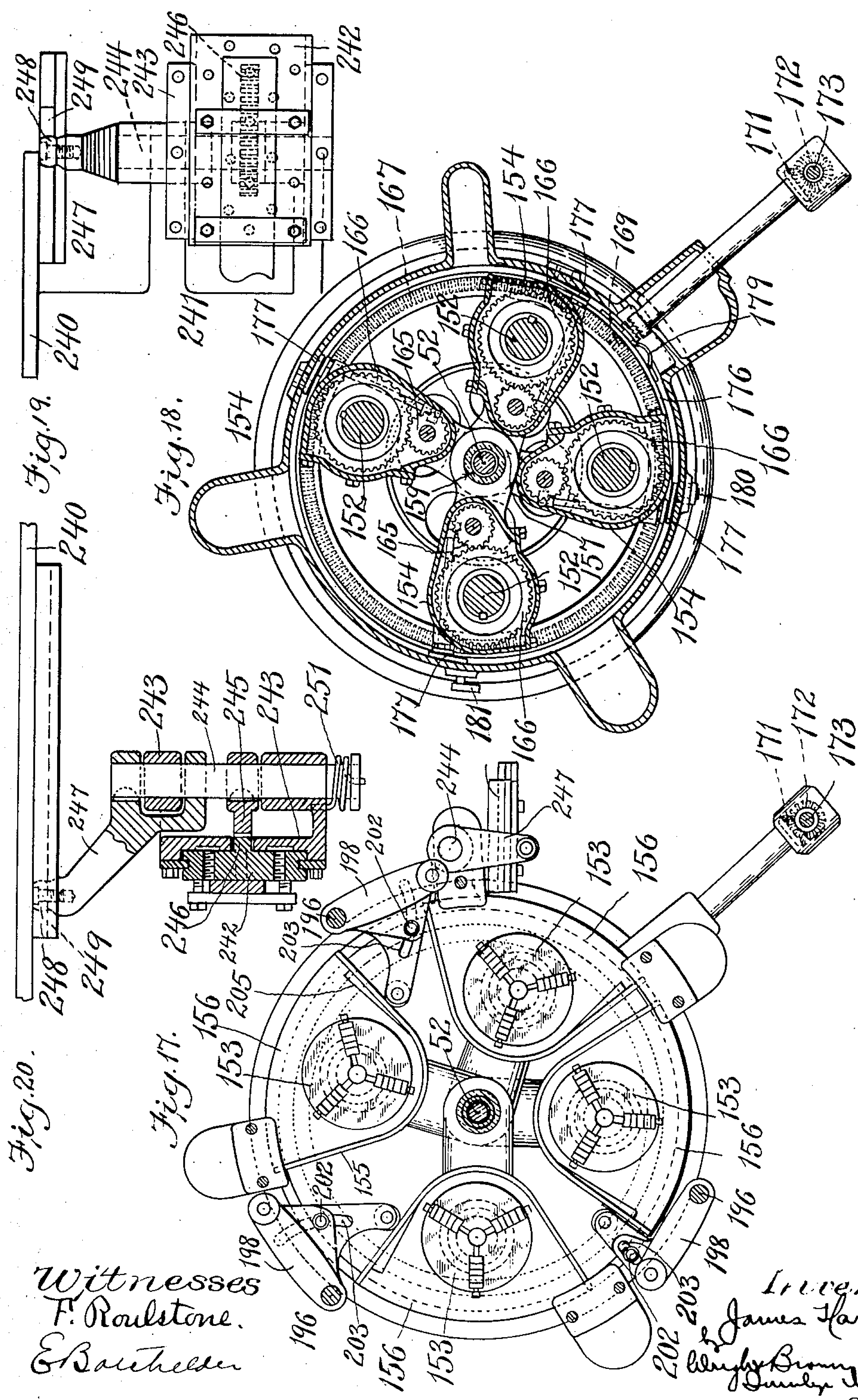

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10 SHEETS—SHEET 8.

Fig. 23.

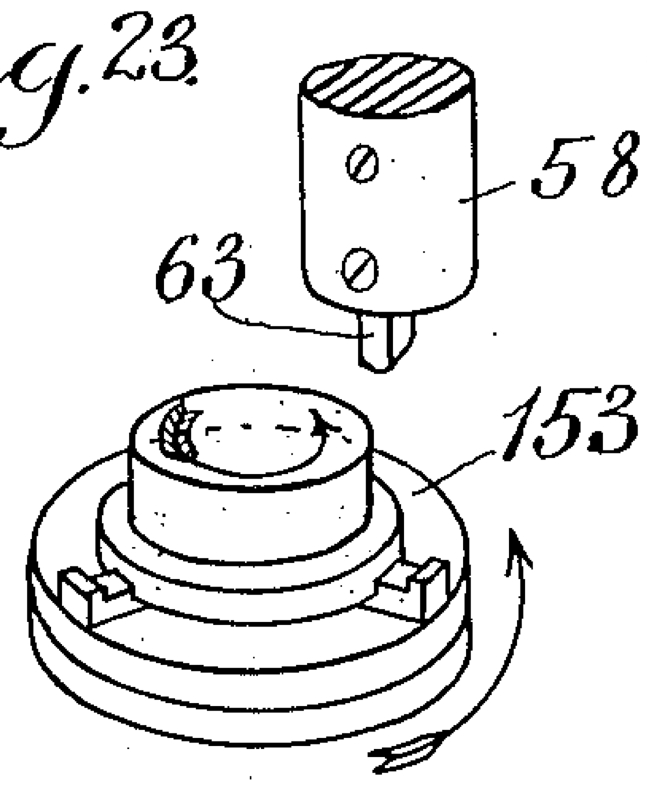


Fig. 21.

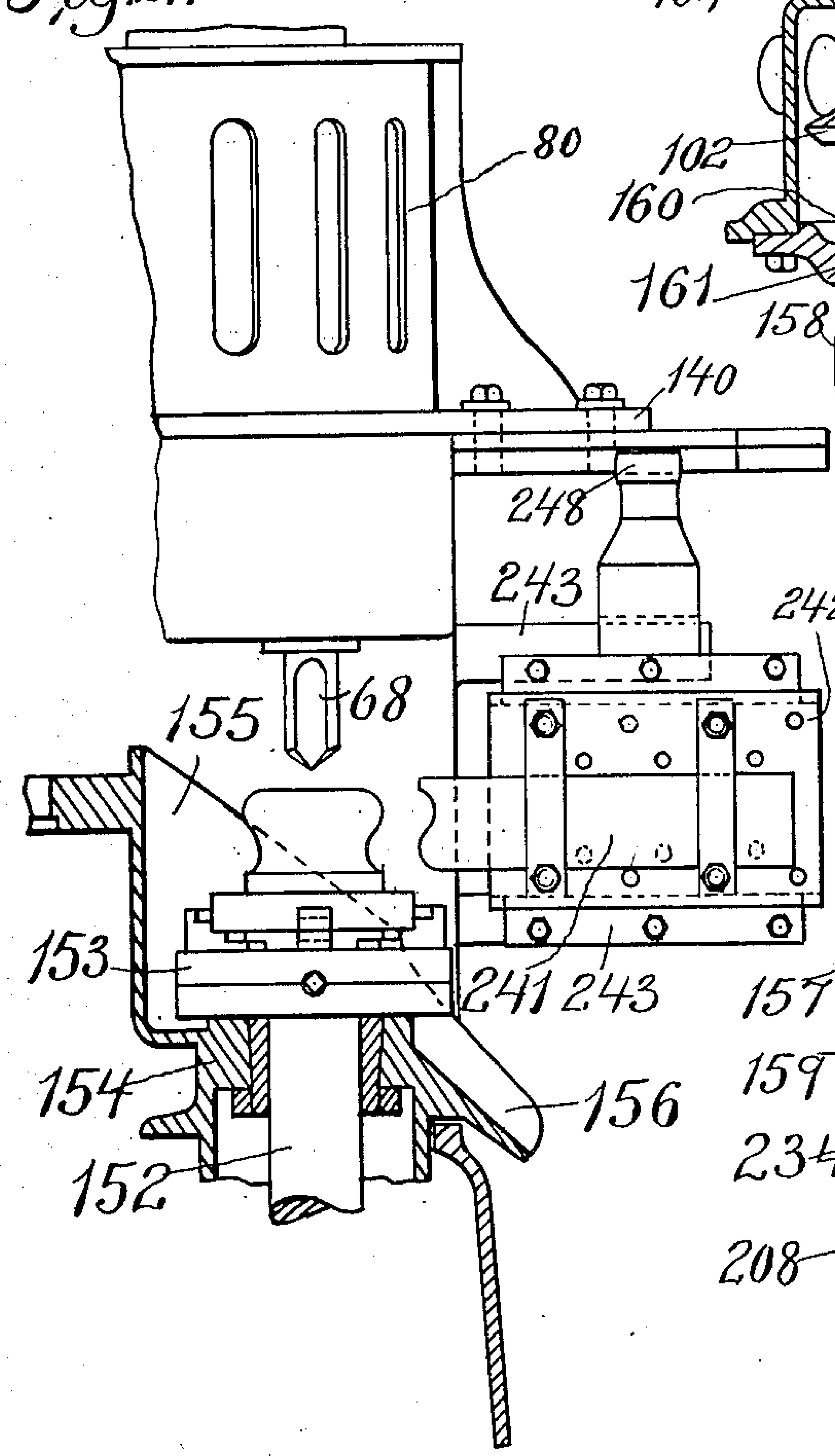
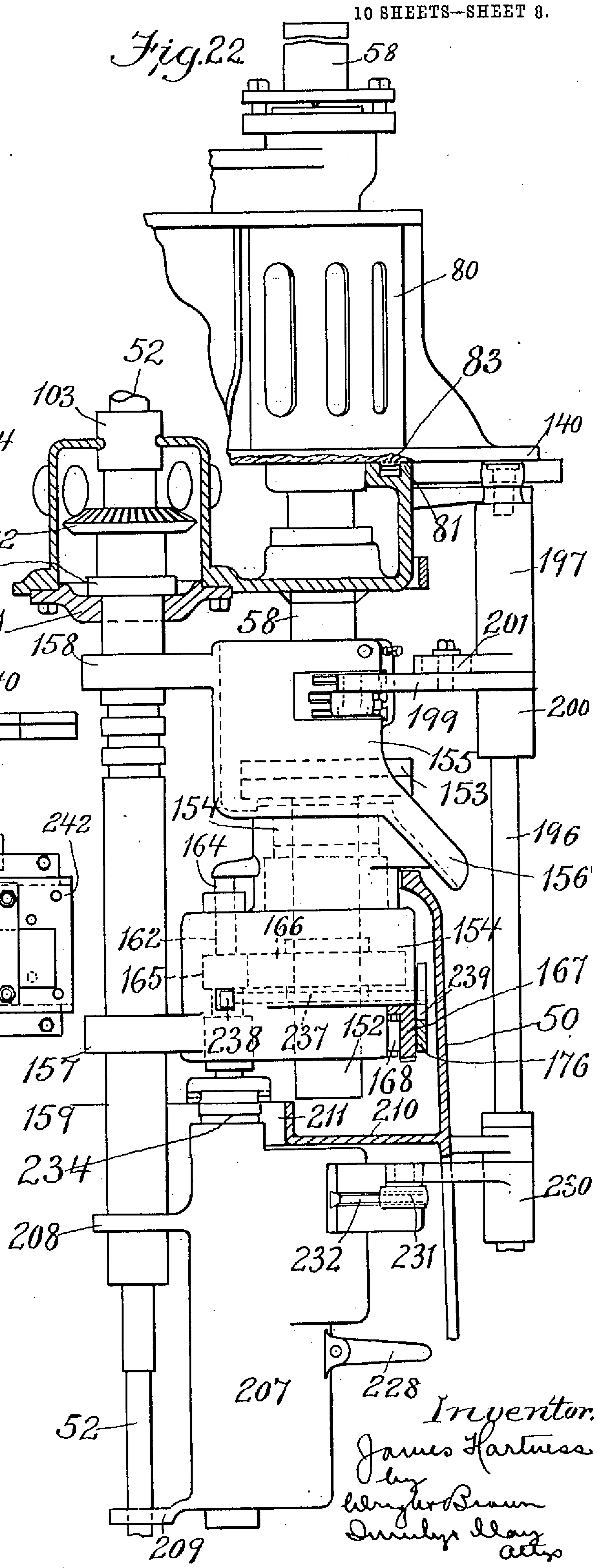


Fig. 22



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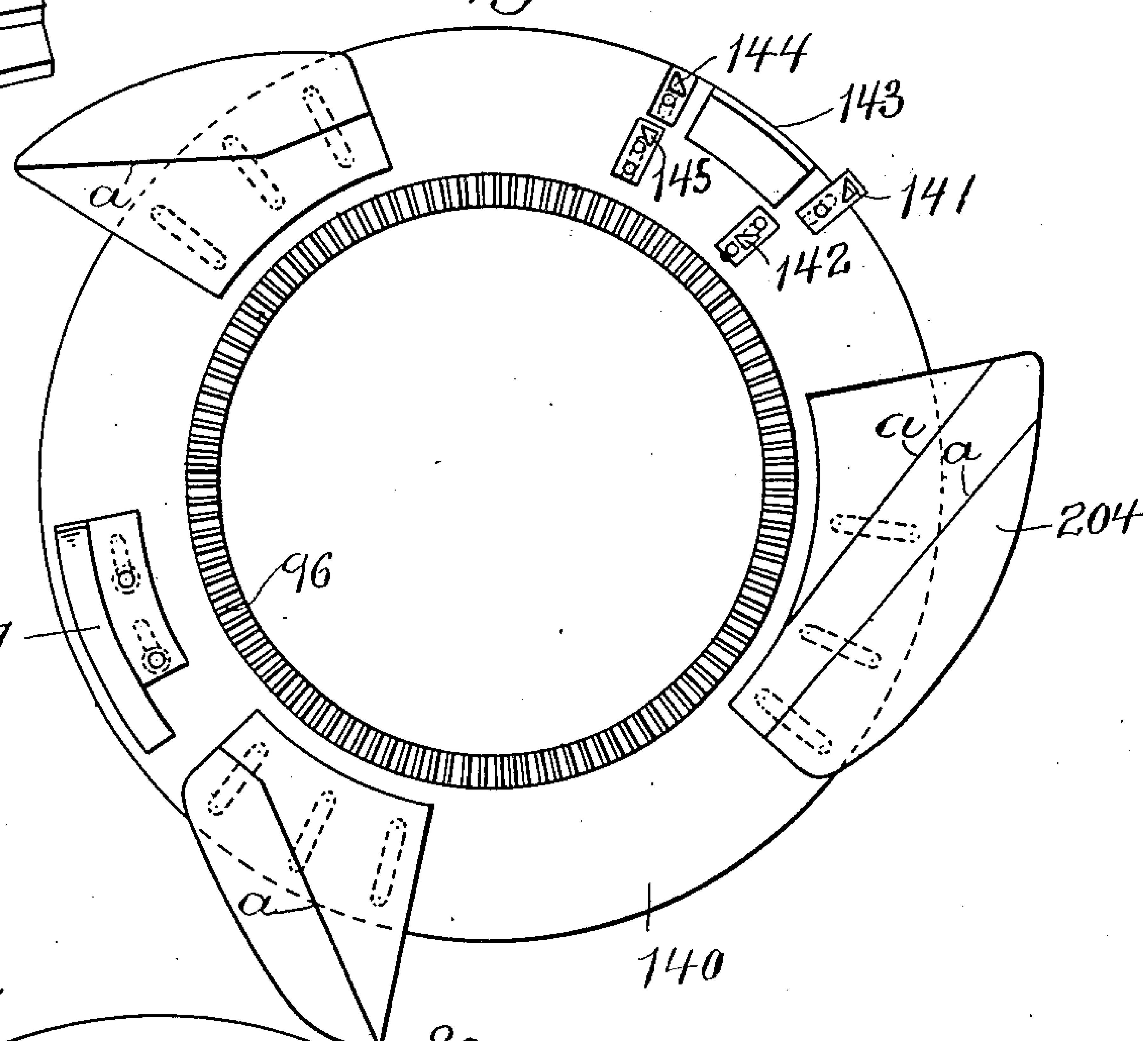
10 SHEETS—SHEET 9.

Fig. 24.



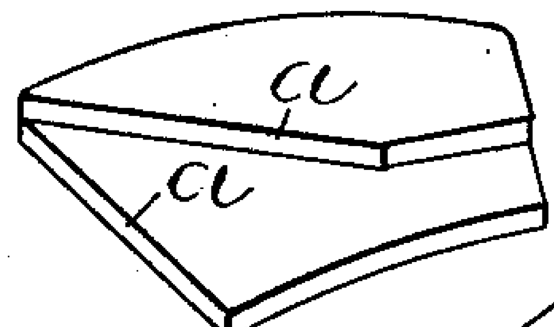


Fig. 25.

Fig. 28.

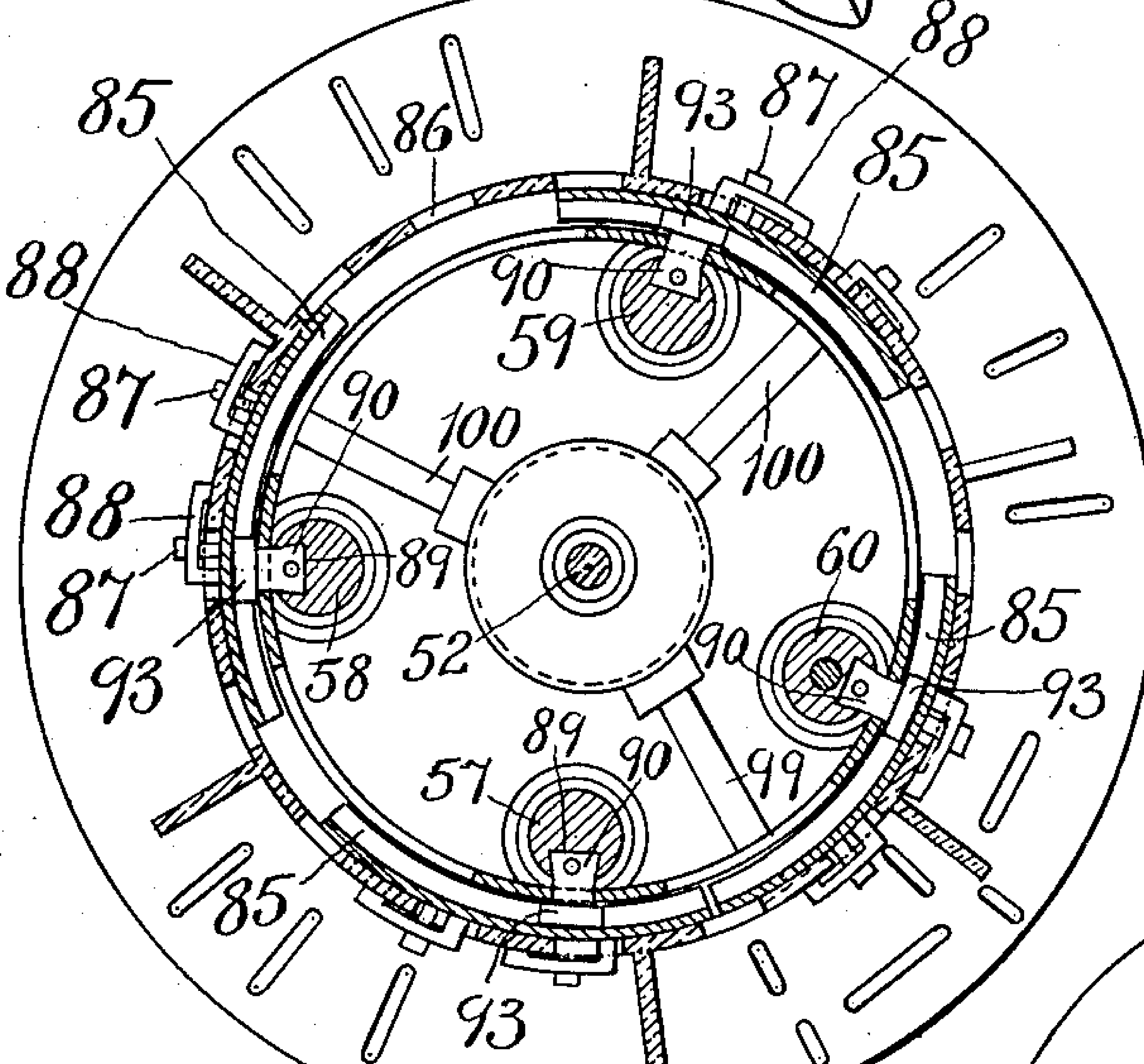


Fig. 26.

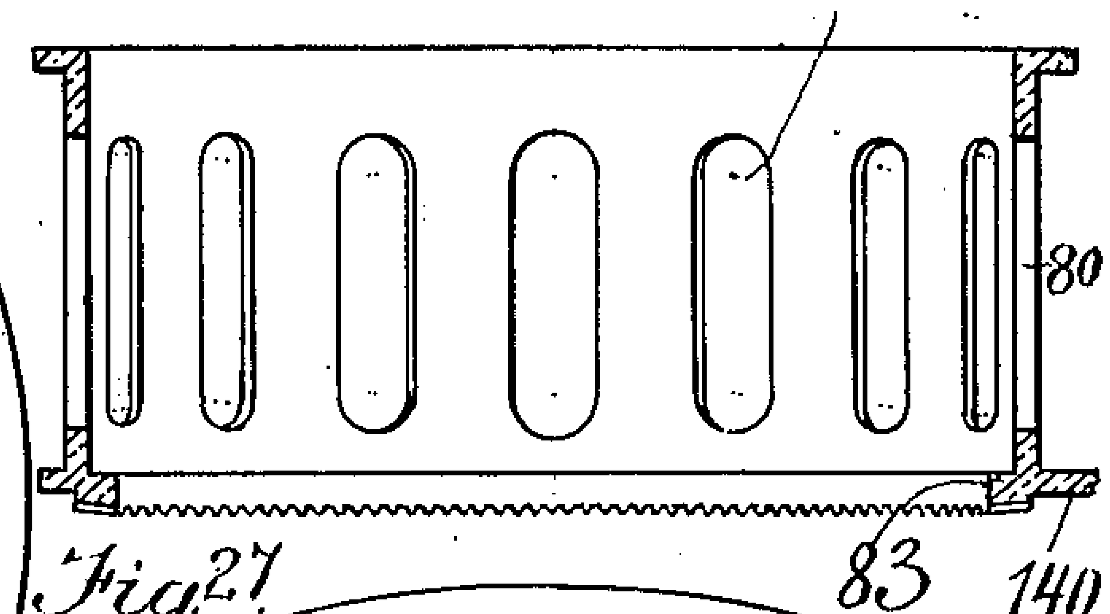


Fig. 27

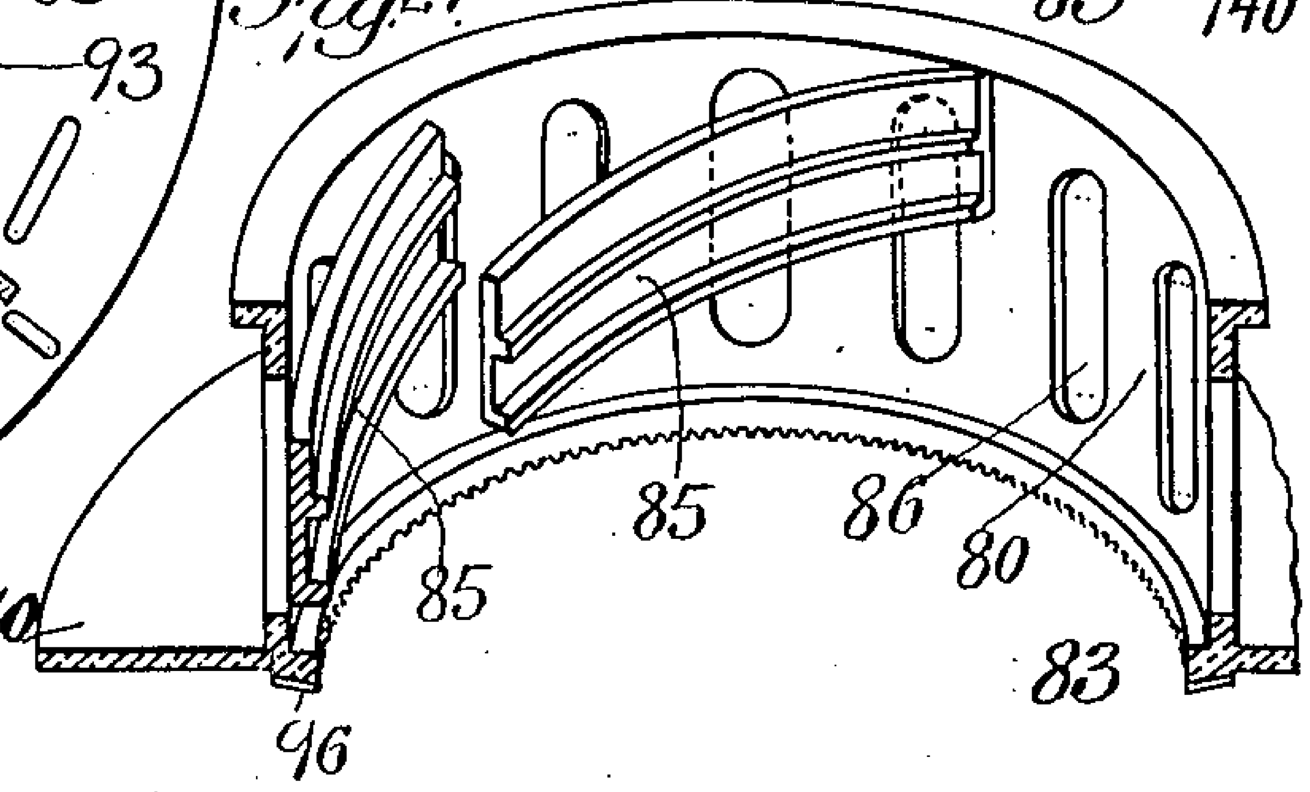


Fig. 30.

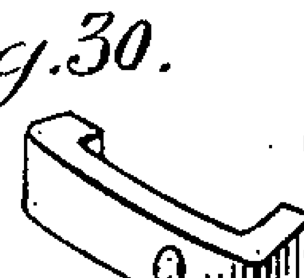
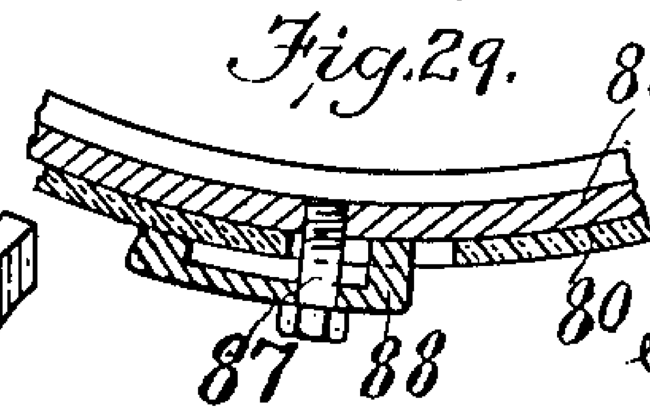


Fig. 29.



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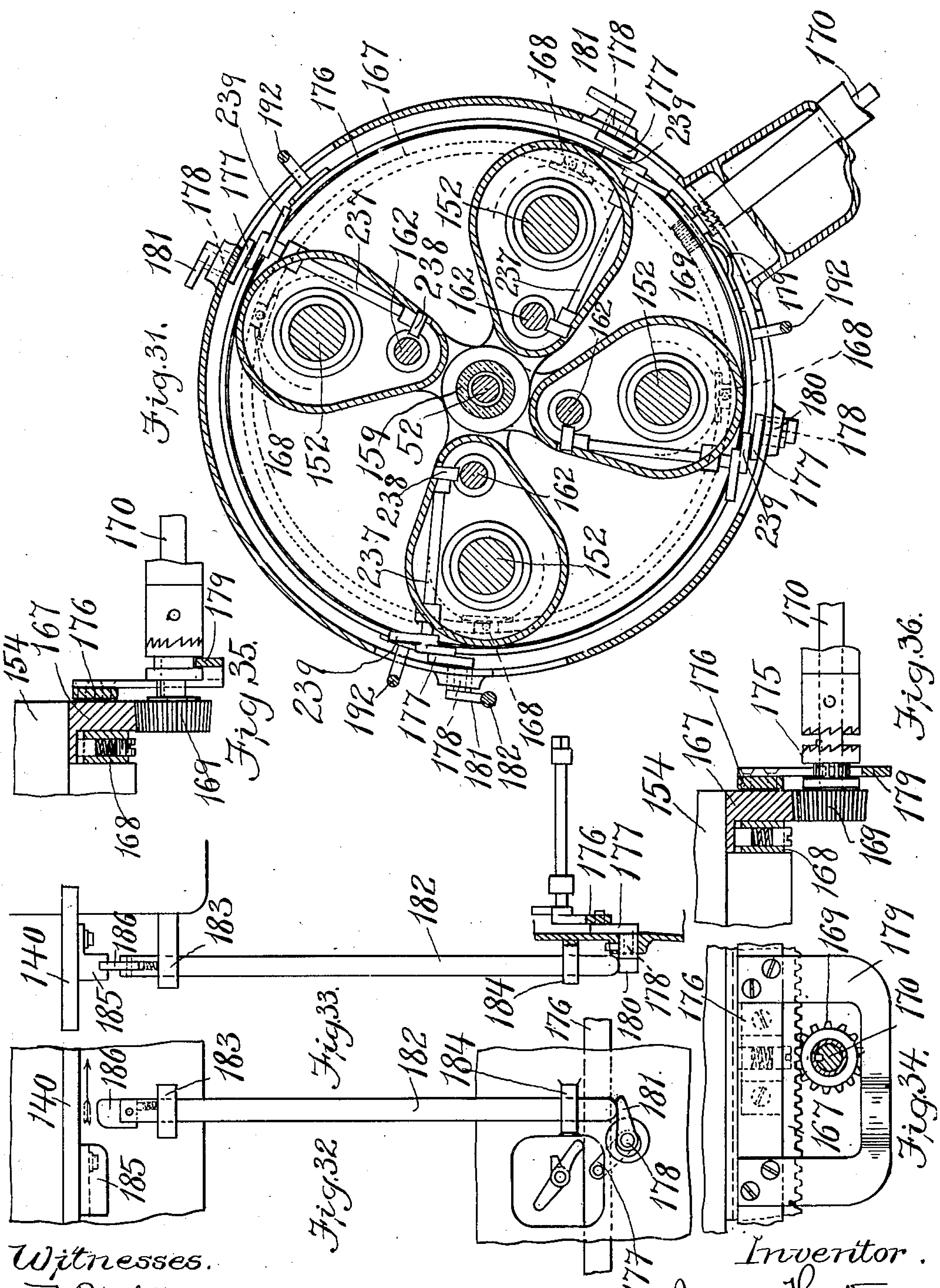
10 SHEETS—SHEET 10.



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UNITED STATES PATENT OFFICE.

JAMES HARTNESS, OF SPRINGFIELD, VERMONT.

METAL-WORKING MACHINE

No. 912,676. Specification of Letters Patent. Patented Feb. 16, 1909.

Application filed April 19, 1907. Serial No. 369,054.

To all whom it may concern:

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

This invention relates to metal-working machines and more particularly to those of the multi-spindle type in which a plurality of pieces of work are successively and simultaneously subjected to the operation of a series of tools. Such machines possess certain advantages over turret lathes, for, although the latter are provided with a plurality of tools which may be brought successively into operative relation to the work, yet not more than one or two tools can act at a time upon the work, so that the other tools must remain idle until those, which are operating upon the work, have completed their operation. In multi-spindle machines, however, where there are a plurality of work-holding spindles, four for instance, and a plurality of tool-holding spindles, the tools may be all caused to operate simultaneously and hence the output is much greater than that of a turret lathe. Theoretically the output of a multi-spindle machine on some kinds of work should be as much greater than the output of a turret machine having a single work-holding spindle, as would be indicated by the ratio of the number of their work-holding spindles, but practically, on account of certain inherent structural characteristics, the output seldom approaches the theoretical or ideal, and on the same account the uniformity of the product is much below the standard of the single spindle machines.

Heretofore multi-spindle machines have usually been employed for bar work, such as in the manufacture of screws and similar small pieces of a diameter of not more than five-eighths or three-quarters of an inch, in which the highest standard of accuracy is not required, for reason that in such machines dependence must be placed on some guiding member or rest to resist the springing of the work. Inasmuch as the work is more or less flexible and the guideways or bearings for the turret or barrel, in which are mounted the spindles (either for carrying the work or carrying the tools) are free enough to allow the necessary lateral adaptation of the work to the tools or vice versa, such machines are unreliable and inaccurate in operation except for work of very small diameter. Moreover the range of work of multi-spindle machines, as heretofore constructed, has been further limited by the practical impossibility of constructing the machine in such manner that all the work-carrying spindles will register with all of the tool-carrying spindles with the same accuracy. These two sets of spindles have always been arranged equi-distant about a common center, about which one set was caused to revolve to advance the tools or the work, and the spindles of each set have always been arranged, necessarily, equi-distant from each other. Consequently the greatest nicety and accuracy of construction and indexing have been essential to secure even imperfect results. With this necessary arrangement of spindles, no practical methods of construction and designing have provided a satisfactory adjustment of parts to compensate for the unequal wear which results from the use of the machine.

Another fault that has been inherent to multi-spindle machines, as heretofore designed, has been the absence of means for accomplishing independent length feeds of the turning tools. Although in such machines special mechanism has been provided to run on and off a screw-cutting die while the turning tools are in operation, yet no general length-feeding mechanism for feeding the turning tools independently of each other has been available, for the reason that in all such machines heretofore constructed, the length-feed of the tools has been secured by feeding the barrel or turret in which they are mounted, thus causing them to travel forward and back simultaneously and to the same extent. Another and serious fault in such machines has been the impossibility of effecting a lateral adjustment or cross-feed of the tool and the work, and as a consequence, the working range of the machine has been limited, and it has been necessary to provide expensive tools made expressly for each piece of work in which a new position of the cutter was required.

A structural defect in multi-spindle machines which has militated against the possibility of securing accurate work, is that the revolving head, which carries the work-spindles or the tool-spindles, yields under the action of almost any one of the cutters, so that, when one of the tools is cutting with nicety, it is disturbed by any other tool which is in action. As the cuts are not the same, every spindle slightly dislocates every other spindle to the detriment of the finished product of the machine.

There are other serious faults and defects to be found in multi-spindle machines and in the operation thereof, which are well known and many of which are remedied by my invention, but they need not be set forth in detail as they are apparent to those skilled in the art.

The present invention has for its object to remedy the evils and overcome the objectionable features and structural defects which I have pointed out as existing in all previous multi-spindle machines, and at the same time to secure the benefits which result from the employment of a plurality of work-carrying spindles for work-carriers and a plurality of tool-carrying spindles or tool-carriers, adapted for successive registration and simultaneous operation.

The invention has further for its object to provide a multi-spindle machine so constructed and designed that it will do the most exacting work that comes within the range of the turret lathe, to wit: "chucking" work, which requires not only a greater diameter capacity on the part of the tools, but also an accurate and reliable control for the tools, since on account of the character of the pieces of work undergoing operation, each tool must be carried in a true path in relation to the work, and, in most cases, without the employment or assistance of back rests or other guides.

It has further been the object of the invention to provide a variety of improvements which may be embodied not only in multi-spindle machines, but also in other metal-working machines for simplifying their construction or enhancing the efficiency of their operation.

In carrying out my invention and obtaining the objects thus briefly referred to, the difficulties of indexing the work and the tools are overcome by separating the work-carrying spindles or work-carriers to render them independent of each other, mounting them so that each may be moved laterally independently of the others, and providing a separate or independent abutment for each of them. In consequence of this, each piece of work may be placed and maintained with the greatest accuracy in the exact relation to each tool which is to operate upon it. Therefore each piece of work, as it is brought into position to be acted upon by a tool, may be held and maintained in the precise position in which the tool may operate upon it to the best advantage. In addition to this, a separate adjustment is provided for each abutment so that the relation between each piece of work and any particular tool may be varied without affecting the relationship of said piece of work with all of the other tools as it is brought into working position with reference thereto, and without affecting the relations of the other pieces of work to that tool. These features are of the greatest importance since the ideal relation of every tool to every piece of work may be maintained without interference with the relations of the other tools to the other pieces of work; and the relation of each tool with each piece of work that is brought to it may be instantly varied quite independently of the other tools or pieces of work.

The independence of the work-carrying spindles enables me to secure another important result in that it permits the machine to perform the operation known as "facing," since each work-carrying spindle may be moved laterally independently of the others to obtain a relative cross-feed of the tool and work so that each turning tool may be used to face the work as well as to turn portions thereof at different distances from its center. In the illustrated embodiment of the invention, cam mechanism is utilized to operate the controlling devices by which the lateral movement of the work-carrying spindle is effected or governed, and these may conveniently include a cam and controlling device near each tool spindle or tool-carrier, although where a drill is mounted upon one of the tool-spindles, the cam and controlling device for that particular spindle would not be necessary. A further important result, which follows from the independence of the work-carrying spindles and the employment of separate abutments therefor, is that each tool has a minimum disturbing effect, when in operation, upon the other tools. This effect is still further decreased by pivoting the carriers, upon which the work spindles are mounted, and arranging each abutment at a sufficient distance from the pivot to take the thrust of the work without bringing an undue strain upon the pivot bearing. In order, however, that the strain upon the pivot bearing may be substantially eliminated and almost ideal conditions secured, the abutment for each work-spindle carrier, according to my invention, is arranged in line with the thrust of the tool upon the work. This of itself is a feature of the invention, and it may be embodied not only in multi-spindle machines, but also in metal-working machines of other types such as turret lathes or analogous machines. In the illustrated embodiment of the invention, the carriers for the work-spindles are pivoted upon a common bearing, but the arrangement of the abutments in line with the thrust of the tools on the work such as to preclude any possible disturbance, by the action of one tool on the work, of the operation of the other tools.

In the illustrated embodiment of the invention, the tool-carrying spindles are all movable lengthwise independently of each other, and an independent cam motion is provided for each spindle, so that each spindle may be fed lengthwise to any desired extent and at any speed independently of all of the other spindles.

According to my invention, I further provide for rotating each piece of work at any one of a number of speeds which is most desirable for the character of the operation or of the tool which is to operate upon it. This I accomplish by providing a plurality of variable speed-driving mechanisms, one for each tool spindle, with means by which each work-spindle is connected to a driving mechanism as it comes into operative relation to the tool spindle; hence each piece of work may be rotated at a different speed for each tool. For convenience, each driving mechanism may receive its power from a prime power shaft, and each is so constructed and arranged as to transmit any one of a plurality of speeds to the work-spindle which is temporarily connected thereto. The work-spindles are successively connected with the driving mechanisms as they are moved successively from one tool to the other.

In carrying out the invention, it may be embodied conveniently in a machine in which the work-carrying spindles and the tool-carrying spindles are arranged upright or vertically, and, as a result, the machines occupy but little floor space and the operator may observe with ease the action of each tool upon each piece of work. While this is a desirable feature of the invention, particularly where the machine is designed for chucking, nevertheless it is not essential. Whether the machine be constructed with the spindles vertical or horizontal, it is desirable that the tool-spindles be arranged at unequal distances from each other, since this irregular spacing of the tools bears a relation to the dimensions of the entire machine, as it takes only the necessary amount of space for each tool. For instance, the drill and forming tools require no lateral movement of the work-carrying spindle and hence the stations for the other tools on each side of the drill may be brought closer to the drill.

The invention, in addition to the features thus referred to, comprises a number of valuable features of construction and arrangement of parts as illustrated in the accompanying drawings, set forth in the following specification, and pointed out in the claims.

Referring to said drawings,—Figure 1 represents an elevation of a machine embodying the invention. Fig. 2 represents a similar view with some of the parts in section, to illustrate the mechanism which drives the main cam-carrier and the mechanism for moving the work-carrying spindles into successive potential working relation to the tool-carriers. Fig. 3 represents a longitudinal vertical section through the machine. Fig. 4 represents a section, on a larger scale, of one of the tool-carriers, a work-carrier and its adjuncts, and the driving mechanism for effecting the rotation of the work-carrier, together with the mechanism for controlling the position or movement of the work-carrier and the driving-mechanism. Fig. 5 represents the machine in plan view. Fig. 6 represents a horizontal section through the upper portion of the machine. Figs. 6ª and 6ᵇ show one of the levers for controlling the speed gearing which actuates the cam-carrier. Fig. 7 represents a section on the line 7—7 of Fig. 2. Fig. 8 (Sheet 2) represents the mechanism, looking from beneath, for transmitting power to the heads of the work-carriers to remove them from one station to another. Fig. 8ª shows in section one of the friction plugs for frictionally engaging the ring with the work-carriers. Fig. 9 (Sheet 3) shows a convenient manner of mounting one of the tools in its carrier. Fig. 10 (same sheet) represents in section the drill and its parts. Fig. 11 (Sheet 4) represents an enlarged section on the line 11, Fig. 4, through one of the tool-carriers to show the means by which it is moved longitudinally for length-feeds. Figs. 12, 13 and 14, represent in detail the means for disengaging the work-carriers from their driving mechanisms. Fig. 15 (Sheet 6) shows how the driving mechanisms are supported to move about the same axis and represents in dotted lines the construction and arrangement of the variable speed gearing of which each is comprised. Fig. 16 represents one of the driving mechanisms and its box or casing. Fig. 17 represents a section on the line 17—17 of Fig. 3. Fig. 18 represents a section on the line 18—18 of Fig. 3. Figs. 19 and 20 represent a forming tool which may be conveniently located at the drill-spindle station and means for operating it. Fig. 21 represents the forming tool and illustrates the same in potential working relation to the work on one of the work-carriers. Fig. 22 represents one of the tool-carriers, the head of one of the work-carriers, the driving mechanism for the work-carrier, and means for controlling the lateral movement of the work-carrier and the driving mechanism. Fig. 23 represents the end of the work-carrier with a piece of work therein, and a tool in potential working relation to the work. Fig. 24 represents the under side of the main cam-carrier. Fig. 25 represents one of the cams for actuating a work-carrier head. Figs. 26 and 27 are other views of the cam-carrier.

Fig. 28 represents a horizontal section on the line 28—28 of Fig. 2. Figs. 29 and 30 illustrate the means for securing to the cam-carrier the cams which effect the longitudinal feeding movement of the tool-carriers. Fig. 31 represents a horizontal section through the lower portion of the machine and illustrates the devices for simultaneously disengaging all of the work-carriers from their driving mechanisms. Figs. 32 and 33 illustrate the means by which the disconnecting devices are actuated from the main cam-carrier. Figs. 34, 35, and 36, which may be read in conjunction with Fig. 8, represent in detail the means for operating the clutch which controls the mechanism for moving the work-carriers successively to the various tool-carriers.

Before attempting to explain in detail the machine which I have illustrated upon the drawings as embodying one form of the invention, I wish to make it clear that the invention is not limited to that particular machine, that the machine is shown more or less conventionally, without attempting to show the exact dimensions of the various parts, that a number of the features of the invention may be embodied in machines which are not of the multi-spindle type, and that the phraseology which I have adopted in the following specification and claims is for the purpose of description and not of limitation.

Reduced to its simplest form, the machine shown upon the drawings would comprise a longitudinally movable tool-carrier, a rotatable work-carrier pivoted to swing about an axis parallel to the axis of rotation of said work-carrier, whereby it may be moved laterally when the work is in potential working relation to the tool for effecting a lateral adjustment of the work or a cross-feed thereof, a driving mechanism for the work, and means for effecting or controlling the lateral movement of the work-carrier. The machine, as illustrated, comprises a plurality of each of these elements, the tool-carriers for convenience being journaled in a single head, and the work-carriers and the driving mechanisms being laterally movable independently of each other. For convenience of construction and operation, a single cam-carrier is mounted to move about an axis which is coincident with the axis about which the work-carriers and the driving mechanisms are movable, and upon said cam-carrier are mounted the various independent cams which effect or control the length-feeds of the tool-carriers and the cross-feeds (wherever they are necessary) of the work-carriers. For each of the work-carriers there is a separate and independently adjustable abutment for determining the exact relation between the tool and the work when the former is acting upon the latter; but, in addition thereto, there is located in proximity to each tool-carrier a separate controlling mechanism, operated by a cam on the carrier, for controlling or effecting the lateral movement of the work-carrier and its driving mechanism, each controlling mechanism being itself adjustable to compensate for differences in the various tools which may be employed on the tool-carriers. Each driving mechanism consists of variable speed gearing mounted in a head or gear-box which is laterally movable, as previously stated, said gearing including clutches whereby different speeds may be imparted to the work-carriers as occasion requires. For convenience, the various driving mechanisms receive their power from a centrally arranged driving shaft. As the machine, illustrated upon the drawings, is of the multi-spindle type, mechanism is provided for moving each work-carrier or work-spindle successively into registration with each tool-carrier and the driving mechanism which is adjacent thereto, means being provided for clutching or connecting each work-carrier to the driving mechanism as it reaches a position where the tool is in potential working relation to the work carried thereby. The work-carriers are illustrated as being mounted, for the sake of convenience, upon a common pivot, and mechanism is provided by which said work-carriers are automatically moved about said pivot from station to station, or from one tool-carrier to the next, when the operations of the various tools upon the pieces of work are finished.

As the illustrated machine is particularly adapted for chucking, I have shown it with the tool-carriers and work-carriers upright or with their axes perpendicular, but I have contemplated arranging said carriers in other positions.

Having thus given a brief general description of the machine, I will now explain and describe the same in detail, reference being had to the drawings. Said machine is illustrated as comprising a bed which is substantially frusto-conical in shape. It comprises two parts or sections 50 51, which are divided on a horizontal plane and are secured together by bolts or other suitable fastenings. The bed is hollow and is provided at intervals with apertures through which access may be had to the various operative parts of the machine. Arranged in the center of the bed is an upright shaft 52, as best shown in Fig. 3, from which, as will be subsequently explained, power is transmitted to the various independent driving mechanisms for the work-carriers. The lower end of this shaft is stepped in a bushing 53 secured in the base plate 54 of the bed, and its upper end is journaled in bearings 55 56 afforded by a superstructure formed on or secured to the upper portion 51 of the bed.

Tool-carriers.—Any convenient number of tool-carriers may be employed, but I have illustrated four as being a convenient number for all general purposes. Each tool-carrier may, as shown, consist of a bar or spindle mounted in the upper portion of the head. These tool-carriers are indicated at 57, 58, 59 and 60, the carrier 60 being especially adapted for a drill.

Referring to Figs. 3 and 4, it will be observed that the upper portion 51 of the bed is formed with a horizontal web 61, located a relatively short distance above the upper end of the lower section 50 of the bed. A second transverse web 62 is formed at the upper end of the upper section 51, and in the two webs or partitions 61, 62 are mounted the three spindles or tool-carriers 57, 58 and 59. These webs or partitions are formed with apertures encircled by annular tapering flanges to receive taper split bushings by which each spindle may be held in place and permitted to slide longitudinally.

The shape of the tool-carriers may be varied, although, for all general purposes, a cylindrical bar, such as illustrated, serves the purpose.

In Fig. 9 I have shown the lower end of a tool-carrier and have illustrated how a cutter or tool 63 is attached thereto. The carrier is shown as having a slot 64 in the end thereof, adapted to receive the shank of the cutter. Screws 65, passed laterally into the carrier, engage the tool or cutter and clamp it at two separated points securely in place. The cutter projects but a short distance beyond the end of its relatively large carrier so that there is little chance of the tool springing when cutting. In this connection, I desire to point out that the tool-carriers or spindles are mounted practically at their ends so that they too are rigidly supported and are rendered practically incapable of springing. The various carriers 58 to 60, although adapted to slide longitudinally, are held against rotation by means which I shall explain.

The drill and its carrier.—The carrier 60 for the drill is mounted in a tubular guideway 66 which may be integral with the other portions of the head 51, as shown in Fig. 3. In this carrier is journaled a live spindle 67 (see Fig. 10, Sheet 3), whose lower end is adapted for the reception of a drill 68. The lower end of the drill spindle 67 is formed with a shoulder, between which and a shoulder in the carrier 60 are placed balls 69 to resist the upward thrust of the spindle and to reduce the friction. On the drill spindle 67 is secured a collar 70 which bears against the upper end of the carrier 60 so as to hold the drill against downward movement relatively to said carrier. The upper end of the spindle 67 projects through a head 71 which closes the upper end of the tubular guideway 66, and splined to said spindle is a gear 72 to which power is transmitted from the central driving shaft 52 by a set of change gears. Any suitable form of change gearing may be utilized for the purpose of transmitting to the drill spindle any one of a plurality of speeds. A convenient form is illustrated comprising three gears 73, 74 and 75, graduated in size and splined to the shaft 52 so as to rotate therewith. On an intermediate shaft 76 are three gears 77, 78 and 79 pinned or otherwise rigidly secured thereto and separated far enough apart so that the three gears 73, 74 and 75 may be caused to separately intermesh with them so as to drive the intermediate shaft 76 at any one of three different speeds. The gear 77 intermeshes with and drives the gear 72 to which the drill spindle 67 is splined. The shaft 76 is journaled in bearings afforded by the upper portion 51 of the bed. The gears 73, 74 and 75 are moved axially and held in position by a lever 731 as shown in Fig. 1.

Feeding mechanism for the tool-carriers.—The four tool-carriers are moved longitudinally to secure length-feeds of the tools relatively to the work independently of each other. That is to say, each carrier may be moved any predetermined distance and at any rate of speed independently of the other carriers. To accomplish this, any suitable form of power-transmitting mechanism may be utilized, although, as previously stated, I have found it convenient to utilize a single oscillatory cam-carrier provided with detachable cams, one for each tool-carrier. The cam-carrier is indicated at 80. It consists of a ring or cylinder which is supported by a track or circular guideway 81 formed on the upper section or portion 51 of the bed, and it is arranged concentrically with the shaft 52. The tool-carriers are arranged equi-distant from the shaft 52 and they are encircled by the cam-carrier 80, as best shown in Fig. 3. The cam-carrier is provided with an inwardly extending flange 83 (see Fig. 4) which is overlapped by gibs 84 secured to the exterior of the upper portion 51 of the bed. The flange 83 is formed with a concentric shoulder which engages the inner surface of the track 81 so that the cam-carrier is held against lateral movement in addition to being held against axial movement by means of the gibs 84. The cams, by which the tool-carriers are fed lengthwise, are indicated at 85 (see Figs. 2, 3, 26, 27, 28 and 29) and are shown conventionally. Each cam is secured to the interior surface of the carrier and is formed with a semi-spiral track or groove. Any convenient form of securing means may be utilized to attach the cams to the carrier; for instance, the cam-carrier may be provided with a series of longitudinal slots 86, through which screws 87 may be passed, as shown in Fig. 29, to draw the clamping strap 88 against the exterior of the carrier so as to bind the cam securely in place. Any number of these clamping members or straps may be used to secure each cam rigidly against dislocation on the carrier. To each of the tool-carriers is attached a roll for engagement with the cam by which said carrier is actuated.

Referring to Figs. 4 and 11, it will be observed that each carrier is formed with a dovetailed groove 89 to receive a sliding block 90. This block projects beyond the periphery of the carrier and extends into a groove 91 formed in the outer wall of the upper portion of the bed so as to hold the carrier against rotation about its axis. From the block passes a headed pin 92 on which there is a roller 93 projecting into the groove in the cam 85. Pinned in the slot 89 in each carrier is another block or abutment 94 in which is journaled a screw-pin 95 in threaded engagement with the roll-carrying block 90. Collars are secured upon the pin 95 to hold it against axial movement relatively to the block 94, and the upper end of the pin is squared so that, by means of a suitable tool or wrench, it may be rotated to adjust the carrier longitudinally relatively to the cam 85 and the roll-carrying block 90. By means of these adjusting devices, each tool-carrier may be adjusted axially relatively to the work with great nicety to compensate for variations in the cutters and for variations in the position of the cams. As thus explained, it is clear that each tool-carrier may be axially adjusted independently of every other carrier and is independently actuated to secure length-feeds of the tools at any speed and to any extent.

The cam-carrier and its actuating mechanism.—The cam-carrier is oscillated about its axis of movement, and to accomplish this, any suitable mechanism may be utilized. A convenient form of mechanism is illustrated, which may be described as follows: The inwardly projecting flange 83 on the cam-carrier is formed with bevel gear teeth as indicated at 96 (see Figs. 24 and 27). These teeth are engaged by gears 97, 98, 98 (see Fig. 6) secured upon shafts 99, 100, 100, which are arranged in the same horizontal plane and extend radially outward from the axis of movement of the cam-carrier. On the inner end of each of the shafts there is a bevel gear 101 which intermeshes with a bevel gear 102, loosely mounted upon the shaft 52. Said bevel gear 102 has an extended hub, the upper end of which serves as a bushing between the shaft 52 and a bearing 103 formed in a small dome 104, which extends upwardly from the transverse partition or web 61 of the upper portion of the bed. This dome incloses the bevel gear 102 and the gears 101, and has bearings through which the shafts 99, 100, 100 extend outward. Power is transmitted from means to be subsequently explained to the shaft 99 and is distributed through the gears 102, 101 and the shafts 100 to the cam-carrier to effect its movement in one direction or the other about its axis. I may dispense with the distributing gearing and drive the cam directly by means of the shaft, the gear 97 and the gear teeth on the carrier, but for reasons, which will be apparent, the distributing gearing may be used to advantage. By employing the distributing gearing, I am able to dispense with a central pivot or hub for the cam-carrier, thus converting it into a ring or hollow cylinder instead of a wheel. In the form of a ring, the carrier may pass over the tool-carrying spindles without interference, thus permitting a compact arrangement, which is not possible with a cam-wheel having a central bearing. Furthermore, a cam-carrying face passes closely to each of the four spindles, so as to drive them directly without intermediate arms or levers. This scheme of driving a cam-carrier at several points near its periphery, insures a steadiness of motion that would be a desirable improvement even in cam wheels having central bearings. The mechanism which transmits power to the shaft 99 is preferably of such character that the cam-carrier may be moved first in one direction and then in the other at different speeds. Preferably the mechanism is constructed and arranged so that, in addition to the variation in the angles of the individual tool-acting cams, the cam-carrier will be actuated so that all the tool-carriers will be moved to retract the tools rapidly, after operation is complete, and also to advance them rapidly to the operating position of the first engaging tool. The further variations are obtained by the individual cams, as the cam-carrier is slowly moved.

A convenient form of driving mechanism for the cam-carrier is illustrated upon the drawings and may be described as follows: The shaft 99 projects outward beyond the cam-carrier and is equipped with a gear 107 to which power is transmitted from power-transmitting gearing inclosed in a gear-box or casing 106 secured to the head in any suitable way. The initial or prime power shaft of the machine is shown at 108 (see Figs. 2 and 6). It is journaled in any convenient manner and is adapted to be driven by a loose pulley 109 and a clutch 110, the latter being moved into and out of operative position by a lever 111. This lever is fulcrumed in a bracket 112 and extends downwardly into convenient reach of the operator. The shaft 108 has rigidly secured to it a pinion 113, between which and the gear

107 on the shaft 99 is interposed the following variable-speed and reverse gearing. Journaled in the casing 106 is a shaft 114, having at one end a gear 115 intermeshing with the gear 113 and at its other end a bevel gear 116. The last-mentioned gear intermeshes with and drives a complemental bevel gear 117 on an upright worm-shaft 118. A worm 119, on said shaft, intermeshes with and drives a worm-gear 120, mounted on a shaft 121, arranged horizontally in the gear-box. The worm is loose upon the shaft 121 and there is a clutch mechanism 123 by which the worm-gear may be clutched to the shaft 121 to rotate it and transmit power to the gear 107 through a pinion 124 on said shaft 121 intermeshing with said gear. When the worm-gear is clutched to the shaft 121, shaft 99 is rotated at a slow speed forward to advance the tool-carriers longitudinally of the work.

To advance the cam-carrier rapidly in one direction, and then retract it rapidly, I mount upon the lower end of the worm-shaft 118 a bevel gear 122 which intermeshes with and drives a bevel gear 125, mounted loosely on a shaft 126 in the gear-box, said shaft being parallel to the shaft 121. The bevel gear 125 is loose upon the shaft and in proximity thereto there is secured to said shaft 126 a gear 127 intermeshing with and driving a gear 128 on the shaft 121. A suitable clutch mechanism is interposed between the bevel-gear 125 and the gear 127, so that, when the worm-wheel 120 is unclutched from its shaft 121 and the bevel-gear 125 is clutched to the gear 127, the shaft 99 will be rotated to move the cam-carrier at a rapid speed forward so as to move the tool-carriers from their raised or retracted position into position where the tools may begin the operation upon the work. The bevel-gear 122 also intermeshes with a bevel-gear 129, which is loosely mounted on the shaft 126. Adjacent the bevel gear 129 there is a gear 130 on the shaft 126, which intermeshes with and drives a gear 131 on the shaft 121, and which may be clutched to the bevel-gear 128. The bevel-gear 129 is rotated in a direction opposite to the direction of rotation of the bevel-gear 125, and hence, when the bevel-gear 129 is clutched to the gear 130, the shaft 121 and the shaft 99 will be rotated in a direction to retract the cam-carrier or move it in a reverse direction at a rapid speed, so as to cause the rapid retraction or raising of the tool-carriers.

Mechanism is provided for automatically operating the three clutches herein referred to. The clutch 123 is controlled by a rod 132 which enters the shaft 121. The gears 127 and 125 and the gears 129 and 130 are clutched together or moved to neutral position by rod 133, which enters the shaft 126. The mechanism by which the rods 132 and 133 effect the operation of their respective clutches need not be described in detail, any convenient mechanism being utilized for this purpose. The two rods 132, 133 are respectively operated by levers 134, 135, fulcrumed on brackets extending from the end of the box or casing 106. To the said levers are pivoted connecting rods 136, 137, the former being connected to a lever 138 and the latter to a lever 139, which levers are pivoted upon any convenient supports afforded by the bed. The main cam-carrier is provided with cams which effect the swinging of the levers 138, 139 at the proper times to throw in and out the clutches. To this end, the cam-carrier 80 is provided with a peripheral flange 140 (see Figs. 24 and 28), to the under side of which are adjustably attached cams conventionally shown at 141, 142, 143, 144 and 145, see Fig. 6. The cams 145 and 142 act indirectly upon the lever 138 to respectively clutch and unclutch the worm-gear 120 to the shaft 131 and thereby cause the main cam-carrier to move slowly to feed the tool-carriers when the tools are in working position, and then to stop the slow movement of the cam-carrier and the tool-carriers. The cams 144 and 141 act indirectly upon the lever 139 in the order named, first, to unclutch the reverse gear 129 from the gear 130 and clutch the gear 125 to the gear 127, and thereby cause the cam-carrier to be rotated to feed the tools downward or towards the work at a rapid speed, and, second, to unclutch the gear 127 from the gear 125 so as to stop the rapid feeding movement of the tool-carriers, and leave the gears 125, 127, 129 and 130 in neutral or unclutched positions. The cam 143 is concentric to the shaft 52 and it engages a roll on the end of the lever 139 in the neutral position to which it was moved by cam 141, and then releases it to permit it to move under spring pressure to clutch the reverse gear 129 to the gear 130, and cause the cam-carrier to be rotated reversely at a rapid speed to retract the tool-carriers. The cams are so located, that the gears for feeding the cam-carrier at a high speed forward to move the tools down rapidly are unclutched simultaneously with the throwing-in of the clutch which causes the cam-carrier to be moved forward slowly to feed the tool-carriers while the cutters are acting upon the pieces of work, and that when the slow feeding movement of the cam-carrier ceases, by reason of the unclutching of the clutch 123, as when the tools have all finished their operations upon the work, the reverse gears 129 and 130 are simultaneously therewith clutched together to cause the cam-carrier to be rotated reversely at high speed. To cause the movement of said levers, there is pivoted upon the fulcrum of each an auxiliary lever which is moved by spring pressure after being actuated by the cams. These auxiliary levers are indicated at 148 and 149.

They have pins 150, 151 which may be engaged by inclined portions of the cams. Between each auxiliary lever and the bed of the machine there is a spring-pressed pin 260 having a beveled end to engage a beveled projection on the corresponding lever. Each main lever has lugs between which the auxiliary lever plays and by which motion is imparted to the main lever. When the auxiliary lever is thrown from one side to the other, the spring-pressed pin, which bears against it, moves it to its extreme limit of movement and causes it to move the corresponding main lever by spring pressure. This is not an essential detail of the construction of the machine and any other suitable mechanism may be utilized in lieu thereof, for effecting the operation of the clutch-controlling levers. I have shown and described it, merely as being something that will accomplish the end which I desire to secure, to wit; the proper actuation of the clutches which control the movement of the main cam-carrier.

It will now be understood, from the description thus far given, that the cam-carrier is moved first in one direction at a high speed to move the tool-carriers rapidly into positions where the tools may act upon the work, and then slowly in the same direction while the tools are performing their allotted operations, and that the cam-carrier is then rotated rapidly in the opposite direction to rapidly retract the tool-carriers and move them away from the work into inactive positions.

Work-carriers.—In the illustrated machine, there are as many work-carriers as there are tool-carriers, but, as previously stated, instead of having a fixed lateral relation, they are independent so that each may be moved laterally without affecting the others. These work-carriers are indicated in Figs. 3, 4, 17 and 31 at 152. Each consists of a live spindle provided at its upper end with a chuck 153. Each is mounted in a head 154 which may be formed of a casting having a closed upper end. Each head is formed or provided with a hood 155 which partially encircles the chuck and the work which is carried thereby, as shown in Figs. 3 and 17, so as to receive oil and chips and prevent the chips from flying into the machine. The importance of these hoods will be explained. From each hood or shield leads a spout 156 for the discharge of oil and chips. Each head is provided with two arms 157, 158 which are journaled upon a sleeve 159 which surrounds the shaft 52. As a detail of construction, the upper end of the sleeve 159 is formed with a collar 160, which is supported by a plate 161, attached to the web or partition 61 of the upper portion of the bed. The arms 157, 158 of the different heads lie in different horizontal planes but the arms of each head are separated as far apart as possible and are arranged as nearly as may be to the ends of each head so as to prevent it from springing or yielding. The heads are so constructed that the live spindles 152 carried by them are equi-distant from the axis of the shaft 52 and of the sleeve 159, and each spindle may be brought into position so that its axis is coincident with the axis of each one of the tool-carriers. The arm 158, of each head is supported against dropping by a split collar inserted between it and the sleeve 159 and arranged in a peripheral groove in said sleeve. Each head is provided with split taper bushings in which its particular work-carrier or spindle 152 is journaled and suitable provision is made for resisting the axial or downward thrust of each spindle. In addition to the spindle, each head is provided with a shaft 162 journaled in bearings in said head and held yieldingly downward by a spring 163 and a pin 164 bearing against a lug on the head. Each shaft 162 has a gear 165 intermeshing with and driving a gear 166 on the spindle to which it is adjacent.

Mechanism for moving work-carrier heads.—Mechanism is provided for simultaneously moving all of the heads about the sleeve 159 so as to advance each piece of work from one tool to the next tool which is to operate upon it, and in addition thereto mechanism is provided for moving each head and the work-carrier thereon transversely independently of the other heads and work-carriers. Now although the tool-carriers are all equi-distant from a common center, yet they are not equi-distant from each other, as will be seen by an inspection of Figs. 5 and 6, and hence, during the simultaneous movement of all of the heads, some heads and tool-carriers will be moved further than others or through arcs of different lengths. Where a drill is employed as one of the tools to operate upon the work, it is unnecessary for the work-carrier and its head to be moved laterally, except for adjustment, after the head has reached a position where the drill is in cutting relation to the piece of work carried by the work-carrier, but the other tools may be employed for facing the work or cutting shoulders thereon (as, for instance, facing a hub or a rim of a wheel or cutting an internal shoulder in the hub), and hence it is desirable that, when each work-carrier reaches a position where such a cutter is in potential working relation thereto, as in Fig. 23, the work-carrier should be capable of moving laterally or transversely to secure a cross-feed of the tool and the work. Preferably the tool-carriers 58 and 59 will carry such tools. Therefore it will be seen that the tool-carriers 58 and 59 are at a greater distance from each other and from the carriers 57 and 60 than the carrier

57 is from the carrier 60 which is provided with the drill. Now, according to my present invention, the work-carriers, although each is moved successively into registration with each of the tool-carriers, are all capable of independent lateral adjustment and lateral movement for cross-feeding.

The mechanism for advancing the work-carriers from station to station or from tool to tool simultaneously may be of any convenient form, but I have illustrated upon the drawings one form of mechanism which may be utilized for the purpose. It comprises a bevel toothed friction ring 167, the upper face of which engages an overhanging portion of each work-carrying head as shown in Figs. 2 and 4. To each work-carrier there is secured a block 168, having a spring-pressed pin (see Fig. 8ª and Figs. 34 and 36), which maintains the frictional engagement of the friction ring 167 with the heads. Intermeshing with the teeth on said ring 167 is a bevel-gear 169 mounted loosely on a shaft 170 arranged horizontally and journaled in a bracket in the bed as shown in Fig. 2. This shaft bears on its outer end a bevel-gear 171 intermeshing with and driven by a similar bevel-gear 172 on an upright connecting shaft 173. Said shaft 173 extends into the casing 106 hereinbefore described, and bears upon its upper end a bevel-gear 174 which intermeshes with both the fast speed bevel-gears 125 and 129 previously described. Power is transmitted through the shafts and gearing thus described to the gear 169 which rotates the friction ring 167 and effects the movement of the work-carriers from station to station. Between the gear 169 and the shaft 170 there is a clutch 175, which is operated by mechanism to be explained, to clutch the shaft and gear together after the tools have completed their cutting operations and the pieces of work are ready to be moved to the next stations.

The clutch operating mechanism is controlled by a cam on the main cam-carrier and may be seen in Figs. 2, 3, 4, 31, 32, 33, 34 and 35. By reference to said figures, it will be seen that there is a ring 176 which is pivotally supported upon arms 177 formed or secured on shafts 178 journaled in bearings afforded by the lower portion of the bed, said shafts extending through said bed so as to be accessible on the outside thereof. By rocking said shafts, or any one of them, said ring 176 will be lifted and at the same time will be partially rotated. The ring is provided with a cam or off-set portion 179 which enters a groove in the sliding member of the clutch 176 (see Figs. 8 and 34), so that, when said ring is moved about its axis, the movable member of the clutch will be thrown into and out of operative position. Normally the clutch-member is in the position shown in Fig. 8 in which it is disengaged from its complemental clutch member. After the cutters have completed their operations upon the pieces of work, the ring is moved and the clutch member is carried to the position shown in Fig. 35, in consequence of which the friction ring 167 will be rotated so as to cause the simultaneous advancement of all of the work-carriers. On one or more of the shafts 178 is mounted a handle 180, as shown in Fig. 4, so that the clutch-controlling ring may be shifted manually whenever desired to effect the actuation of the head-moving friction ring. Another of the shafts 178 is provided with an arm 181 which extends substantially horizontally, as shown in Figs. 32 and 33. Above the said arm is arranged a vertical rod 182 which rests thereon and which is adapted to slide in guides 183, 184 on the bed. This rod is adapted to be depressed by a cam 185 adjustably secured to the under side of the laterally projecting flange 140 of the main cam-carrier 80 (see Fig. 5). Since the cam-carrier oscillates, the cam 185 must move in one direction without depressing the rod 182, but should depress it when the carrier moves in the opposite direction. To this end there is pivoted upon the upper end of the rod 182 a spring-pressed trip latch 186, so that, when the carrier is moving in the direction of the arrow in Fig. 32, the rod will be depressed, but, when it is moving in the opposite direction, the latch will yield without causing the depression of the rod. The cam 185 is so located on the cam-carrier that the rod is not depressed except upon the reverse movement of the cam-carrier and after the tools have been drawn clear of the work. The said cam 185 is long enough so as to hold the rod depressed and the clutch-operating ring 176 raised and thereby to maintain the clutch in its active position, until the work-carrying heads have all had a chance to be moved to their next succeeding stations. The clutch-operating ring 176 performs another function which I will subsequently explain in connection with the driving mechanisms for the work-carriers.

Independent adjustable abutments for work-carriers.—I have stated that there is a separate abutment for each work-carrying head, by which any predetermined relation between any cutter and each piece of work as it is brought into potential working relation thereto may be secured and maintained. Each abutment, which is movable into and out of active position, is arranged to engage the work-carrying heads in succession substantially in line with the thrust of the cutter upon the work in the work-carrier, which of itself is an important feature of the invention. Adjustably attached to the under face of the web 61 of the upper portion of the bed are four blocks, one for each tool-carrier. These blocks are shown in Fig. 4 at 187. They are rigidly secured to the bed and each of them is provided with a movable abutment member 188 fitting in a deep slot therein. This member, as shown in Fig. 4, is pivoted upon the pin 189 and may be raised, as shown in said figure, to clear the heads and permit them to pass under it. Each of the members has an adjustable pin, screw or projection 190 which may be engaged by a complemental adjustable screw or pin 191 at the upper end of each of the heads. As illustrated, the screw or pin 191 is secured in the hood of each head. When the member 188 is dropped, the projection or pin 190 will register with the pin or screw 191, and since the projection 190 has a fixed relation to the cutter and the screw or pin 191 has a fixed relation to the work-carrier and the work thereon, their engagement will determine the exact relation of the tool to the work. Each of the projections 190 is adjustable transversely of the tool as stated, and hence each head may be stopped at any exact point which may be desired for any particular tool. That is to say:—When each of the pieces of work has reached a position where the cutting tool is in potential relation thereto (that is, has reached a position as in Fig. 23 where, if all conditions were perfect, the cutter, if advanced longitudinally far enough towards the work, could cut), the work-carrier and its head may be moved bodily transversely of the work-axis to adjust the work relatively to the tool. This may be done by adjusting either the pin 190 or the pin 191. These abutments will probably be used only at one station for finishing the work, or for the drill, but they will be ready for use at the other stations. The movable members of the abutments are moved into and out of operative positions by automatic mechanism controlled by the ring 176 hereinbefore referred to which advances the work-carriers. To this end, as shown in Figs. 1, 4 and 31, there is connected to the ring 176 by rods 192 a ring 193, with which the abutments 188 are loosely connected by hooks 1931. When the ring 176 is lifted and rotated just before the work-carrying heads are bodily moved to the next succeeding stations, the ring 193 is raised by it and the abutments are thereby withdrawn to permit the passage of said heads beneath them, being dropped again before the work-carriers reach their next positions or stations.

So far as I am aware, no one has ever heretofore pivoted a work-carrier to move about its pivot transversely of the axis of the work to bring it into potential working relation to the tool and employed in connection therewith means for adjusting the tool-carrier and the work-carrier transversely relatively to each other, and this I believe to be new.

Cross feeding mechanism.—The independent cross-feeds, which are obtained by moving each work-carrier relatively to the tool-carrier transversely of the work-axis, are accomplished by the following mechanism: Journaled in bearings 194, 195, formed on or secured to the upper and lower portions of the bed respectively, are rock-shafts 196. There is one of these rock-shafts to each tool-carrier (except the drill-carrier, and there may be one for that also in case said carrier should be used for another kind of tool), and each is provided with a bell-crank comprising a hub or sleeve 197, a roll-carrying arm 198 at its upper end, and a second roll-carrying arm 199 adjacent its lower end, see Figs. 1, 4, 6, and 17. The arm 198 of each bell-crank is adjustable about the axis of the hub or sleeve 197, relatively to the arm 199, and to this end the arm 199 is formed on a separate hub 200, pinned to the shaft 196. Said arm 199 is adjustably secured to a supplemental arm 201 on the hub 197 by a bolt or pin 202. The arms 199 are shaped as shown in Fig. 17 and each is formed with a curved slot 203 to receive the securing pin or bolt 202. The arm 198 of each of the bell-cranks is provided with a roll, as previously stated, said rolls being engaged by independent cams 204 secured to the under face of the flange 140 of the main cam-carrier 80, as best shown in Fig. 24. These cams which are shown conventionally are so constructed that each one of them will impart a cross-feed of the same character to each work-carrier corresponding to said cam. In Fig. 24 only three cams are shown since the machine has been described as being provided with a drill, and it is unnecessary of course to provide any cross-feed for the work-carrier which is presenting the work to the drill. These cams are further so constructed that they move the work-carriers in a direction opposite to the thrust of the tool upon the work, through the medium of the bell-cranks referred to and opposite to the direction of movement of the work carriers as they are transferred from station to station. These bell-cranks themselves may be used as abutments for the various work-carriers, and, in fact, do constitute abutments for the purpose stated and engage the heads in line with the thrust of the tools on the work; but, if they were not relied upon to obtain cross-feeds, the cams would be formed with concentric roll-engaging edges instead of inclined or spiral edges. Each cam 204 is formed with an inner engaging edge *a*, which swings the bell-crank to feed the work-carrier inward against the thrust of the cutter, and which permits the bell-cranks to move outward when the cam-carrier is moving reversely.

The arms 199 of the bell-cranks are arranged in different horizontal planes and they are provided with rolls for engaging the hoods on the heads of the work-carriers in line with the thrust of the cutters on the work. Therefore each hood has a particular bearing surface for each of the arms, being provided with as many bearing surfaces as there are arms. Each bearing surface is formed on the face of a longitudinally adjustable wedge-shaped block 205, said blocks on each head being longitudinally adjustable relatively to each other. This provides an adjustment between each head and each of the bell-crank arms with which it is successively engaged so as to secure an exact predetermined relation between each piece of work, and the tool which is operating upon it. Any convenient means may be utilized for adjustably securing the wedge-shaped blocks 205 in place. The provision of the independent adjustable features, just described, enables the machine to produce pieces of work which are exactly similar in every respect. The arms and rolls constitute one set of abutments, stops or stop faces at the several stations, and the blocks 205 constitute another set of stops or stop faces, the latter being arranged in groups as shown so that each work-carrier will be accurately positioned at a station by one stop face of one of the groups.

Independent variable-speed driving mechanisms.—A separate and independent driving mechanism is provided for each work-carrier so as to drive it at any predetermined speed independently of the speeds at which the other work-carriers are being rotated. These driving mechanisms are equal in number to the tool-carriers or to the work-carriers, and they are arranged substantially in alinement with the tool-carriers, although each is adapted to move laterally to some extent independently of the others. Each driving mechanism which comprises variable speed-gearing, is mounted in a separate head or gear-box 207 (see Figs. 1, 2, 3, 4, 7, 15, 16 and 22). Like the work-carrying heads, the driving heads are pivoted upon an axis coincident with the axis of the shaft 52. To this end, each of the gear-boxes or heads is provided with an arm 208 pivoted upon the sleeve 159, and an arm 209 pivoted upon the bushing 53. Considering the driving heads as a whole, they are located below a transverse web 210 which extends across the interior of the lower portion 50 of the bed, as shown in Figs. 2, 3 and 4, but said partition has flanged apertures through which the power-transmitting member of each driving head extends for engagement with the intermediate shaft in one of the work-carrier heads, said apertures being indicated at 211.

Referring to Figs. 4, 7 and 15, it will be seen that, journaled in each driving head or gear-box, there is a power-transmitting shaft 212, on which are placed a number of gears, for instance three, as indicated at 213, 214 and 215. These gears are of different diameters and they intermesh with and are driven by gears 216, 217 and 218, keyed to the central driving shaft 52. The gears 213, 214 and 215 of two of the heads are on a horizontal plane above the plane in which are located similar gears in the other two heads so that they will not interfere, and for this reason the gears 216, 217 and 218 are elongated as shown in Fig. 4. The three gears 213, 214 and 215 of each head will be driven at different speeds from high to low in the order named. They are all mounted loosely upon their transmission shaft 212 and are adapted to be clutched thereto so as to drive said shaft at any one of three different speeds. The gear 215, when the other gears 213 and 214 are unclutched, drives the shaft 212 by means of a silent ratchet clutch indicated conventionally at 219. This clutch may be substantially similar to that illustrated in Letters Patent No. 703,411, granted to me July 1, 1902. The gears 213 and 214, however, may be alternately clutched to the shaft 212 by a sliding toothed clutch-member 220 splined on the shaft. This clutch member may be moved in one direction or the other by a hand-lever 228, there being one for each head. Mounted on a bushing loose on the upper end of each shaft 212, there is a driving member or gear 222 whose hub projects upwardly through the aperture 211 in the transverse partition 210 in the bed. This hub in each case carries a device by which it may be engaged with each one of the intermediate shafts 162 in the various work-carrying heads. This device I will subsequently explain. The gear 222 is loose with relation to the shaft, but it is formed with clutch teeth which may be engaged by complemental teeth on a gear 223 splined on said shaft. The said gear 223 is moved into position to clutch it to the gear 222 by a hand-lever 224 (see Fig. 15) which extends outward from the head. Normally the two gears 222 and 223 are clutched together and they are unclutched only when it is desired to throw in the back gearing. The back gearing consists of two gears 225, 226, formed on a single hub which is journaled loosely upon a back gear-shaft 227 mounted in each driving head. Said gears 225, 226 are of different diameters and may be engaged with their complemental gears 222 and 223 so as to drive said gear 223 at a lower speed than that at which it had been rotating. Since the shaft 212 of each head may be driven at any one of three speeds, the provision in each head of a back gearing enables the ultimately driven member 222 to be rotated at any one of six speeds, and consequently any one of the six speeds may be imparted to the work-carrier which is registering therewith. The back gear 226 is shifted by means of a forked lever 221 having a handle by which it may be moved, as shown in Fig. 15. This lever has a concentric portion or edge *c* with a notch to receive a pin 229 on the lever 224 previously described. When the pin 229 is in the notch, both levers are held against movement with the gear 223 clutched to the gear 222 and with the back gears in their inoperative positions. When the lever 224 is lifted to unclutch the gear 225 from the gear 222, the lever 221 may be shifted to throw the back gears into action and the concentric surface *c* on the lever 221 holds up the lever 224 to prevent the gears 223 and 222 from becoming clutched. Thus the two levers 224 and 221 are interlocking, each at certain times preventing the operation of the other.

The intermediate shafts 162 in the carrier-heads and the transmission-shafts 212 in the driving heads all are equidistant from the axis about which their respective heads are adapted to swing, and the driving-heads are unequally spaced apart, as shown in Fig. 7, in the same manner that the tool-carriers are unequally spaced. Consequently, when the work-carriers are moved into position where the pieces of work carried thereby are in potential working relation to the tools, the axes of the shafts 162 are substantially coincident with the axes of the shafts 212. In one sense, it may be stated that the driving heads are fixed, and that the work-carriers are moved relatively thereto. This is true while the work-carriers are being moved from station to station, but, after they have reached their stations, the work-carriers are connected to the driving members of the driving heads and then the driving heads may be moved with the work-carriers, as they are laterally adjusted or as they receive their cross-feeding movements. The lateral movement of each of the driving-heads is therefore somewhat limited, but their movement is controlled by the same cams which govern or effect the cross-feeding movement of the cam-carriers. To this end, there is secured to the lower portion of each of the rock-shafts 196, to which the bell-crank arms 199 are pinned, arms or levers 230, as shown in Figs. 4 and 7. Each of these arms carries upon its end a roll 231 which engages an adjustable wedge-shaped block 232 attached to a projecting portion on one of the driving-heads or gear-boxes. These arms 230 serve as abutments for the driving-heads, just as the arms 199 serve as abutments for the carrier-heads, and moveover when each carrier-head is moved transversely by one of the cams on the cam-carrier, the corresponding driver-head is moved simultaneously therewith to substantially the same extent. Furthermore, the two arms 199 and 230 on each rocker-shaft 196 serve to effect the registration of the driving member on the corresponding head with the shaft 162 on the carrier-head, which is in position to have its work-carrier driven by the power-transmitting mechanism in the driving head.

Convenient means may be utilized to connect the variable speed-gearing in each driver-head with the work-carrying head which is at its station, and I have shown a means in Figs. 4 and 14 which may be utilized for this purpose. This device consists of a loosely rotatable pin 233 which is transversely mounted in the end of the hub in each of the gears 222. This hub is separately designated at 234. The ends of the pins are flattened and are adapted to engage lugs 235 on the flat head 236 formed on or secured to the end of each shaft 162, so that, when the parts are in the positions shown in Figs. 4 and 14, the shaft 162 will be driven by the driving member or gear 222 on the shaft 212.

Prior to the simultaneous movement of all of the work-carrying heads to their next successive stations, it is desirable that the shafts 162 should be disengaged from the driving members 222. To this end said shafts 162 may be moved axially or upwardly against the tension of the springs 163 previously described as holding them yieldingly downward. The releasing movement of said shafts 162 is accomplished by the same ring 176 which I previously stated controls the clutch 175. In each of the work-carrying heads, there is a rock-shaft 237 (see Figs. 12, 13 and 14) journaled in suitable bearings and having on its inner end a finger 238 which extends under the gear 165. On its outer end, each of the shafts 237 has an arm 239, the end of which rides upon the ring 176. The arm 239, the shaft 236, and the finger 238 in each carrier-head constitute a bell-crank, and, as I explained in connection with the ring 176, that as it is rotated it is also lifted, it will be seen that all of the bell-cranks will be simultaneously rocked to lift all of the shafts 162 and permit the work-carrying heads to be swung away from the driving-heads. The work-carriers are all disconnected from their driving mechanisms at the same time that the clutch 175 is shifted to cause the work-carriers to be moved to their next stations, and the shafts 162 are all held in their raised positions until the various work-carriers cease movement and the ring 176 is permitted to drop by the trip latch 186 (Fig. 33) riding off the end of the cam 185. As it is sometimes desirable to disengage a work-carrier from its driving mechanism while the others remain engaged, the end of each of the arms 239 is extended to form a handle 240 (see Fig. 13), to which the operator may gain access through a convenient aperture in the cylindrical wall of the bed. The thrust of the gearing in transmitting power through the heads is sufficient to return them to the same relative initial positions as soon as the work-carriers are disengaged from the heads, so that the work-carriers may always register with their driving mechanisms when they are moved into potential working relation to the tools, since the several abutments serve to bring the work-carriers and their driving mechanisms into proper alinement or registration.

Forming tool.—In addition to the tools on the tool-spindles or tool-carriers, I may of course use other tools which are mounted in other ways; for instance, in Figs. 17, 19, 20, 21 and 22 I have illustrated how a forming tool may be located at the same station as the drill. I have selected a forming tool as one of many tools which may be used and have no intention of limiting myself to its use. The tool itself is indicated at 241 and its shank is adjustably affixed to a slide 242 mounted to travel in gibbed ways in a bracket 243 formed on or secured to the bed and projecting radially outward therefrom. Journaled in the bracket is a shaft 244 having a gear-segment 245 intermeshing with a toothed rack 246 formed on the slide 242. To the upper end of the shaft is secured an arm 247, bearing on its end a roll 248 which may be engaged by a shoulder or edge 249 on one of the cams attached to the flange 140 of the cam-carrier 80, (see Figs. 6 and 24). By means of the cam edge 249, the arm 248 is moved to feed the tool towards the work, a spring 251 being employed to move it in the other direction. Any other convenient means for effecting the operation of the supplemental tool may be used in lieu of that illustrated and described.

It is unnecessary to describe in detail the operation of the machine, more than to state that the work-carriers are successively and simultaneously advanced from station to station, where the pieces of work are acted upon by the tools in the tool carrier, since I have already set forth fully the manner in which the work-carriers are connected to and disconnected from the driving-heads, in which the bell-crank abutments for the carriers are controlled by cams on the cam-carrier, and the rigid auxiliary abutments are raised and lowered by the ring which controls the mechanism for advancing the work-carriers, and in which variable speeds are imparted to the cam-carrier.

Two separate sets of abutments for the work-carriers have been described, both adjustable, but only one set movable by power to impart a cross feeding movement to the work. Both sets of abutments engage the hoods of the carriers substantially in line with the thrust of the tool on the work, so that the hoods serve two purposes, since they not only protect the parts of the machine from flying chips and oil, but also provide rigid members which extend from the work-carrier heads into the transverse planes of the work where they may be engaged by the abutments as described so as to relieve the bearings for the heads from heavy thrusts or strains.

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

1. In a metal-working machine, a tool-carrier, a rotatable work-carrier, means for pivotally mounting said work-carrier on an axis parallel to its axis of rotation, means for moving said work-carrier about said axis at one speed to bring it in potential working relation to the tool, and mechanism whereby said work-carrier may be moved bodily transversely about said axis at a different speed when in potential working relation to the tool.

2. In a metal-working machine, a tool-carrier, a rotatable work-carrier, a head in which said work-carrier is mounted, means for pivoting said head on an axis substantially parallel to the axis of said work-carrier, means by which cross-feeds or adjustments may be obtained by laterally moving the said head about its axis, and separate means by which said head may be moved about said axis to bring the work in position to be operated upon by said tool.

3. In a metal-working machine, a longitudinally movable tool-carrier, a rotatable work-carrier, a head in which said work-carrier is mounted, means for pivoting said head upon an axis substantially parallel to the axis of the work-carrier so as to oscillate about said pivot, means for longitudinally feeding the tool-carrier for securing length-feeds, and means for oscillating said head about its pivot when it is in potential working position for securing cross-feeds.

4. In a metal-working machine, a tool-carrier, a rotatable work-carrier, a head in which said carrier is mounted, means for pivoting said head upon an axis substantially parallel to the axis of the work-carrier so that said carrier may be oscillated towards and from the tool-carrier, and an abutment for limiting the movement of the head and resisting the thrust of the tool on the work, said abutment being movable to effect a cross-feed of the head and work-carrier.

5. In a metal-working machine, a tool-carrier, a rotatable work-carrier, power-transmitting mechanism, means for permit-

ting said work-carrier to move laterally relatively to the tool-carrier and the power-transmitting mechanism to bring it into coöperative relation to the power-transmitting mechanism and into working relation to the tool, and means for detachably connecting said work-carrier and the power-transmitting mechanism.

6. In a metal-working machine, a tool-carrier, a work-carrier head, a rotatable work-carrier thereon, a driving head, power-transmitting mechanism therein for actuating said work-carrier, said heads being independently movable transversely one with relation to the other, and abutments for determining the positions of said heads with respect to the tool-carrier.

7. In a metal-working machine, a work-carrier head, a rotatable work-carrier thereon, a driving head, power-transmitting mechanism therein for actuating the work-carrier, said heads being separable and independently movable, and means for moving said heads transversely.

8. In a metal-working machine, a work-carrier head, a rotatable work-carrier thereon, a plurality of driving heads, power-transmitting mechanism therein for actuating said work-carrier, said work-carrier head and said driving heads being separable and independently movable, and means for moving the work-carrier head and either of said driving heads transversely relatively to effect a cross-feed of the work.

9. In a metal-working machine, a tool-carrier, a work-carrier head, a rotatable work-carrier thereon, a driving head, power-transmitting mechanism therein for actuating said work-carrier, said heads being independently movable about a common axis, whereby said work-carrier may be moved into and out of operative relation to said driving head, and mechanism for moving said heads in unison about said axis.

10. In a metal-working machine, a tool-carrier, a work-carrier head, a rotatable work-carrier thereon, a driving head, power-transmitting mechanism therein for actuating said work-carrier, said heads being independently movable, power-actuated means for moving said work-carrier head transversely with respect to the driving head to bring it into operative relation to said driving head, and power-actuated means for moving said heads transversely in unison to effect a cross-feed of the work.

11. In a metal-working machine, a tool-carrier, a work-carrier head, a rotatable work-carrier thereon, a driving head, power-transmitting mechanism therein for actuating said work-carrier, said heads being independently movable so that said heads may be moved into and out of operative relation to the tool-carriers, and instrumentalities for moving the tool-carrier longitudinally and for moving said heads transversely to obtain length and cross feeds of the tool and work.

12. In a metal-working machine, a tool-carrier, a work-carrier head, a rotatable work-carrier thereon, a driving head, power-transmitting mechanism contained therein for actuating said work-carrier, said heads being independently movable, a device for connecting said power-transmitting mechanism with said work-carrier, means for moving said work-carrier head into and out of coöperative relation to the driving-head, means for operating said connecting device to connect or disconnect said power-transmitting mechanism to and from said work-carrier, and means for moving said heads laterally in unison relatively to the tool carrier.

13. In a metal-working machine, a plurality of independent work-carrier-driving mechanisms, a plurality of tool-carriers corresponding thereto, a work-carrier, means for moving said work-carrier into registration with each of the driving-mechanisms and the corresponding tool-carrier, and a plurality of abutments or stops for said work-carrier to determine its relation to each tool-carrier.

14. In a metal-working machine, a plurality of independent work-carrier-driving mechanisms, a plurality of tool-carriers corresponding thereto, a work-carrier, means for moving said work-carrier into registration with each of the driving-mechanisms and the corresponding tool-carrier, and means for laterally moving said work-carrier, and the driving mechanism with which it registers, relatively to the tool-carrier.

15. In a metal-working machine, a plurality of tool-carriers and a plurality of work-carrier-driving mechanisms disposed equidistant from a common axis, a work-carrier movable about said axis to register successively with the driving-mechanisms and the corresponding tool-carriers, and means for moving said work-carrier about said axis to secure a cross-feed.

16. In a metal-working machine, a plurality of tool-carriers and a plurality of work-carrier-driving mechanisms disposed equidistant from a common axis, a work-carrier movable about said axis to register successively with the driving-mechanisms and the corresponding tool-carriers, means for longitudinally feeding each of the tool-carriers, and means for transversely feeding said work-carrier about said axis relatively to the tool-carrier with which it is registering.

17. In a metal-working machine, a plurality of tool-carriers and a plurality of work-carrier-driving mechanisms disposed

equidistant from a common axis, a work-carrier movable about said axis to register successively with the driving-mechanisms and the corresponding tool-carriers, and means for transversely moving said work-carrier and the driving-mechanism with which it registers about said axis.

18. In a metal-working machine, a plurality of tool-carriers and a plurality of work-carrier-driving mechanisms disposed equidistant from a common axis, a work-carrier movable about said axis to register successively with the driving-mechanisms and the corresponding tool-carriers, means for moving said work-carrier to register successively with the driving-mechanisms, and a plurality of abutments, one to each tool-carrier, disposed about said axis to engage said work-carrier.

19. In a metal-working machine, a rotatable work-carrier revoluble about an axis, a series of separate driving-mechanisms disposed about said axis and each adapted to drive said work-carrier when it registers therewith, each driving-mechanism comprising variable speed-gearing and a containing head, and a common driving shaft for the variable speed-gearings disposed with its axis coincident with the axis first mentioned.

20. In a metal-working machine, a plurality of tool-carriers, a rotatable work-carrier revoluble about an axis, a series of separate driving-mechanisms disposed about said axis and each adapted to drive said work-carrier when it registers therewith, each driving-mechanism comprising a containing head movable to a limited extent about said axis with said work-carrier.

21. In a metal-working machine, a rotatable work-carrier revoluble about an axis, a series of separate driving-mechanisms disposed about said axis and each adapted to drive the said work-carrier when it registers therewith, each driving-mechanism comprising a containing head, means for revolving said work-carrier successively into registration with said driving-mechanisms, and clutch members and means for operating them to connect said work-carrier to and disconnect it from each of said driving-mechanisms.

22. In a metal-working machine, a series of unequally spaced tool-carriers arranged equidistant from a common center, and laterally and independently movable rotatable work-carriers revoluble about said center to register successively with said tool-carriers.

23. In a metal-working machine, a plurality of separate driving-mechanisms having their work-carrier-driving members equidistant from a common center but unequally spaced therearound, a plurality of similarly disposed tool-carriers, laterally and independently movable rotatable work-carriers revoluble about said center into registration with each of said driving-members, and mechanism for revolving said work-carriers about said center.

24. In a metal-working machine, a plurality of unequally spaced tool-carriers arranged equidistant from a common center, a plurality of laterally and independently movable work-carriers movable about said center to register successively with said tool-carriers, and mechanism for yieldingly moving said work-carriers about said center.

25. In a metal-working machine, a plurality of unequally spaced tool-carriers arranged equidistant from a common center, a plurality of laterally and independently movable work-carriers movable about said center to register successively with said tool carriers, mechanism for yieldingly moving said work-carriers about said center, and stops or abutments so related to the tool-carriers as to cause the registration of the work-carriers therewith.

26. In a metal-working machine, a plurality of separate driving-mechanisms having their work-carrier-driving members equidistant from a common center but unequally spaced therearound, a plurality of similarly disposed tool-carriers, laterally and independently movable rotatable work-carriers revoluble about said center into registration with each of said driving-members, friction mechanism for revolving said work-carriers through arcs of different lengths, and abutments to stop the revolution of said work-carriers.

27. In a metal-working machine, a plurality of unequally spaced tool-carriers equidistant from a common center, and a plurality of laterally and independently movable rotatable work-carriers hung upon a common pivot simultaneously revoluble to cause each work-carrier to register successively with said tool-carriers.

28. In a metal-working machine, a plurality of tool-carriers disposed about a common center, and a plurality of rotary work-carriers revoluble about said center, one of the work-carriers being bodily movable laterally independently of the other work-carriers.

29. In a metal-working machine, a plurality of tool-carriers, a plurality of independent heads movable about a common center, and a rotary work-carrier supported by each head, each head being transversely movable independently of the other heads.

30. In a metal-working machine, a plurality of tool-carriers, a plurality of heads adapted to register successively with said tool-carriers, a rotary work-carrier on each head, means for mounting said heads independently whereby each one may be moved independently of all of the others, and

means for automatically moving said heads relatively to each other.

31. In a metal-working machine, a set of tool-carriers, a set of rotatable work-carriers, movable about an axis to register with the tool carriers, means for independently supporting the work carriers to render them movable transversely independently of each other, and means for simultaneously moving the work carriers about said axis to present them successively to the tool carriers.

32. In a metal-working machine, a set of tool-carriers, a set of rotatable work-carriers, the carriers of one set being movable about an axis to register with the carriers of the other set, means for independently supporting the carriers of said movable set to render them movable transversely independently of each other, means for simultaneously moving the carriers of said set about said axis to present them successively to the carriers of the other set, and means for moving one or more of said independently movable carriers transversely relatively to the corresponding carriers of the other set.

33. In a metal-working machine, a set of tool-carriers, a set of rotatable work-carriers, the carriers of one set being movable about an axis to register successively with the carriers of the other set, means for supporting the carriers of said movable set independently to render them movable transversely independently of each other, means for simultaneously moving the carriers of said set about said axis to present them successively to the carriers of the other set, means for moving one or more of said independently movable carriers relatively to the corresponding carriers of the other set, and means for feeding the carriers of one set longitudinally independently of each other, whereby both length-feeds and cross-feeds are obtained.

34. In a metal-working machine, a set of tool-carriers, a set of rotatable work-carriers, the carriers of one set being movable about an axis to register successively with the carriers of the other set, means for supporting the carriers of one set independently to render them movable transversely independently of each other, means for simultaneously moving the carriers of one set about said axis to present them successively to the carriers of the other set, and an independent abutment for each of the independently movable carriers.

35. In a metal-working machine, a set of tool-carriers, a set of rotatable work-carriers, the said work carriers being movable about an axis to register successively with the tool carriers, means for supporting the work carriers independently to render them movable transversely independently of each other, means for simultaneously moving the work carriers about said axis to present them successively to the tool carriers, means for moving one or more of said independently movable work carriers relatively to the corresponding tool carriers independently of each other, whereby cross-feeds of the tools and the pieces of work are obtained, and means for feeding the tool carriers.

36. In a metal-working machine, a plurality of tool carriers, a plurality of independently movable rotary work-carriers, means for bodily moving said carriers simultaneously about a center, and abutments for positioning said carriers at any predetermined positions.

37. In a metal-working machine, a plurality of tool-carriers, a plurality of work-carriers adapted to register successively with the several tool-carriers, a cam-carrier, a plurality of cams thereon for feeding said tool-carriers independently of each other, and mechanism for oscillating said cam-carrier.

38. In a metal-working machine, a plurality of tool-carriers, a plurality of independently mounted work-carriers adapted to register successively with the tool-carriers, a cam-carrier, cams thereon for moving the tool-carriers independently of each other, cams on said cam-carrier for transversely moving said work-carriers independently of each other, and means for moving the work-carriers to the successive tool-carriers.

39. In a metal-working machine, a set of tool-carriers, a set of work-carriers, the carriers of one set being transversely movable independently of each other, means for moving the carriers of one set successively into registration with the carriers of the other set, and abutments for the independently movable carriers, and means for adjusting said abutments independently.

40. In a metal-working machine, a set of tool-carriers, a set of work-carriers, the carriers of one set being transversely movable independently of each other, means for moving the carriers of one set into registration with the carriers of the other set, and abutment members movable into the paths of the independently movable carriers for the purpose set forth.

41. In a multi-spindle metal-working machine, a plurality of tool-carriers and a plurality of work-carriers arranged successively to register with each other, one set of carriers being transversely movable independently of each other, and a plurality of independently adjustable stop means for each registering position adapted to correct the registration of each of the carriers in each position.

42. In a metal-working machine, a plurality of carriers which are movable transversely with reference to each other, means for moving said carriers transversely to suc-

cessive stations, and means for stopping said carriers at said several stations, comprising a set of stop faces on the carriers and a set of stop faces at the stations, one set of said stop faces consisting of groups, so arranged that each carrier will be accurately positioned at a station by one stop face of one of the groups.

43. In a metal-working machine, a plurality of carriers which are movable transversely with reference to each other, means for moving said carriers transversely to successive stations, means for stopping said carriers at said several stations, comprising a set of stop faces on the carriers and a set of stop faces at the stations, one set of said stop faces consisting of groups, so arranged that each carrier will be accurately positioned at a station by one stop face of one of the groups, and means for permitting the adjustment of each stop face of each group.

44. In a metal-working machine, a set of tool-carriers, a set of work-carriers, the carriers of one set being transversely movable independently of each other, means for moving the carriers of one set successively into registration with the carriers of the other set, independent abutments for the independently movable carriers, said abutments comprising shafts, arms fixed on said shafts adapted to project into the paths of said last-mentioned carriers, arms fixed on said shafts and adapted to be actuated, and mechanism for actuating said last-mentioned arms.

45. In a metal-working machine, a tool-carrier, a work-carrier, means for moving the work-carrier transversely to position it with respect to the tool-carrier, an abutment which limits the movement of the work-carrier and resists the thrust of the tool against the work, and means for moving the abutment to control the cross-feed of the work-carrier.

46. In a metal-working machine, a plurality of fixed tool carriers, a plurality of independently movable work-carriers, means for moving said work-carriers in one direction to register with the tool-carriers successively, a plurality of independent abutments to limit the movement of the work-carriers, and means for actuating said abutments to feed said work-carriers.

47. In a metal-working machine, a plurality of tool-carriers, a movable abutment arranged near each tool carrier, a plurality of independently movable work-carriers, means for moving each work-carrier into engagement with said abutments successively so as to substantially register with the several tool-carriers, and means for imparting independent movements to the abutments to feed said work-carriers transversely to the tool-carriers.

48. In a metal-working machine, a set of tool-carriers, a set of work-carriers, means for moving the carriers of one set to register with the carriers of the other set, and heads in which said work-carriers are mounted, each head having a hood, substantially as set forth.

49. In a metal-working machine, a work-carrier-head, comprising a casing, a spindle journaled in said casing, and having its end projecting through the end thereof, a chuck on the said projecting end of the spindle, and a hood on said head partially inclosing said chuck.

50. In a meal-working machine, a work-carrier-head, comprising a casing, a spindle journaled in said casing, a chuck on the spindle, and lugs or projections extending laterally from said casing by which it may be pivoted to move about an axis.

51. In a metal-working machine, a work-carrying spindle, a head or support in which it its journaled, means for supporting said head to permit it to be moved transversely to said spindle, a cutter for operating on the work, and an abutment arranged to engage said head or support substantially in the lines of the thrust of the cutter on the work to resist said thrust.

52. In a metal-working machine, a work-carrying spindle, a head or support in which it is journaled, means for pivoting said head on an axis parallel to said spindle, a cutter on one side of the plane of said axis and an abutment on the other side of said plane, said abutment being located substantially in line with the thrust of the cutter on the work.

53. In a metal-working machine, a tool, a work-carrying spindle, a head or support in which said spindle is journaled, a hood projecting from the head beyond the work-carrying end of the spindle, and an abutment for engaging the projecting portion of said hood.

54. In a metal-working machine, a tool, a work-carrying spindle, a head or support in which said spindle is journaled, a hood projecting from the head beyond the work-carrying end of the spindle, an abutment for engaging the projecting portion of said hood, and means for moving said abutment into and out of active position.

55. In a metal-working machine, a tool, a work-carrying spindle, a head or support in which said spindle is journaled, a hood projecting from the head beyond the work-carrying end of the spindle, an adjustable projection on said hood, and an abutment for engaging said projection.

56. In a metal-working machine, a plurality of tools, a plurality of independent heads, a rotary work-carrier journaled in each head, a plurality of separate abutments for said heads, and means for moving said abutments into and out of the paths of said heads.

57. In a metal-working machine, a plurality of tools, a plurality of independent heads, a rotary work-carrier journaled in each head, a plurality of separate abutments for said heads, and a plurality of adjustable engaging members on each head equal in number to said abutments, said abutments and members being arranged so that no two abutments engage the same or corresponding members on said heads.

58. In a metal-working machine, a plurality of tools, a plurality of independent heads, a rotary work-carrier journaled in each head, a plurality of separate abutments for said heads arranged in different planes, and a plurality of independently adjustable members on said heads arranged in said planes.

59. In a metal-working machine, a plurality of tools, a plurality of independent heads, a rotary work-carrier journaled in each head, a plurality of separate abutments for said heads, means for pivoting said abutments, and means for swinging said abutments about their pivots into and out of the paths of movement of said heads.

60. In a metal-working machine, a work-carrier, a tool-carrier, a cam for moving one of said carriers, and means for supporting said cam at a distance from its center, a driver, and distributing gearing actuated by said driver for imparting power to said cam at separate points.

61. In a metal-working machine, a work-carrier, a tool-carrier, a cam-carrier for moving one of the first-mentioned carriers, a support for said cam-carrier, distributing shafts and gears to impart power to the cam-carrier at separate points, and means for actuating said distributing shafts.

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

JAMES HARTNESS.

Witnesses:

Marcus B. May,

J. W. Bennett.