963,691.

W. S. DAVENPORT.

METAL WORKING MACHINE.

APPLICATION FILED DEC. 15, 1905.

Patented July 5, 1910.

10 SHEETS—SHEET 1.

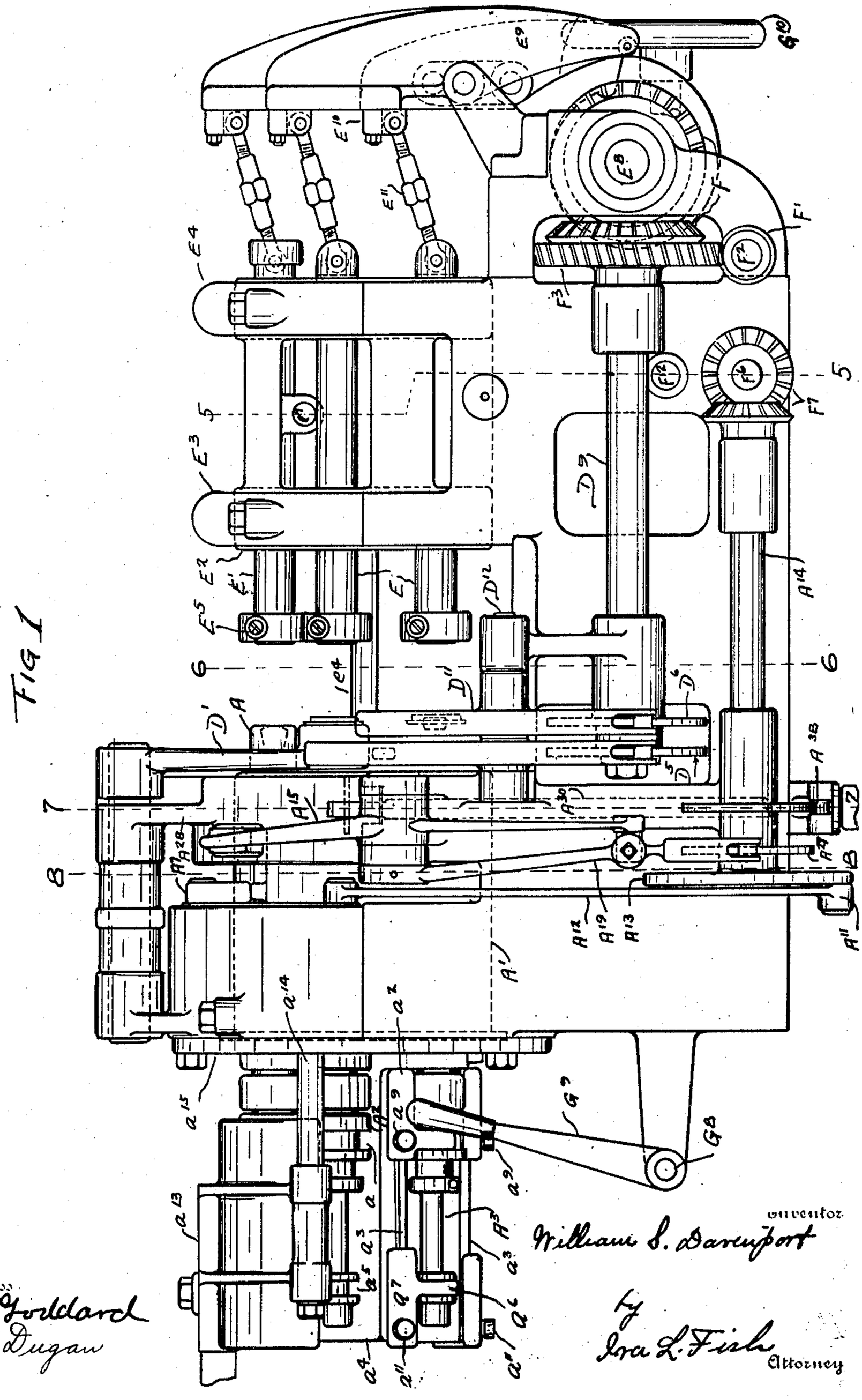

FIG 1

Witness:
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10 SHEETS—SHEET 2.

FIG 2

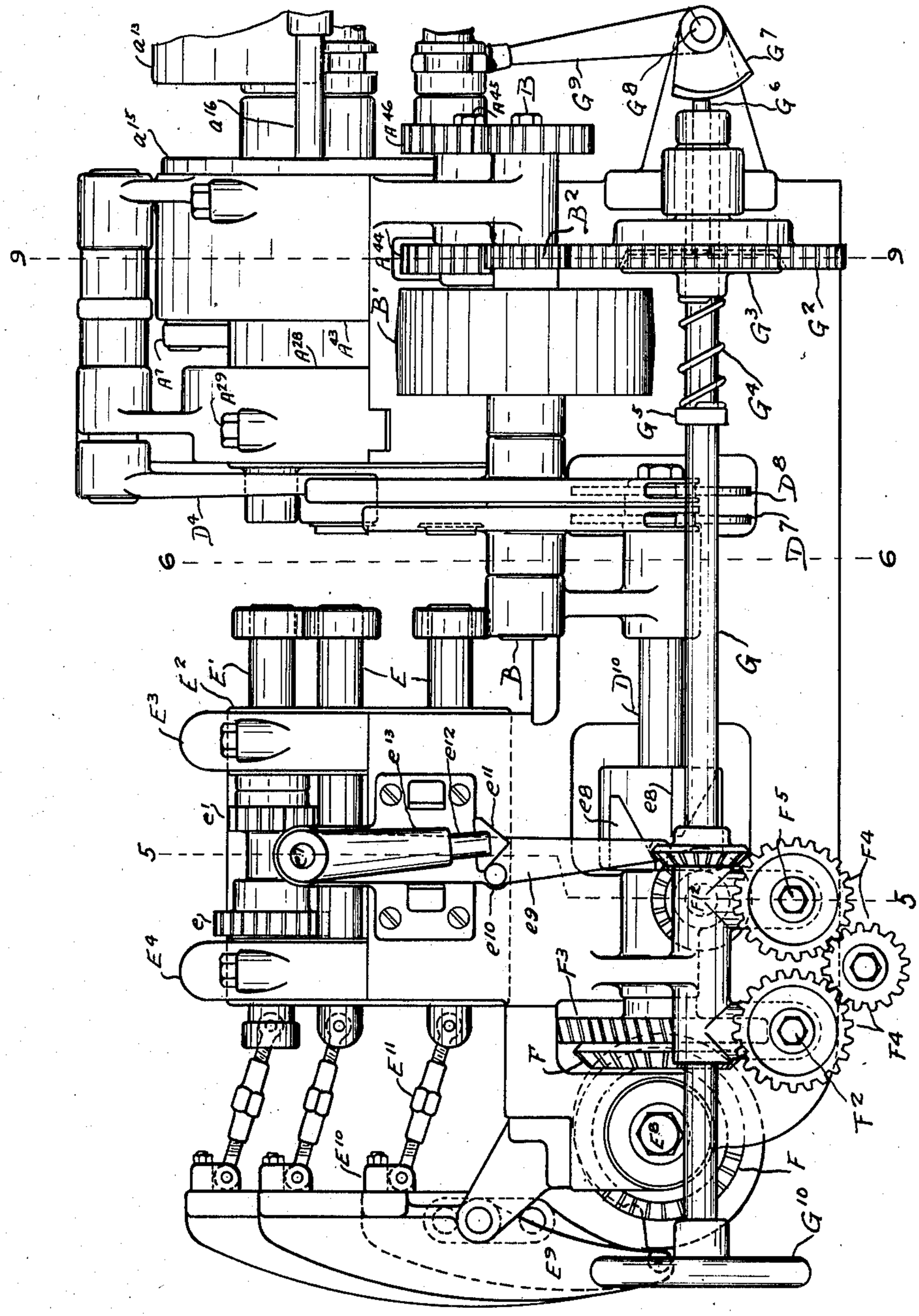

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FIG 3

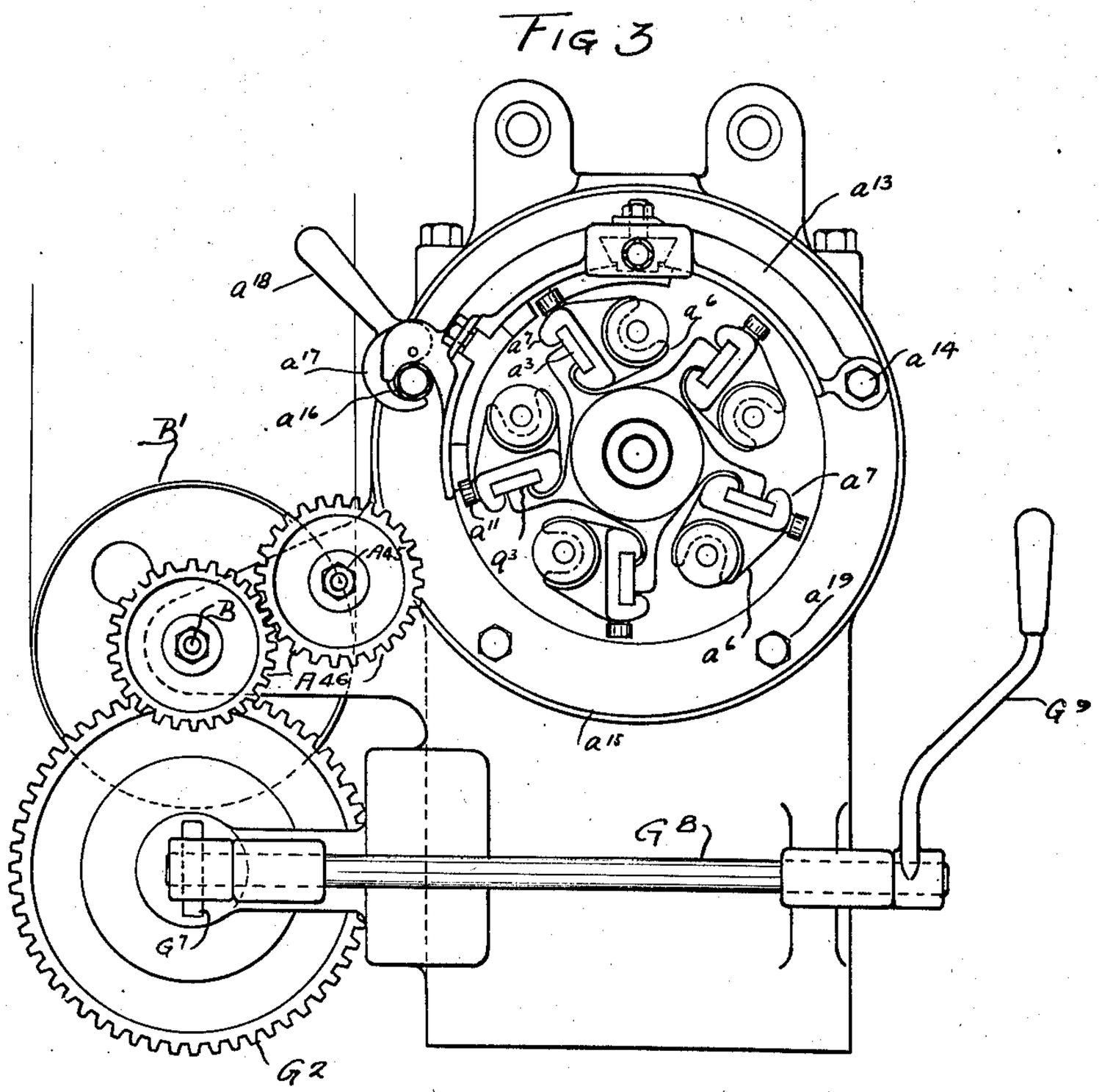

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Fig. 5

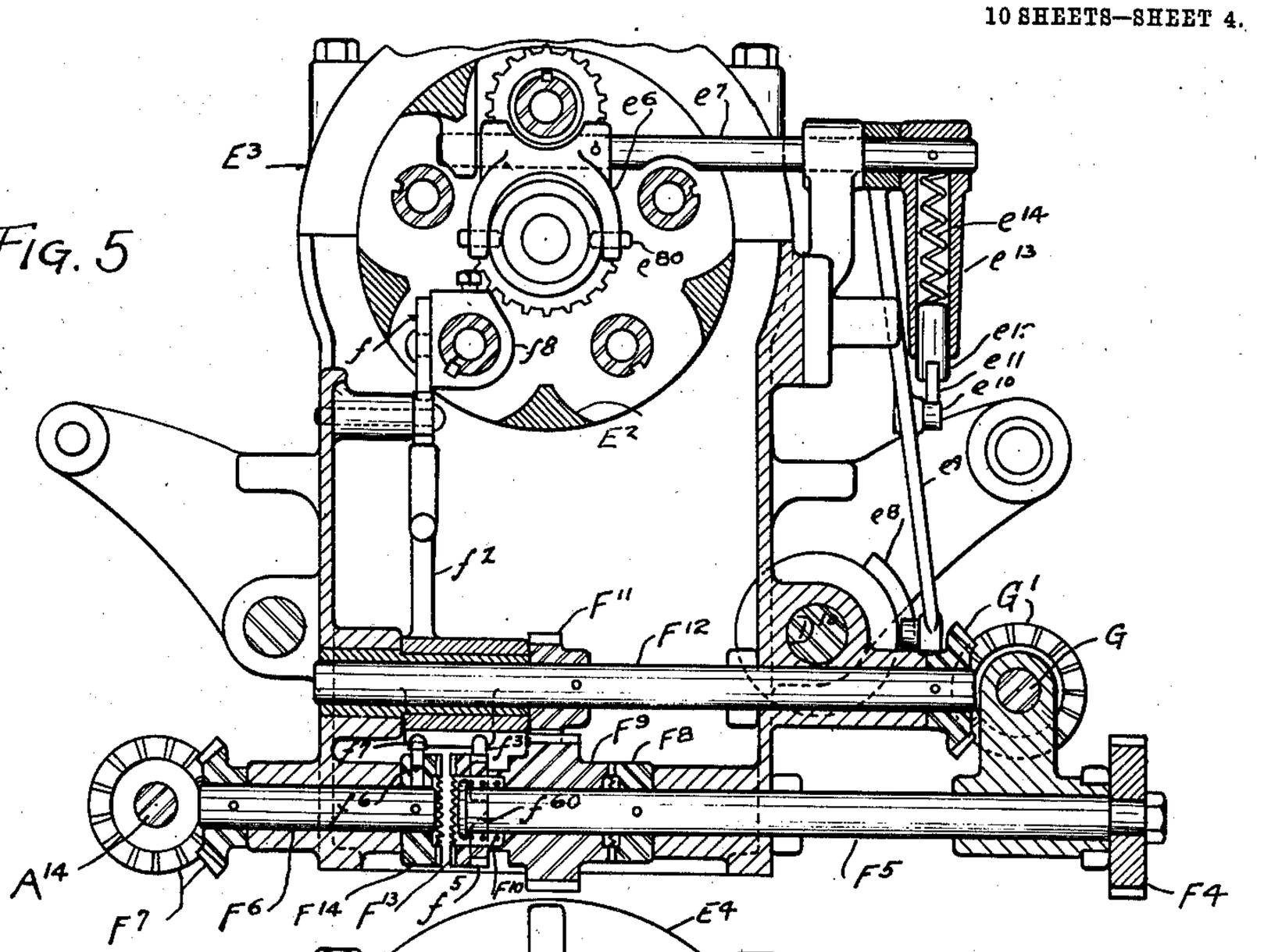
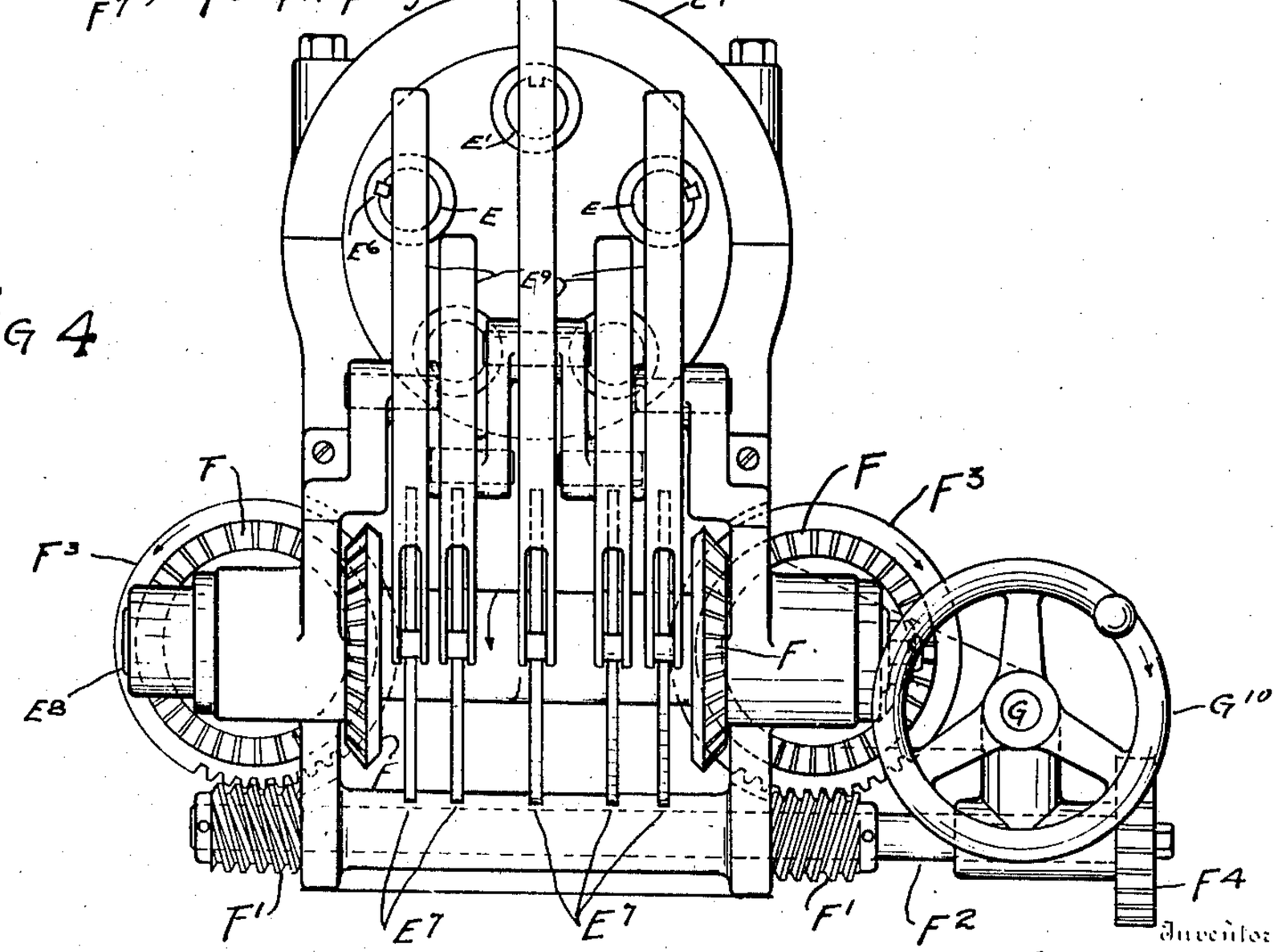


Fig 4



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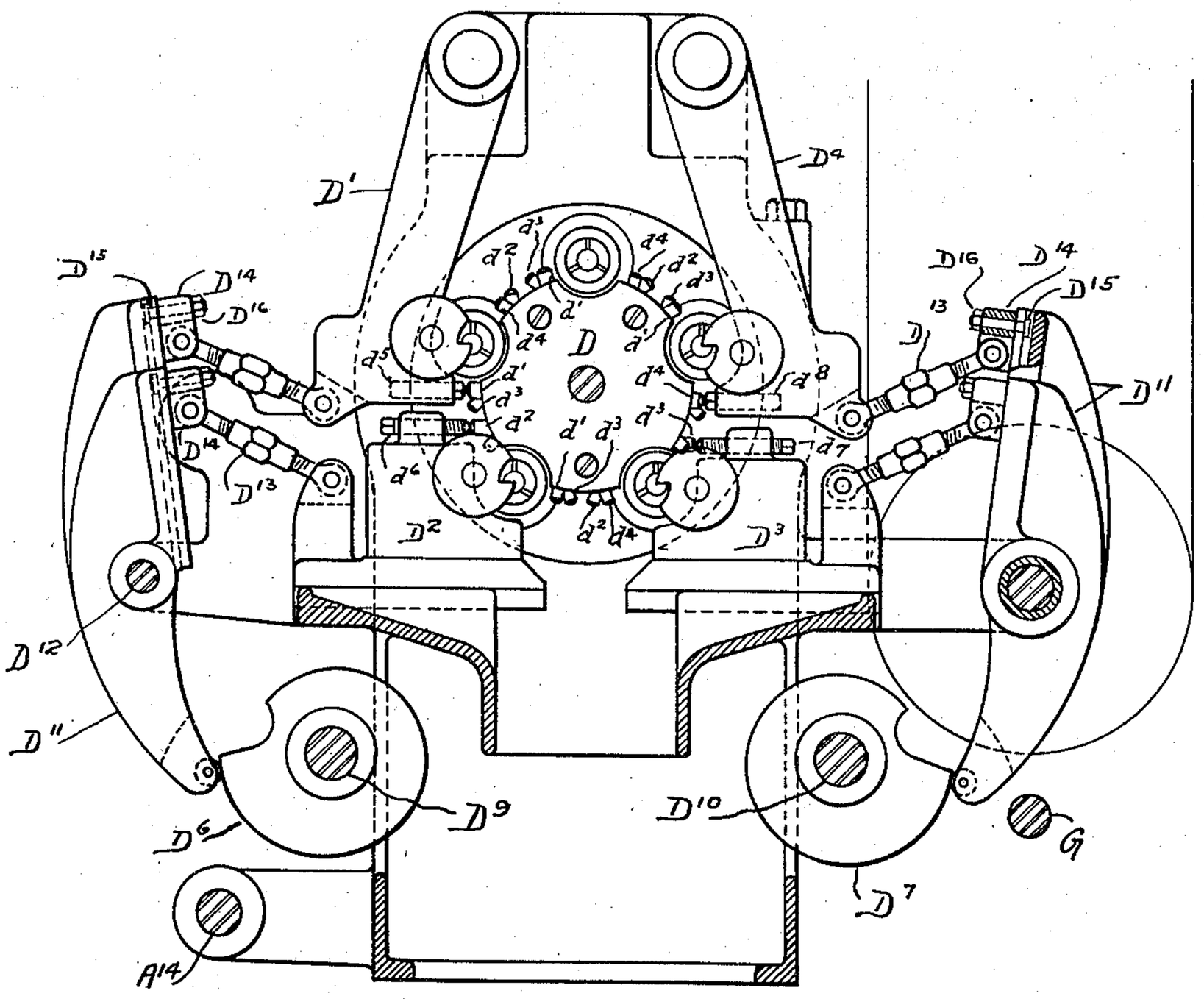

FIG 6

Witness
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10 SHEETS—SHEET 6.

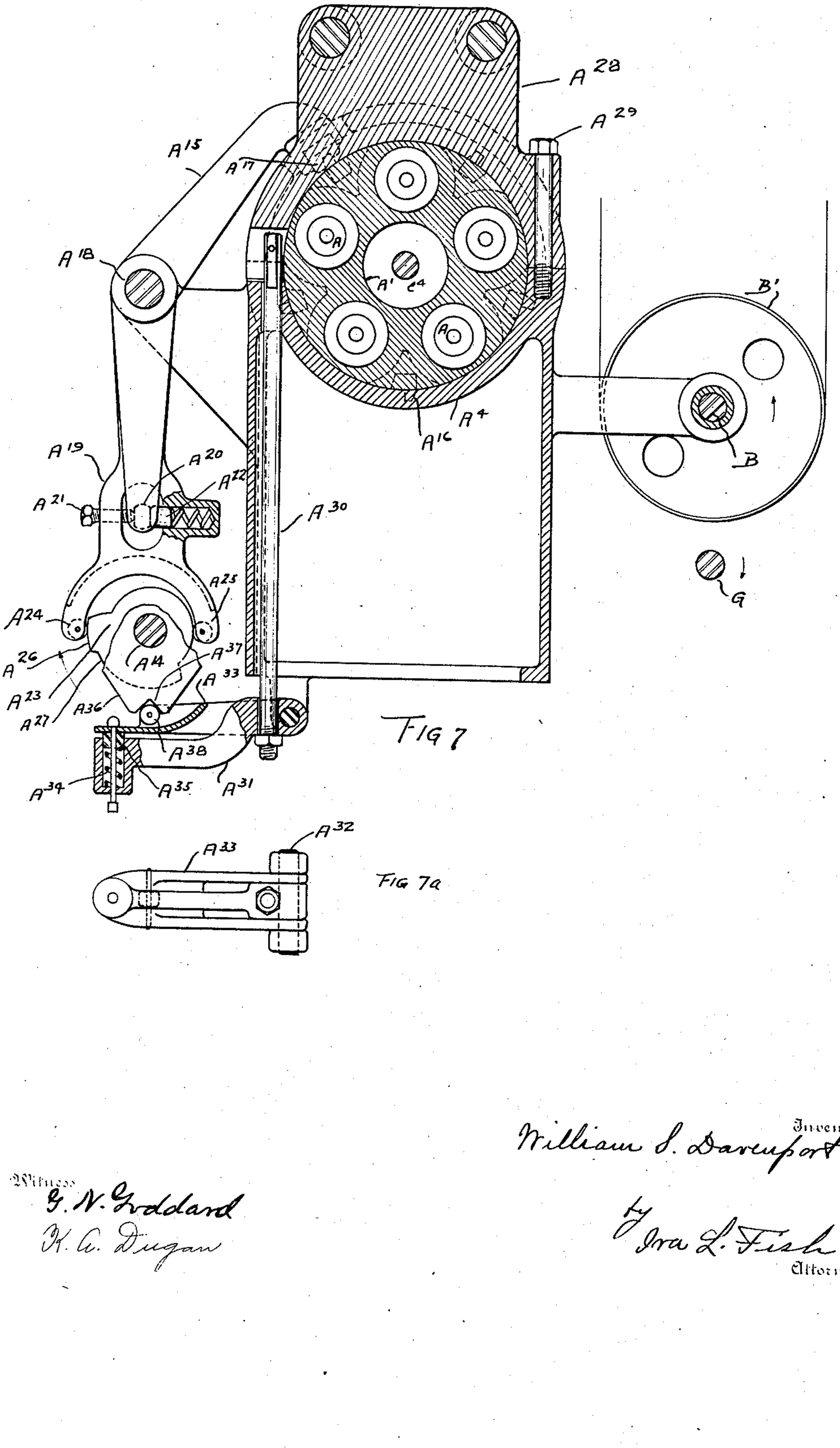

FIG 7

FIG 7a

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10 SHEETS—SHEET 7.

FIG 9

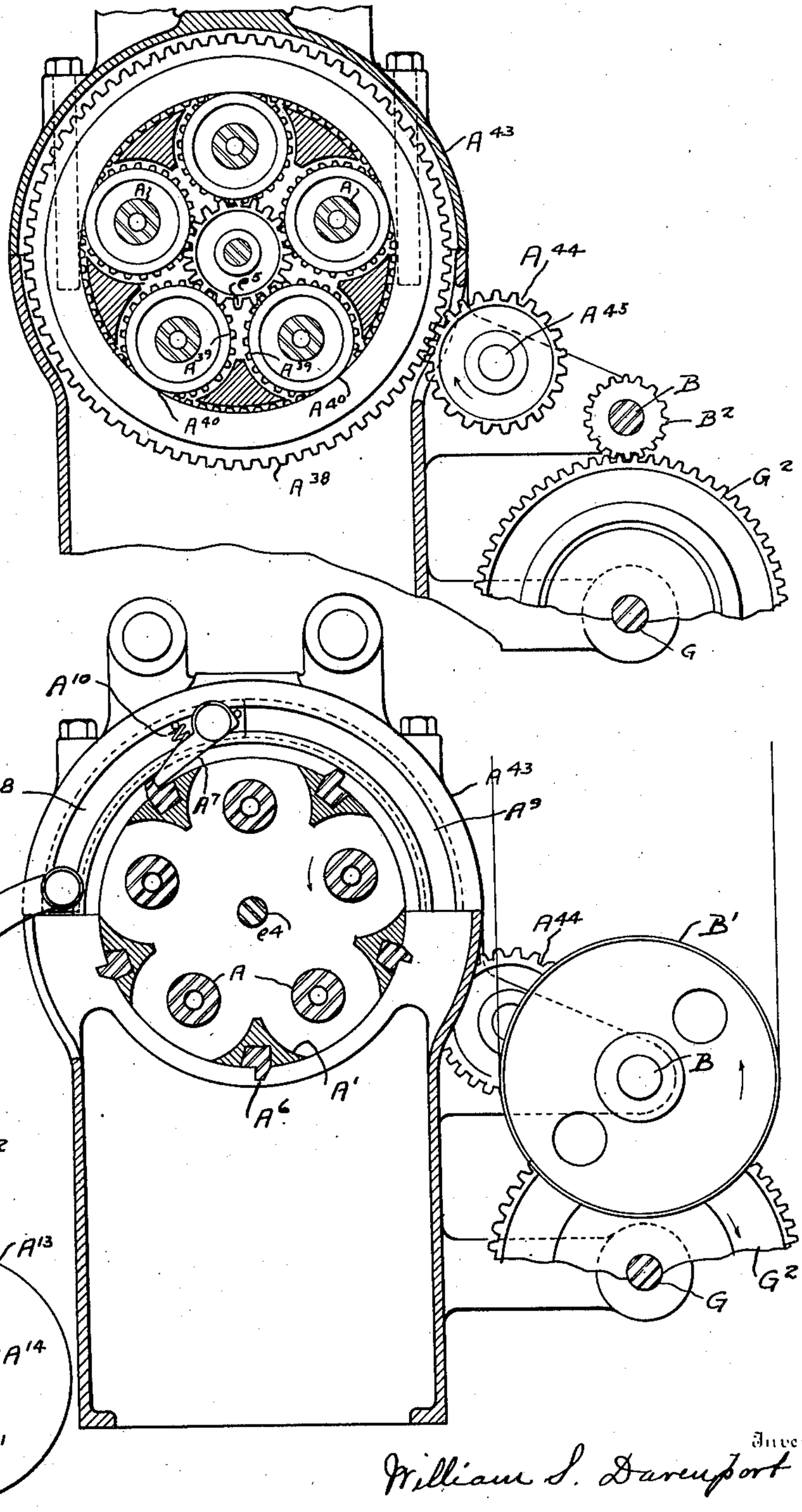

FIG 8

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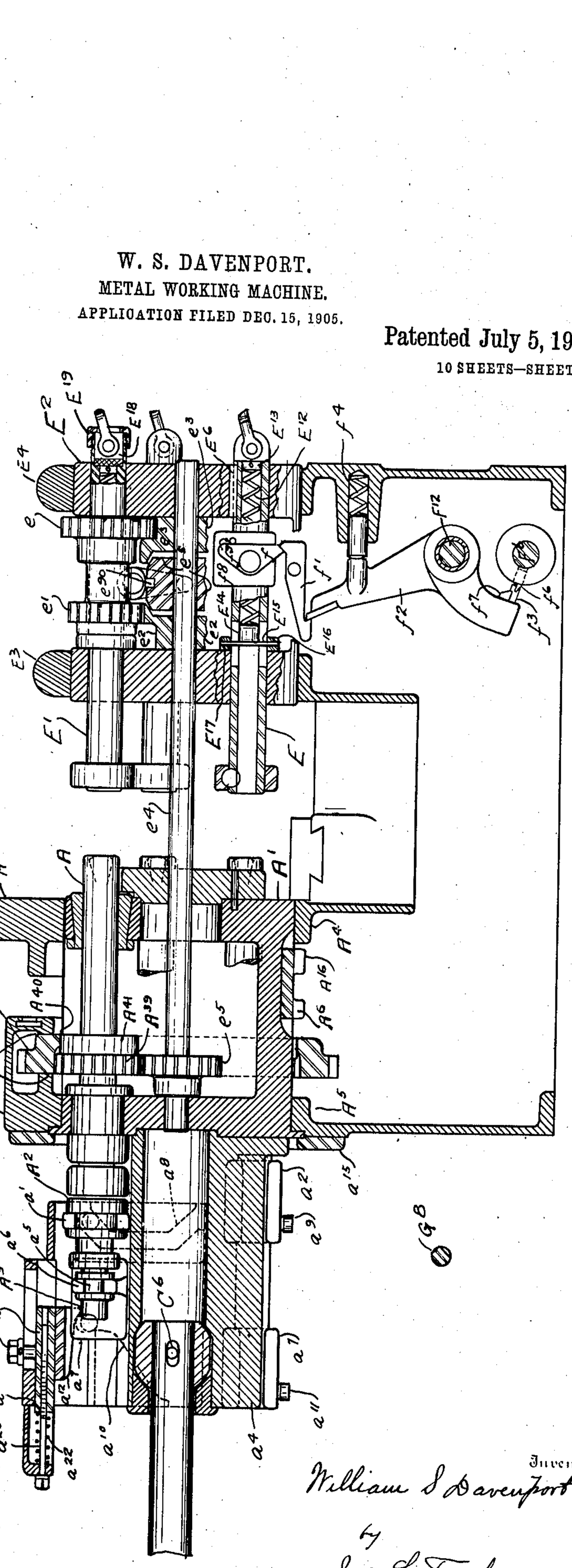
10 SHEETS—SHEET 8.

FIG. 10



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10 SHEETS—SHEET 9.

FIG 12

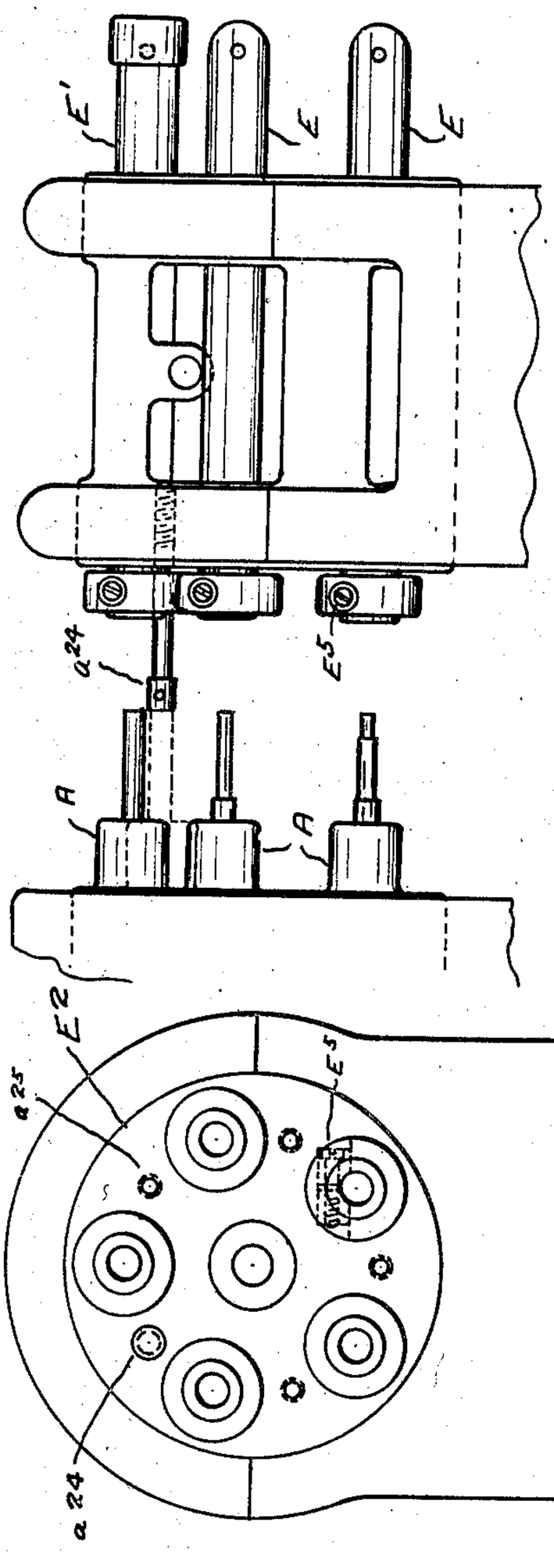

FIG 11

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10 SHEETS—SHEET 10.

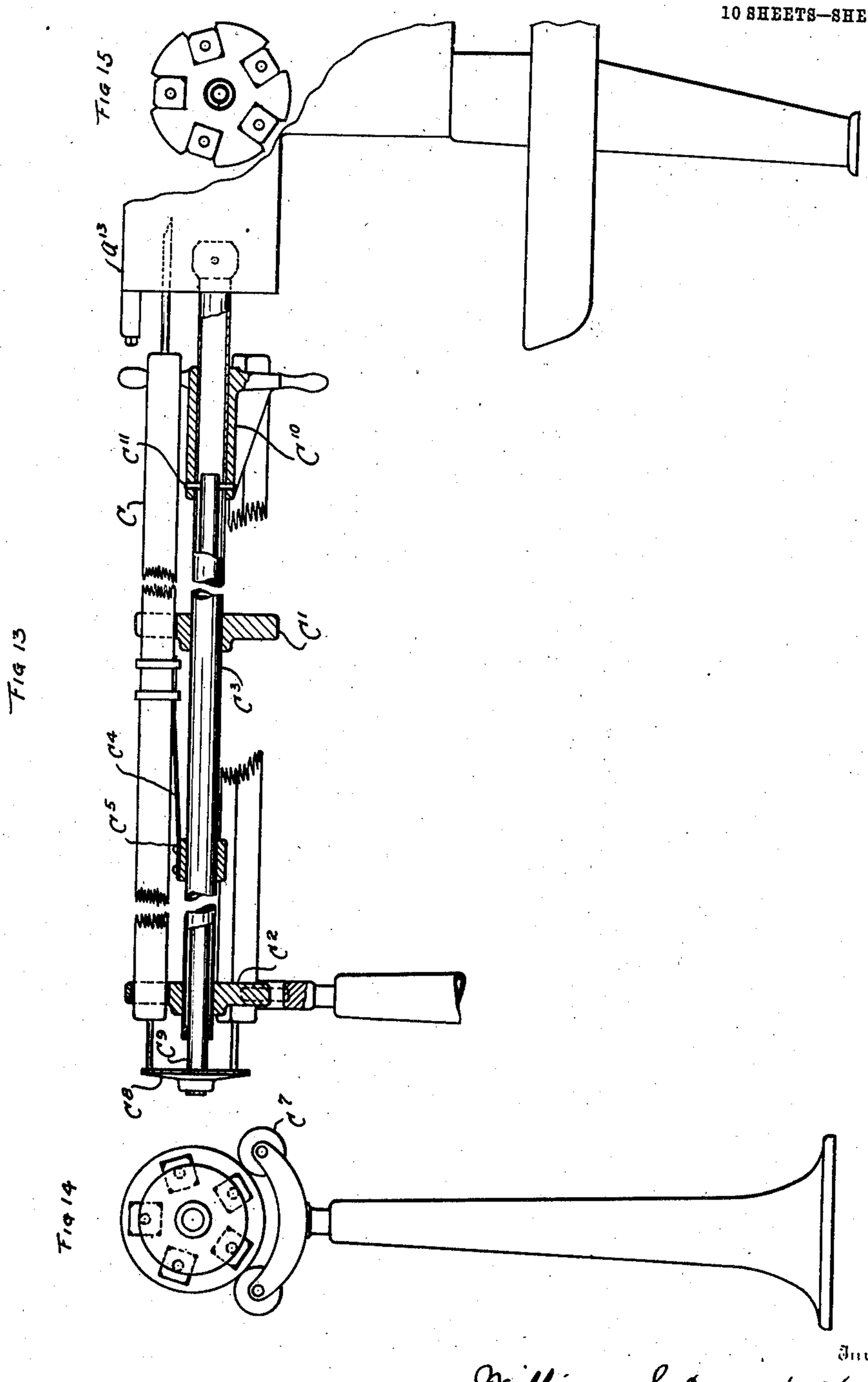

Fig 13

Fig 14

Fig 15

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UNITED STATES PATENT OFFICE.

WILLIAM S. DAVENPORT, OF SPRINGFIELD, MASSACHUSETTS.

METAL-WORKING MACHINE.

963,691. Specification of Letters Patent. Patented July 5, 1910.

Application filed December 15, 1905. Serial No. 291,872.

To all whom it may concern:

Be it known that I, WILLIAM S. DAVENPORT, citizen of the United States, and resident of Springfield, Hampden county, Massachusetts, have invented certain new and useful Improvements in Metal-Working Machines, of which the following is a specification.

The invention relates to that class of metal working machines known as multiple spindle screw machines in which there is a series of work holding spindles which are so arranged with relation to the various cutting tools that the work carried by the different spindles is simultaneously presented to different tools and the work carried by each spindle is presented in succession to each of the cutting tools by successive indexing movements of the work carrying spindles.

The primary object of the present invention is to produce a machine of this type in which the "idle movements" of the machine are eliminated as far as possible or reduced to a minimum, so that the work may be produced at the maximum speed and to also provide a machine in which the different tools may be fed and operated in such manner that each shall work under the conditions requisite for its most efficient and accurate action, thus insuring work of a high degree of excellence.

A further object is to provide for eliminating any possible errors due to inaccuracies in the construction and arrangement of the work carrying spindles which may occur in the manufacture of the machine or may develop by reason of wear so that the accurate duplication of the pieces of work is insured.

In prior machines of the multiple spindle type it has been customary to open the spindle chuck which holds the rod of stock, feed the stock, and then close the chuck before beginning to index the head which carries a series of work spindles. In practicing the present invention the loss of time involved in thus performing these operations is eliminated by opening and closing the spindle chuck and feeding the rod of stock during the indexing of the spindle carrying head. The time consumed in indexing the head and in performing the operations of opening and closing the chuck and feeding the stock, are also reduced to the minimum and at the same time the indexing efficiently and accurately performed by performing the indexing by a crank motion which starts the spindle carrying head slowly, moves it at high speed at the middle of the indexing and brings the head gradually to rest at the end of the indexing.

Heretofore it has been customary to drive the spindles of a multiple spindle screw machine by means of a gear arranged in the center of the spindle carrying head and engaging gears connected with the different spindles, the shaft for the driving gear extending longitudinally of the machine toward the right where it is driven through a pulley connected by a belt with the countershafting. In this construction the pulley is inconveniently arranged and its location, as well as the location of the shaft and gearing, is such as to prevent the arrangement of the other parts of the machine to the best advantage. In practicing my invention I overcome the objections to this construction and arrangement, by driving the work carrying spindles from an annular or ring gear which surrounds and engages all of the spindle gears and is in turn driven by a pinion engaging the gear teeth formed on its outer periphery. The pinion is in turn driven by a system of change gears from a driving pulley arranged at the back of the machine where it does not interfere with the most effective arrangement of other parts of the machine. In embodying this feature of the invention in an efficient and simple construction I provide the annular gear with an inner bearing surface or tread which engages and is supported by the hubs of the spindle gears, the bearing tread for the annular gear and the bearing surfaces of the hubs of the spindle gears coinciding with the respective pitch surfaces of the gears, so that the spindle gears form a roller bearing for the annular gear. By employing change gears for varying the speed of the spindle gear drive, the full belt power is at all times utilized which is not the case where cone pulleys of varying diameters are employed as is the usual practice in multiple spindle screw machines, and thus the desired speed of the spindles can be readily obtained while maintaining a highly efficient drive for the spindles.

In multiple spindle machines a considerable portion of the work of forming the articles being made is done by what are termed "forming tools" which are moved radially toward the center or axis of the work in operating thereon. Since each of the work carrying spindles presents the work carried thereby to each of the radially moving forming tools any variation in the position of the different work carrying spindles with relation to the axis of the spindle carrying head will result in inaccuracies in the work provided the forming tools are moved forward to exactly the same position when operating upon the work carried by different spindles. In constructing a machine it is impracticable to mount the spindles in the spindle carrying head so that they will be exactly equi-distant from the center of the head and so that the distance from center to center of the several spindles will be exactly the same. To overcome any possible inaccuracy in different pieces of work due to any inaccuracy in the mounting of the spindles in the spindle carrying head, I have provided rectifying means for eliminating such inaccuracies and insuring that the pieces produced from the stock carried by the spindles shall be accurate duplicates. The form of rectifying means which I prefer to employ consists of rectifying stops for each of the work carrying spindles against which the tool carriers or some part connected with them abut when the tools are moved into position for finishing the work to size. If a a single cross tool is employed in the machine there will be a single rectifying stop corresponding to each work spindle. These stops may be of any form and may be connected with, or may be secured to, or may be formed on the spindle head in any manner, so that a stop is brought into operative position or relation when the corresponding spindle is brought into operative relation to the tool. These stops will be adjusted or ground so that the cutting edge of the forming tool will be exactly the same distance from the center of each work carrying spindle when the tool is in its advanced position. When the stops have been thus ground or adjusted they remain unaltered unless wear upon the machine requires a change to rectify any inaccuracies developed by such wear. In case there are a number of radially moving or cross tools employed in the machine the number of rectifying stops for each spindle will correspond to the number of cross tools employed.

Another important feature of the machine embodying my invention is the construction and mode of operation which insures the production of good threaded work and also prolongs the life of the dies for cutting the thread. It is desirable that the speed of rotation of the work relative to the cutting tools should be much slower for the threading dies than for other cutting tools, mainly because the chip taking is heavier and also because these tools cannot be as well lubricated. To accomplish this end I rotate the spindles carrying the work in the usual direction for lathe work and rotate the die or tap in the same direction but at a slower speed, preferably at about three-quarters the speed of the spindle, thus making the relative rotation of the spindle with respect to the die about one-fourth the speed of the spindle. In this way a smooth thread is cut and the life of the die is prolonged, the work being done in the same length of time that the other tools are operating, for the reason that the feed of the other tools is much slower per revolution of the spindle. For withdrawing or unscrewing the die or tap at the completion of the threading operation, I rotate the die carrying spindle in the same direction as the work carrying spindle but at a faster speed, preferably at five-fourths of the speed of the spindle the relative speeds being the same as when threading but with the die unscrewing instead of screwing on.

It is important to the commercial success of a machine such as a multiple spindle screw machine that the machine should be adapted to do a large variety of work with the least number of special cams and parts and with as little removal and change of parts as practicable. It is also important that the threading die or tap should follow "the lead" of the screw being cut in order that the thread cutting may be accurately and uniformly performed. In practicing my invention I provide for properly feeding the die or tap to cut a large number of different screw pitches with a single feeding cam by providing connections between the cam and the die carrying slide or spindle which may be adjusted to vary the speed with which the die carrying slide or spindle is advanced by the cam. I also apply this adjustable feature to the connections between the other cutting tools and their feed cams with equally good results in respect to feeding each tool at the speed which is best calculated for the efficient operation of the tool in doing this particular part of the cutting. There is the same advantage in providing such an adjustment between the cams and the cross slides or other tool carrying devices which carry the forming tools and I also provide for such adjustment in connection with these tools. With this adjustment each of these tools can be fed as is best suited to the work to be done by it. The system of adjustable connections between the cams and the tools fed thereby is of even greater advantage in enabling the same set of cams to be employed for various pieces of work and in enabling the changes to be

readily made in changing the machine to produce different pieces of work. In changing from one piece of work to another the connection between each cam and the tool operated thereby is adjusted to give the desired speed to that tool and the change-gearing which determines the speed of rotation of the cam shafts is adjusted to suit the slowest cut or the one requiring the most time to do its work. Thus any piece of work within the range of the machine can be made with a single set of cams and without requiring the removal and replacing of the cams.

Another feature of the invention which contributes to the rapid operation of the machine and the elimination of lost time in effecting the various operations under the varying conditions incident to the use of the machine in doing a large variety of work, is the stopping of the shafts which carry the feed cams during the indexing and the starting of said shafts immediately the indexing is completed. This feature is of especial importance in connection with the use of the same set of cams for doing a variety of work since under such conditions these cams must rotate much faster in doing some classes of work than in doing others, and if the cams are to rotate continuously the part of the cams which would pass the cam roll during the indexing would vary widely. This would result in a loss of time or of length of feed. By stopping the feeding cams at the end of their working rotation and then starting the indexing and then again starting the feed cams at the end of the indexing, the feed cams may be rotated quickly for small pieces of work or slowly for large pieces of work and the whole of their rotation be employed in feeding the tool carriers and at the same time there will be a minimum loss of time for indexing the spindle carrying heads.

In embodying the various features referred to above in a simple and efficient construction I have employed various other features of invention relating more or less to the construction and arrangement of various parts of the machine which, while they are not essential to the broader features of invention, are of importance in contributing to the efficiency and simplicity of the machine.

All the various features of the invention will be understood from the following detailed description of the machine in which I have embodied them and will be set forth in the claims.

The machine in which I have embodied the various features of my invention in the forms in which I prefer to employ them is shown in the accompanying drawings.

In these drawings—Figure 1 is a front side elevation of the machine, certain parts being omitted for the sake of clearness. Fig. 2 is a rear side elevation. Fig. 3 is an end elevation looking toward the right in Fig. 1. Fig. 4 is an end elevation looking toward the left in Fig. 1. Fig. 5 is a section on line 5—5 Fig. 2. Fig. 6 is a section on line 6—6 Fig. 1. Fig. 7 is a section on line 7—7 Fig. 1. Fig. 7ª is a detail of parts shown in Fig. 7. Fig. 8 is a section on line 8—8 Fig. 1. Fig. 9 is a section on line 9—9 Fig. 2. Fig. 10 is a vertical longitudinal section through the center of the machine. Fig. 11 is an end elevation of the tool carrying head. Fig. 12 is a detail side elevation showing the arrangement of the feed stop. Fig. 13 is a side elevation showing the devices for introducing new rods of stock into the work carrying spindles. Fig. 14 is an end elevation looking toward the right in Fig. 13; and Fig. 15 is a detail of parts shown in Fig. 13.

The machine shown in the drawings is constructed to operate simultaneously upon five rods of stock and there is accordingly a series of five work carrying spindles A mounted in the spindle carrying head A′. The work carrying spindles A are provided with the usual chuck jaws which are opened to release the rod of stock and are closed to grasp the rod of stock by the movement of a chuck sleeve A^2 connected to operate the chuck jaws in any well known manner. The spindles are also provided with feeding tubes A^3 which may be of usual and well known construction and which are advanced at the time the chuck jaws are opened to advance the stock and are retracted after the chuck jaws have closed preparatory to the succeeding feeding movement. Since the specific construction of the connections between the clutch sleeve A^2 and the chuck jaws and also the specific construction of the feeding tube is not material to the present invention, and since constructions of this sort are common and well known, the details of these constructions have not been illustrated.

The spindle carrying head A′ is mounted in front and rear bearings A^4 A^5 and is indexed at proper intervals to bring the work carrying spindles successively into position to present the rods of stock to the various tools for operating thereon. The mechanism for indexing the spindle carrying head is best shown in Figs. 8 and 10. As shown in these views the spindle carrying head A′ is provided with a series of projecting teeth or lugs A^6 corresponding in number to the number of spindles carried by the head. Coöperating with these lugs A^6 is an index pawl A^7 pivoted upon a segmental slide A^8 which is mounted in a guideway A^9 formed in the upper front face of the rear bearing A^5. The pawl is forced yieldingly toward the spindle carrying head A′ by a spring A^{10}. The pawl carrying slide A^8 is recip-

rocated at proper intervals to effect the indexing by means of a crank pin A^{11} connected to the slide A^{8} by a connecting rod A^{12}. The crank pin is mounted upon a disk A^{13} carried by a shaft A^{14} which is given a single revolution at suitable intervals. When the shaft A^{14} is rotated through a single revolution, the first half revolution carries the index pawl A^{7} from the position indicated in Fig. 8 into position to engage the next succeeding lug A^{6}. During the last half of the revolution of the shaft A^{14} the index pawl acts to advance the spindle carrying head through one-fifth of a revolution, the index head being started slowly, rotated rapidly through the middle portion of its movement, and then gradually slowed down as the pawl reaches the end of its forward movement. The spindle carrying head may therefore be indexed in a short space of time without shock or jar to the indexing mechanism. At the end of the indexing movement the spindle carrying head should be accurately positioned and locked in position until the next indexing movement is to take place. The spindle carrying head is thus positioned and locked by means of a locking arm A^{15} which coöperates with a series of locking steps or lugs A^{16} secured to the spindle carrying head (Figs. 7 and 10). The locking arm A^{15} is provided at its upper end with a recess for embracing the lugs A^{16} and the rear side of this recess is extended beyond the front side at A^{17} to form a stop which cooperates with the stops A^{16} on the spindle carrying head to prevent any over-rotation of the spindle carrying head at the end of its indexing movement. The locking arm A^{15} is mounted upon a shaft A^{18} and has its lower end connected with an arm A^{19} by means of a lug A^{20} which projects laterally from the arm A^{15} into position between an adjusting screw A^{21} and a spring pressed pin A^{22} which are carried by the arm A^{19} and engage opposite sides of the lug A^{20}. The adjusting screw A^{21} forms a rigid connection between the arm A^{19} and the locking arm A^{15} so that the locking arm is moved positively with the arm A^{19} in a direction to disengage the locking arm from the lugs A^{16}. The spring pressed pin A^{22} on the other hand forms a yielding connection between the locking arm and the operating arm A^{19} for moving the locking arm into position to engage with the lugs A^{16}. The operating arm A^{19} is operated at proper intervals to disengage and then reengage the locking arm A^{15} with the lugs A^{16} by means of a cam A^{23} secured to the intermittent shaft A^{14} and arranged to engage cam rolls A^{24} A^{25} which are mounted in a yoke at the lower end of the arm A^{19} and lie on diametrically opposite sides of the cam A^{23}. When the shaft A^{14} is rotated to effect the indexing the high part A^{26} of the cam A^{23} strikes the roll A^{25} just previous to the beginning of the indexing movement of the spindle carrying head and swings the locking arm A^{15} upward so that the stop A^{17} is out of the path of the lugs A^{16}. After the indexing movement has carried the lug A^{16} past the stop A^{17} the cam roll A^{25} rides on to the lower part A^{27} of the cam A^{23} thus advancing the stop A^{17} on the locking arm into the path of the succeeding stop lug A^{16}. As the indexing is completed the lug A^{16} brings up against the stop A^{17}, thus preventing further movement of the spindle carrying head and just previous to this the high part A^{26} of the cam A^{23} engages the cam roll A^{24} and forces the locking arm A^{15} forward, the connection between the arm A^{19} and the locking arm yielding to allow that part of the locking arm in front of the locking recess to ride on the top of the lug A^{16} until the lug registers with the recess in the locking arm when the locking arm is advanced into the position indicated in Fig. 7 and locks the spindle carrying head in position.

It is desirable that the spindle carrying head be as solid as possible when the tools are cutting, and provision is therefore made for positively clamping the head in its bearing after each indexing so that it is as solid and rigid as if it were a part of the body of the machine. The means for thus clamping the spindle carrying head is shown in Figs. 1 and 7. As shown in these views the cap piece A^{28} forming the upper half of the front bearing for the spindle carrying head, is bolted to the lower half of the bearing at the rear side of the bearing by a bolt A^{29}. During the operation of the cutting tools the front side of the bearing cap is drawn firmly down so that the spindle carrying head is firmly and rigidly clamped in the front bearing. During the indexing the pressure upon the front side of the bearing cap is relieved so that the cap may spring upward sufficiently to release the spindle carrying head, the cap being again forced downward at the end of the indexing operation. The mechanism which I employ for thus operating upon the bearing cap A^{28} consists of a rod A^{30} connected at its upper end to the front side of the bearing cap and connected at its lower end to a lever A^{31} which is mounted upon a pivot A^{32}. A second lever A^{33} is mounted upon the pivot A^{32} and is connected with the lever A^{31} by means of a spring A^{34}. This spring is mounted in a recess in the lever A^{31} and engages a block A^{35} secured to the lever A^{33}. Pressure applied to the lever A^{33} is transmitted through the spring A^{34} to the lever A^{31} so that the bearing cap A^{28} is forced downward with a pressure depending upon the tension of the spring A^{34} at such times as this spring is under tension.

The lever A^{33} is operated to apply and relieve the pressure upon the clamping lever A^{31} by a cam A^{36} secured to the shaft A^{14} and provided with a notch A^{37} within which the roll A^{38} carried by the lever A^{33} normally rests. When the roll A^{38} is in the recess A^{37} the spring A^{34} is under tension and the spindle carrying head is therefore rigidly clamped by the bearing cap A^{28}. During this time the roll A^{38} in connection with the recess A^{37} also acts as a yielding lock for holding the shaft A^{14} in position. When the shaft A^{14} starts, the side of the recess in the cam A^{36} acting against the roll A^{38} forces the lever A^{33} downward until the roll passes out of the recess, after which continued movement of the cam allows the arm A^{33} to move upward, thus relieving the tension upon the spring A^{34} and the pressure upon the bearing cap for the spindle carrying head. As the rotation of the shaft A^{14} is completed at the end of the indexing the roll A^{38} on the lever A^{33} again enters the recess A^{37} locking the shaft A^{14} in position and also maintaining the pressure upon the spring A^{34} so that the spindle carrying head is again firmly locked in position by the bearing cap A^{28}.

The work carrying spindles A are continuously driven during the operation of the machine through an annular or ring gear A^{38} which surrounds a series of gears A^{39} secured to the spindles and is provided with internal gear teeth engaging the gears A^{39}. The annular gear A^{38} is provided with an internal bearing surface A^{40} corresponding to the pitch surface of the internal gear teeth and the annular gear is supported and carried by bearing hubs A^{41} formed on the gears A^{39} which engage the bearing surface A^{40} of the gear and are formed in the pitch surface of the gears A^{39}. The hubs of the gears A^{39} thus form a roller bearing for supporting and centering the annular gear so that the gear runs smoothly and with little loss of power, thus forming a simple and effective driving mechanism for the spindles and one which leaves the space within the spindles unobstructed. The annular gear is held from movement longitudinally of the spindle by bearing surfaces A^{42} formed in the rear bearing cap A^{43} and arranged to engage opposite sides of the annular gear. The annular or ring gear is provided with gear teeth upon its outer periphery and is continuously driven through a gear A^{44} which engages these gear teeth and is secured to a shaft A^{45} arranged back of and parallel to the spindle carrying head (Figs. 2 and 9). The shaft A^{45} is connected by change gears A^{46} with the main driving shaft B of the machine which is continuously driven at a constant speed by a belt passing over a pulley B'. By changing the gears A^{46} the spindle speed may be varied to suit the particular work to be done and the full belt power be utilized under all conditions.

As has already been stated the chuck jaws of the spindles are opened and closed by reciprocating the chuck sleeves A^2 and the feed of the rods of stock is effected by reciprocating the feed tube A^3. In order to eliminate the loss of time incident to the usual method of opening and closing the chuck jaws and feeding the rod of stock, I have provided mechanism for performing these operations during the indexing of the spindle carrying head. While it is not essential to this feature of my invention that the movement of the spindle carrying head be utilized in effecting the opening and closing of the jaws of the chuck and the feed of the rod of stock, yet I prefer to embody this feature of my invention in a construction which thus utilizes the movement of the spindle carrying head on account of the simplicity of the construction which may be used and the efficient and accurate action of such construction. A simple and efficient form of mechanism for thus utilizing the indexing movement of the spindle carrying head is that which I have embodied in the machine which is being described. This mechanism is clearly shown in Figs. 1, 3 and 10. As shown in these figures each chuck sleeve A^2 is provided with an annular groove a which is engaged by the arms of a yoke a' projecting laterally from the chuck slide a^2. The chuck slides a^2 are mounted upon guideways a^3 formed upon a frame a^4 which is secured to the rear end of the spindle carrying head A'. The feed tube is also provided with an annular groove a^5 which is engaged by the arms of a yoke a^6 projecting laterally from a feed slide a^7 which is mounted to slide upon the guideway a^3. The chuck is opened and closed by a stationary cam a^8 arranged to act upon the roll a^9 carried by the chuck slide as the spindle carrying head is indexed. The feed tube slide is advanced to feed the stock during the time that the chuck jaws are open, by a stationary cam a^{10} arranged to act upon the cam roll a^{11} secured to the feed slide and the feed slide is retracted preparatory to the next feeding movement by a second stationary cam a^{12} arranged to act upon the roll a^{11} of the feed slide.

The cams for opening and closing the chuck and for feeding the stock are mounted upon a supporting hood a^{13} which partially surrounds the frame a^4 upon which the chuck and feed slides are mounted and this supporting hood is so connected with the frame of the machine that it may be readily moved to carry the operating cams out of the path of the cam rolls on the feed and chuck slides whenever it is desired to operate the machine without feeding the stock or opening and closing the chuck jaws as

for instance in setting up or adjusting the machine for different pieces of work. Provision is also made for changing the position of the hood to change the timing of the feed of the stock with relation to the cutting tools as is frequently desirable in setting up the machine for different pieces of work. In order that the supporting hood a^{13} may be thus moved or adjusted it is pivoted at one end upon a rod a^{14} which passes through the retaining plate a^{15} for the spindle carrying head A′ and forms one of the bolts for securing said plate to the frame. The other end of the supporting hood is arranged to rest upon a second rod a^{16} which also extends through the retaining plate a^{15} and forms one of the bolts for securing said plate in position. The hood is locked in position by means of a retaining lever a^{17} which is pivoted to the hood and has a lower hooked end arranged to pass beneath the bolt a^{16} and rigidly bind the supporting hood in position. The lever a^{17} is provided with a handle a^{18} by which the hooked end of the lever may be swung from beneath the bolt a^{16} so that the hood may be swung up out of position whenever desired.

With the arrangement of the supporting hood shown in Fig. 3 the chuck operating and feeding cams are supported in position to effect the feeding of the stock as the work carrying spindle moves from the position at the left of Fig. 3 to the position of the upper spindle. If it is desired to effect the feeding of the stock between any other two successive positions of the spindle, the position of the supporting hood may be changed by removing the rods a^{14} and a^{16} and introducing them into the holes occupied by the proper bolts a^{19} for the retaining plate a^{15}, the retaining bolts a^{14} which are removed to enable this adjustment being introduced into the holes from which the rods a^{14} and a^{17} have been removed.

In order that the lengths of stock feed may be varied as desired, the cam a^{12} for retracting the feeding tube is adjustably mounted to vary the extent to which the feeding tube is withdrawn during the indexing movement subsequent to the indexing movement during which the feed of the rod takes place. As shown in Fig. 10 the cam a^{12} is secured upon a slide a^{20} guided in a slot in the hood a^{13} and held in adjusted position by a clamping nut a^{21}. The slide a^{20} is forced forward by a spring a^{22} and its forward position is regulated by an adjusting screw a^{23}. If it is desired to operate the machine without feeding the stock as in setting up, the cam a^{12} may be moved forward to such a position that it will not act upon the cam rolls of the feeding slides and consequently will not withdraw the feeding tubes as the spindle carrying head is indexed. The same result may be effected if desired by removing the cam a^{10} from the hood. As an additional safeguard to insure the feeding of the correct length of stock for the piece being made, I provide a feed stop a^{24} (Figs. 11 and 12) against which the forward end of the rod of stock abuts as the spindle head is rotated and the stock advanced by the feeding mechanism. The feeding stop a^{24} consists of a rod screw threaded in one of a series of holes a^{25} formed in the fixed head for the tool slides or spindles, the position of the stop depending upon the position of the hood carrying the feeding and chuck operating cams.

In using multiple spindle machines it is customary to employ rods of stock all of which are of the same length and it is desirable that new rods of stock may be introduced into the machine in the least possible time after one set of rods has been used up. In order to facilitate the introduction of new rods of stock I have provided a series of stock carrying pipes C which are connected to rotate with the spindle carrying head and are so mounted that the ends of the pipes adjacent to the spindles may be moved radially thus allowing the introduction of the rods of stock at the front ends of the pipes. (Figs. 13–15.) These stock carrying pipes C are mounted in a rack consisting of heads C′ C^2 which are secured to a central shaft C^3, the head C′ being provided with open recesses for receiving the stock pipes, while the head C^2 is provided with closed recesses for retaining the rear ends of the pipes in the head. The pipes are retained yieldingly within the recesses in the head C′ by means of leaf springs C^4 which are secured to a collar C^5 on the shaft C^3 and are connected at their forward ends with the pipes C. By reason of this yielding connection between the pipes and supporting rack, the front ends of the pipes may be moved radially outward so that the rods of stock may be introduced into the front ends of the pipes after which the pipes are returned to position by the springs C^4. The central shaft C^3 of the stock rack is secured to the rear end of the frame a^4 which forms a continuation of the spindle head by a pin and slot connection C^6 as indicated in Fig. 10 so that the stock supporting rack rotates with the spindle head. The rear end of the rack is supported upon rolls C^7 upon which the head C^2 rests as indicated in Figs. 13 and 14.

In order that the rods of stock introduced into the stock pipes may be conveniently advanced through the spindles into proper position to be acted upon by the cutting off tools, the stock carrying rack is provided with a device for engaging the rear ends of the rods of stock and this device is connected with operating devices whereby it may be operated from the front end of the

stock supporting rack which is within convenient reach of the operator. This stock advancing device consists in the construction shown, of a disk C^8 secured to the outer end of a rod C^9 which extends forward through the shaft C^3 which is made hollow to receive it. At its front end the rod C^9 is connected with a sleeve C^{10} by means of a pin C^{11} which extends through the sleeve and rod and plays in slots formed in the hollow shaft C^3. The sleeve C^{10} is mounted upon the shaft C^3 and is provided with a series of handles which may be grasped by the operator in operating the rod and connected stock advancing device C^8.

In introducing new rods of stock into the machine the operator moves the front end of the stock pipe C which corresponds to the spindle whose chuck is open radially outward and introduces a rod of stock into the tube, the end of the rod of stock striking the disk C^8 and forcing it to the left until its movement is arrested as the introduction of the rod of stock is completed. The pipe C is then returned to normal position bringing the front end of the rod of stock into line with the bore of the feeding tube in the corresponding spindle. The slide C^{10} is moved forward by the operator, thus advancing the stock engaging disk C^8 which drives the rod forward into the spindle of the machine through the feed tube and the chuck just far enough so that the cutting off tool will finish the end of the rod of stock. The machine is then turned through a cycle and then another bar of stock inserted in the same manner. After the rods of stock have been thus introduced, the next feed of the stock will result in the production of perfect pieces of work.

By the indexing movements of the spindle carrying head each spindle is presented in succession to tools mounted in carriers arranged to move radially of the work held by the spindles. As indicated in Fig. 6 the machine being described is provided with 4 cross tools and these tools are mounted in 4 carriers D′ D^2 D^3 D^4, the carriers D′ D^4 being pivoted carriers, while the carriers D^2 D^3 are in the form of cross slides arranged in suitable ways in the bed of the machine. Each of the cross tools acts upon the work carried by each of the spindles and if one of the spindles should be so mounted that it is nearer the axis of the spindle head than one or the other of the spindles and the cross tool should be advanced to exactly the same position when operating upon the work carried by each of the two spindles, then the work carried by the spindle which is nearer to the axis of the spindle head would be finished to a larger diameter by the cross tool than would the work carried by the other spindle. The two pieces of work formed from the different rods of stock carried by the two spindles would not therefore be exact duplicates of each other. In other words, slight inaccuracies in the mounting of the spindles would result in inaccuracies in the product of the machine. In order to prevent the occurrence of such inaccuracies due to unavoidable inaccuracies in constructing the machine, or due to inaccuracies which may be developed by reason of unequal wear upon the parts, I have provided a rectifying stop for each spindle corresponding to each cross tool carrier. The rectifying stops for coöperating with the cross tool carrier D′ consist of a series of pins d' projecting radially from the disk D which is secured in the front end of the spindle head. There is a pin d' corresponding to each of the spindles and these pins are so arranged that they are engaged by a coöperating stop d^5 on the tool carrier D′. In building the machine these pins d' are adjusted or ground off so that the cutting edge of the tool carried by the carrier D′ will be exactly the same distance from the center of each spindle when the stop d^5 is pressed against the corresponding pin d'. For instance if the forming tool on the carrier D′ is adjusted so that it will turn the work carrier by one of the spindles about $\frac{1}{4}$ of an inch in diameter when the stop d^5 is in engagement with the corresponding pin d' and it is found that the tool forms the work carried by the succeeding spindle slightly larger in diameter than $\frac{1}{4}$ of an inch when the stop d^5 is in engagement with the corresponding pin d' for the succeeding spindle, then this pin d' is adjusted or ground so that the tool will form the work on this spindle to exactly $\frac{1}{4}$ of an inch in diameter when the stop d^5 is in engagement with the pin. Thus each of the pins is ground or adjusted so that the stock carried by each of the spindles is turned to exactly $\frac{1}{4}$ of an inch by the action of the tool carried by the tool carrier D′. The stop pins d' are then left permanently in this adjustment unless wear upon the machine develops some inaccuracy in which case the pins are readjusted or reground to rectify such inaccuracy.

The rectifying stops for the tool carrier D^2 consist of pins d^2 and are arranged to cooperate with a stop d^6 on the tool carrier. The rectifying stops for the carriers D^3 and D^4 consist of pins d^3 d^4 respectively arranged to coöperate with stops d^7 d^8 on the tool carriers D^3 D^4 respectively.

The stops carried by the tool carriers consist of adjustable screw rods which may be adjusted according to the position which the forming tools should occupy when in advanced or finishing position. The cross tool carriers are operated by a series of cams D^5 D^6 D^7 D^8 secured upon two cam shafts D^9 D^{10} which extend longitudinally at the

front and back of the machine and are driven in unison by mechanism which will be hereinafter described. The cams D^5 D^6 D^7 and D^8 are all of the same form and the devices for connecting the cams with the respective tool carriers are substantial duplicates in construction and mode of operation. A description of the construction and mode of operation of the devices for operating the cross slide D^2 will therefore be sufficient for an understanding of this mechanism.

As shown in Fig. 6 the connections between the cam D^6 and the cross slide D^2 comprise a lever D^{11} which is pivoted at D^{12} and is connected with the cross slide D^2 by a link D^{13}. The link D^{13} is pivoted at one end to the cross slide D^2 and at the other end is pivoted to a block D^{14} secured to the lever D^7. The block D^{14} is connected with the lever D^{11} by means of a bolt D^{15} and nut D^{16}. The bolt passes through the block D^{14} and the head of the bolt lies within a T-shaped slot which extends longitudinally of the upper arm of the lever so that the radial distance of the block D^{14} from the pivot D^{12} of the lever may be varied by sliding the block along the upper arm of the lever and then clamping the block in adjusted position by tightening the nut D^{16}. By means of this adjustable connection between the lever D^{11} and the link D^{13} the speed of the movement imparted to the cross slide D^2 and the distance through which it is moved by the cam D^6 may be varied according to the character of the work being done by the tool carried by the cross slide. The link D^{13} is adjustable in length, being formed of two oppositely screw-threaded rods connected by a turn buckle so that by turning the turn buckle the length of the link may be increased or diminished to bring the tool carried by the cross slide into proper relation with the axis of the work carrying spindle when the tool slide is in its advanced position. The connections between the cam D^6 and the cross slide are adjusted so that the stop d^6 is pressed firmly against the rectifying stops d^2 when the cross slide is in its advanced position and the spring in the connections is sufficient to compensate for any slight variation which there may be in the advance position of the slide when the stop d^6 is in engagement with the different rectifying stops.

By reason of the adjustable connections between the cam D^6 and the cross slide D^2 the same cam may be used for operating different tools and the feed of the tool be regulated according to the requirements of the work being done, with the result that a change from one piece of work to another within the capacity of the machine does not require the removal of the cam D^6 and the replacing of it with another cam suitable for the efficient action of the particular tool to be used and the particular work to be done, as is necessary with the usual construction of screw machines.

The rods of stock carried by the spindles are also presented successively by the spindles in position to be acted upon by cutting tools carried by a series of tool slides or spindles arranged in axial alinement with the work carrying spindles and arranged to move longitudinally of the work. These tool carrying spindles or slides as shown consist of 4 spindles E which do not rotate and a tap or die carrying spindle E′ which is mounted to rotate in a manner to be described, the number of tool carrying spindles thus corresponding in number to the number of work carrying spindles in the spindle carrying head. The tool carrying spindles are mounted in a head E^2 which is rigidly held in bearings E^3 E^4 in alinement with the bearings for the spindle carrying head A. The tool carrying spindles are provided at their forward ends with the usual clamping devices E^5 for retaining the tools in the forward ends of the spindles. The non-rotary spindles E are held from rotation by means of keys E^6 which engage slots formed in the spindles. The spindles are operated by means of a series of cams E^7 secured to a cam shaft E^8 which is geared to and rotates in unison with the cam shafts D^9 D^{10} for the cross tool carriers. The connections between the tool carrying spindles and the operating cams E^7 are the same in construction and mode of operation as the connections between the cross tool carriers and their operating cams. These connections consist of levers E^9 arranged to engage the cams and provided with slots in their upper arms in which are mounted adjustable blocks E^{10} connected by means of adjustable links E^{11} with the rear ends of the tool spindles. The tool spindles are forced rearwardly so as to maintain the cam rolls on the levers in engagement with their cams by means of springs E^{12} mounted within the spindles. These springs are interposed between a plug E^{13} at the rear end of the spindle and a plug E^{14} mounted within the spindle and arranged to engage a pin E^{15} which extends through slots formed in the spindle and is carried by a collar E^{16}. Fig. 10.) The collar E^{16} is loosely mounted on the spindle and is forced against the disk E^{17} which forms the front end of the tool spindle head by the spring E^{12}. In the case of the non-rotary tool spindles E the links E^{11} are pivoted directly to ears formed on the rear end of the spindle. In the case of the rotary spindle E′ the link E^{11} is pivoted to a cylindrical piece E^{18} held within the rear end of the spindle by a collar E^{19} having an inward projecting flange which engages the rear end of the piece E^{18} and retains it within the end of the spindle.

While I have shown but one rotary spindle it will be understood that two or more of the spindles may be rotated if desired.

By reason of the adjustable connections between the tool carrying spindles or slides and the operating cams, the slides or spindles may be advanced at the speed and through the distance requisite for the proper operation of the particular tool carried thereby and the spindles or slides may be operated by the same set of cams in doing the various pieces of work within the capacity of the machine. In the case of the die carrying spindle or spindles the adjustable connections between the spindle and spindle advancing cam enables the feed of the spindle to be adjusted according to the pitch of the screw being cut and the same cam may be employed for cutting the various threads required in doing different pieces of work.

In cutting threads the spindle E′ is rotated in the same direction as the work carrying spindle both during the threading operation and during the running off of the die or tap, the speed of rotation being retarded during one operation and accelerated during the other. With this mode of operation there is no stopping or reversing of either the spindle or die and no violent change of the direction of rotation of any part and thus the threads may be accurately and smoothly cut and the die or tap run off without undue wear or injury to the threading tool and the threading be performed under the most favorable conditions. The mechanism for thus rotating the die carrying spindle E′ is shown in Figs. 2, 5 and 10. As shown in Fig. 10 there are two gears e e' of different diameters secured to the spindle E′ and these gears are engaged by gears e^2 e^3 loosely mounted on a shaft e^4. The shaft e^4 extends longitudinally through the axis of the spindle carrying head A′ and through the tool spindle head E^2 and is connected by a gear e^5 with the spindle gears A^{39}. The shaft e^4 is thus continuously driven through the annular gear A^{38} and the spindle gears. Either one or the other of the gears e^2 e^3 may be connected with the shaft e^4 by means of the clutch e^5 keyed to rotate with the shaft e^4 and provided with clutch faces arranged to engage corresponding clutch faces on the gears e^2 e^3. When the clutch e^5 is in engagement with the gear e^3 the die carrying spindle will be rotated in the same direction as the work carrying spindles but at a slower speed and when the clutch is in engagement with the gear e^2 the die carrying spindle will be rotated in the same direction as the work carrying spindle but at a faster speed. In cutting right handed threads the die spindle E′ is rotated in the same direction as the work carrying spindle and at a slower speed during the threading and is rotated in the same direction and at a higher speed during the unthreading. In cutting left handed threads the relative speeds would be the reverse, that is to say during the threading operation the die carrying spindle would rotate in the same direction as the work carrying spindle and at a higher speed and during the unthreading operation would rotate in the same direction as the work carrying spindle but at a slower speed. The clutch e^5 is shifted at the proper intervals to throw the gears e^3 and e^2 into and out of operation through the movement of a yoke e^6 which is secured to a rock shaft e^7 and is provided with pins e^{80} engaging an annular groove e^{90} in the clutch. The rock shaft e^7 is operated by cams e^8 secured to a cam drum carried by the cam shaft D^{10} on which the cams for the cross tools are mounted. The connections between the cams e^8 and the rock shaft e^7 consist of a lever e^9 pivoted upon a rock shaft and provided at its lower end with a cam roll which is acted upon by the cams e^8. The lever e^9 is provided with a pin e^{10} arranged to engage one side or the other of a V-shaped plate e^{11}. The plate e^{11} is formed on the lower end of a rod e^{12} which is mounted in an arm e^{13} secured to the rock shaft e^7 the rod being forced downward by a spring e^{14}. By this construction when the lever e^9 is moved toward the right in Fig. 2 for instance the pin e^{10} acts against the side of the V-shaped plate e^{11} forcing the pin e^{12} upward against the tension of the spring e^{14} until the pin e^{10} passes the point of the V. During this time the clutch will remain in engagement with the gear e^2. As soon as the pin e^{10} passes the point of the V the downward pressure of the spring will force the V-shaped plate e^{11} downward and the right side of the V acting against the pin e^{10} will cause the arm e^{13} to be suddenly shifted toward the left, thus disengaging the clutch from the gear e^2 and engaging it with the gear e^3. When the lever e^9 is shifted in the opposite direction the same action will take place except that the arm e^{13} will be suddenly shifted toward the right as the pin e^{10} passes the point of the V, thus disengaging the clutch from the gear e^3 and reëngaging it with the gear e^2, the parts being then in the position shown in Fig. 2.

In order to avoid the loss of time which would result from continuously rotating the cam shafts for effecting the feeding of the cutting tools, I have provided mechanism for stopping the rotation of the cam shafts at the beginning of the indexing of the spindle head and then starting the cam shafts again at the end of the indexing. The form of mechanism which I prefer to employ for this purpose is shown in Figs. 1, 2, 4, 5 and 10. The cam shafts D^9 D^{10} which carry the cams for the cross tool carriers and the cam shaft E^8 which carries the

cams for operating the tool carrying spindles or slides, are connected together by bevel gears F so that the shafts rotate in unison and these shafts are driven through worms F′ secured to a worm shaft F^2 and engaging worm wheels F^3 which are secured to the cam shafts D^9 D^{10}. The worm shaft F^2 is driven through a system of change gears F^4 from a shaft F^5. The shaft F^5 extends transversely of the machine and is in alinement with a shaft F^6 which is connected by bevel gears F^7 with the index shaft A^{14}. During the operation of the cutting tools the shaft F^5 is continuously rotated and drives the cam shafts through the gearing described, the speed of the cam shafts being varied to suit the requirements of the work being done by means of the change gears F^4. The mechanism for driving the shaft F^5 consists of a clutch member F^8 secured to the shaft and engaged by a clutch member on a gear F^9 which is loosely mounted on the shaft F^5 and is held in engagement with the clutch member F^8 by a spring F^{10}. The gear F^9 is engaged and continuously driven by a pinion F^{11} secured to a continuously rotating shaft F^{12}. The gear F^9 is provided with a second clutch member F^{13} arranged to engage a clutch member F^{14} secured to the shaft F^6 when the gear F^9 is shifted to disengage it from the clutch F^8. The clutch gear F^9 is shifted to disengage it from the clutch F^8 and thus stop the rotation of the cam shafts and to engage it with the clutch member F^{14} and thus throw the indexing mechanism into operation by a mechanism which is controlled from one of the tool slides. The devices for throwing the driving mechanism for the cam shafts out of operation and throwing the driving mechanism for the indexing mechanism into operation, are shown in Figs. 5 and 10. During the operation of the cutting tools the clutch gear F^9 is held in engagement with the clutch member F^8 by the spring F^{10}. As the operation of the cutting tools is completed a trip *f* carried by one of the tool spindles E operates a latch *f′* and releases a spring pressed lever f^2. The lever f^2 carries at its lower end a pin f^3 and when the lever is released the spring f^4 rocks said lever on its pivot carrying the pin f^3 into an annular groove f^5 which is formed in the periphery of the clutch member F^{13}. The clutch member F^{13} is provided with a cam f^{60} which projects across the annular groove f^5 and extends to the rear side of the clutch member. When the pin f^3 enters the groove f^5 it is brought into the path of the cam f^{60} and when this cam in its rotation rides against the pin f^3 it acts to force the clutch gear F^9 toward the left in Fig. 5, against the tension of the spring F^{10}, thus disengaging the clutch gear from the clutch member F^8 and engaging the clutch member F^{13} with the clutch member F^{14} thus throwing the indexing mechanism into operation. As the clutch member F^{13} engages the clutch member F^{14} the pin f^3 moves forward so that it engages the rear side of the clutch member F^{13}, thus retaining the clutch member in engagement with the clutch member F^{14}. The shaft F^6 and the index shaft F^{14} now continue to rotate until they have made a single revolution. As they complete this revolution a projecting finger f^6 on the clutch member F^{14} acts against a finger f^7 on the lever f^2 forcing the lever back and carrying the pin f^3 out of engagement with the rear side of the clutch member F^{13} so that the clutch member and gear F^9 are returned by the spring F^{10} into engagement with the clutch member F^9 thus stopping the rotation of the index shaft and starting up the cam shafts. When the lever f^2 is thus swung back against the tension of its spring by the fingers f^6 f^7 its upper end is engaged by the latch *f′* and the lever is retained in this position until it is again released by the action of the trip *f* on the succeeding return movement of the tool slide or spindle E. The trip *f* is pivoted to a block f^8 secured to the spindle E and normally rests against a stop pin f^9. When the tool slide is advanced the trip *f* will ride over the end of the latch *f′*, the trip swinging on its pivot so that the latch is unaffected. On the return movement of the tool spindle however, the pin f^9 prevents the swinging movement of the trip in the opposite direction so that it will act against the latch *f′* and release the arm f^2.

The shaft F^{12} through which the cam shafts and the indexing mechanism are driven, is continuously rotated from a shaft G arranged at the back of the machine and connected with the shaft F^{12} by bevel gears G′. The shaft G is driven from the main driving shaft B through a pinion B^2 which engages a gear G^2 which may be connected and disconnected with the shaft G at the will of the operator through a clutch G^3. The clutch G^3 is normally held in engagement with the gear G^2 so that the parts driven from the shaft G are operated from the driving shaft by means of a spring G^4 interposed between the clutch G^3 and a collar G^5 on the shaft G. The clutch G^3 may be disengaged to throw the shaft G out of action at the will of the operator by means of a rod G^6 engaging the clutch and arranged to be operated upon by a cam G^7 which is secured to a rock shaft G^8 extending transversely of the machine and provided at its front end with an operating handle G^9. When the operating handle G^9 is thrown into the position indicated in Fig. 2 the cam G^7 will act upon the rod G^6 forcing the clutch G^3 out of engagement with

the gear G^2 so that the rotation of the shaft G from the driving shaft will be stopped, the cam retaining the clutch in this position until the operator swings the handle G^9 toward the right in Fig. 2. When the clutch is thus disconnected the shaft G may be rotated by hand through a hand wheel G^{10}.

The general operation of the machine will be readily understood from the previous description and is briefly as follows. Assuming that the cutting tools have completed their operating movement and have been returned to their retracted or rear positions, the driving mechanism for the cam shafts will be thrown out of operation and the indexing mechanism started. The index shaft will now make a single revolution during which the spindle carrying head will be unclamped and unlocked and turned through $\frac{1}{5}$ of a revolution. During this movement of the spindle carrying head the rod of stock from which the completed article was severed just previous to the indexing will be fed forward preparatory to the forming of a new piece of work from the stock carried by this spindle. This movement of the spindle carrying head will also bring the rods of stock carried by the other spindles into position to be operated upon by a new set of cutting tools. As the indexing movement of the spindle carrying head is completed the head will be clamped and locked in position and the driving mechanism for the cam shafts will be thrown into operation, the indexing mechanism being stopped just previous to the starting of the cam shafts. The various cutting tools will now be fed forward by their respective cams and then retracted to their rear positions when the same cycle of operations will be again repeated. Thus for each indexing movement of the spindle carrying head a piece of work will be completed and a rod of stock will be fed forward in position to be acted upon by the various cutting tools between the subsequent indexing movements of the spindle carrying head.

While I prefer to employ the construction and arrangement of the various mechanisms embodying the features of my invention in the form in which I have shown them in the accompanying drawings, it will be understood that various changes and modifications in the specific construction of the parts and in the specific construction and arrangement of the various mechanisms may be made without departing from my invention.

Without attempting to set forth in detail the various constructions and arrangements in which the features of invention may be embodied, what I claim and desire to secure by Letters Patent is:—

1. The combination of a spindle carrying head, a plurality of spindles mounted therein provided with stock feeding and chuck operating devices, mechanism for indexing the spindle head, and operating mechanism for the feeding and chuck operating devices arranged to be engaged by said devices during the movement of a spindle from one indexed position to the next succeeding indexed position and operating to open the chuck and effect the feed during said movement.

2. The combination of a spindle carrying head, a plurality of spindles mounted therein, indexing mechanism for the spindle head, feeding devices acting to engage the stock, and operating mechanism constructed and arranged to actuate the feeding devices during the indexing of the spindle head.

3. The combination of a spindle carrying head, a plurality of spindles mounted therein provided with chuck opening and closing devices, indexing mechanism for the spindle head, and operating mechanism for the chuck opening and closing devices arranged to be engaged with said devices during the movement of a spindle from one indexed position to the next succeeding indexed position and operating to open the chuck during said movement.

4. The combination of a spindle carrying head, a plurality of spindles mounted therein provided with stock feeding devices, stationary operating cams for the stock feeding devices, and indexing mechanism for the spindle head.

5. The combination of a spindle carrying head, a plurality of spindles mounted therein provided with chuck opening and closing devices, stationary operating cams arranged to engage with the chuck opening and closing devices of each spindle during the movement of the spindle from one index position to the next succeeding indexed position and indexing mechanism for the spindle head.

6. The combination of a spindle carrying head, a plurality of spindles mounted therein provided with stock feeding and chuck operating devices, stationary operating cams for the feeding and chuck operating devices, and indexing mechanism for the spindle head.

7. The combination of a movable spindle carrying head, a plurality of spindles mounted therein provided with feed tubes, a stationary advancing cam for the feed tubes, and an adjustable stationary cam for retracting the feed tubes.

8. The combination of a spindle carrying head, a plurality of spindles mounted therein provided with stock feeding devices, indexing mechanism for the spindle head, operating mechanism for the stock feeding devices arranged to be engaged by said devices during the movement of a spindle from

one indexing position to the next succeeding indexed position and operating to effect the feed during the said movement.

9. The combination of a spindle carrying head, a plurality of spindles mounted therein provided with feed tubes, a slide frame secured to the spindle head, slides mounted on the frame and connected with the feed tubes, stationary operating cams for the slides, and mechanism for indexing the spindle head.

10. The combination of a spindle carrying head, a plurality of spindles mounted therein provided with feed tubes and chuck sleeves, a slide frame secured to the spindle head, slides mounted on the frame and connected with the feed tubes and chuck sleeves, stationary operating cams for the slides, and mechanism for indexing the spindle head.

11. The combination of a spindle carrying head, a plurality of spindles mounted therein and provided with stock feeding devices, mechanism for operating said feeding devices having provision for changing from one indexing position to another at the will of the operator, and mechanism for indexing the spindle head.

12. The combination of a spindle carrying head, a plurality of spindles mounted therein, and provided with stock feeding devices, stationary operating cams for the feeding devices, devices for supporting said cams in different positions about the spindles, and mechanism for indexing the spindle head.

13. The combination of a spindle carrying head, a plurality of spindles mounted therein, and provided with stock feeding devices, stationary operating cams for the feeding devices, a supporting hood for said cams, means for securing said hood in different positions circumferentially about the spindles, and mechanism for indexing the spindle head.

14. The combination of a spindle carrying head, a plurality of spindles mounted therein and provided with stock feeding devices, stationary operating cams for said feeding devices, a support for the cams movable to carry the cams out of and into operative position, and mechanism for indexing the spindle head.

15. The combination of a spindle carrying head, a plurality of spindles mounted therein and provided with chuck operating devices, mechanism for operating said devices having provision for changing the point where the chuck is opened and closed during the indexing of the spindle head, and mechanism for indexing the spindle head.

16. The combination of a spindle carrying head, a plurality of spindles mounted therein provided with chuck operating devices, stationary operating cams for the chuck operating devices, a supporting hood for said cams, means for securing said hood in different positions circumferentially about the spindles, and mechanism for indexing the spindle head.

17. The combination of a movable spindle carrying head, a plurality of spindles mounted therein provided with stock feeding and chuck operating devices, stationary operating cams for said devices, and a pivoted hood carrying said cams.

18. The combination of a spindle carrying head, a plurality of spindles mounted therein, gears connected with the spindles and provided with bearing hubs, an annular driving gear surrounding and engaging the spindle gears and provided with a bearing surface engaging and supported by the bearing hubs.

19. The combination of a spindle carrying head, a plurality of spindles mounted therein, indexing mechanism for the spindle head, a locking arm provided with a positioning stop and a locking stop, coöperating positioning and locking stops on the spindle head and mechanism for moving the arm to disengage the stops in advance of the indexing, moving the arm partially inward during the indexing to bring the positioning stop into the path of the coöperating stop and completing the inward movement of the arm to interlock the stops on the arm and head at the end of the indexing.

20. The combination of a spindle carrying head, a plurality of spindles mounted therein, indexing mechanism for the spindle head, a locking arm provided with a locking recess, a series of coöperating lugs on the spindle head, an inwardly projecting stop shoulder at the rear side of the locking recess, and an operating cam for the locking arm having two throws for moving the arm into stopping and then locking position.

21. The combination of a spindle carrying head, a contractible bearing therefor, a plurality of spindles mounted in the head, indexing mechanism for the spindle head, and mechanism for contracting said spindle head bearing to clamp the head between indexing movements.

22. The combination of a spindle carrying head, a plurality of spindles mounted therein, indexing mechanism for the spindle head, a bearing for the head provided with a bearing cap, and mechanism for applying pressure to one side of the bearing cap between indexings and relieving said pressure during indexings.

23. The combination of a spindle carrying head, a plurality of spindles mounted therein, indexing mechanism for the head, a bearing for the head provided with a bearing cap, means for securing the cap at one side, a lever connected with the other side of the bearing, and a cam for operating the lever.

24. The combination of a spindle carrying

head, a plurality of spindles mounted therein, a stock carrying rack connected to rotate with the spindle head, stock carrying pipes mounted in the rack and radially movable at the spindle end.

25. The combination of a spindle carrying head, a plurality of spindles mounted therein, a stock carrying rack connected to rotate with the spindle head, stock carrying pipes mounted in the rack and radially movable at the spindle end, a rod advancing device arranged to engage the rear end of the rods, and an operating device therefor at the spindle end of the rack.

26. The combination of a spindle carrying head, a plurality of spindles mounted therein, a stock carrying rack provided with a central shaft connected with the spindle head, heads secured to said shaft, radially movable stock carrying tubes mounted in said heads, and means for yieldingly holding said stock tubes from radial movement at the spindle end.

27. The combination of a spindle carrying head, a plurality of spindles mounted therein, a stock carrying rack provided with a central hollow shaft connected with the spindle head, heads secured to said shaft, stock carrying tubes mounted in said heads and radially movable at the spindle end, a rod extending through said hollow shaft, a stock engaging device at the other end of the rod, and one or more operating handles connected to the front end of the rod.

28. The combination of a spindle carrying head, a plurality of spindles mounted therein, a cross tool carrier to which the spindles are successively presented, and a rectifying stop corresponding to each spindle for determining the advanced position of the tool.

29. The combination of a spindle carrying head, a plurality of spindles mounted therein, a plurality of cross tool carriers, and a rectifying stop for each spindle corresponding to each cross tool carrier.

30. The combination of a spindle carrying head, a plurality of spindles mounted therein, a cross tool carrier, a rectifying stop for each spindle, and an adjustable stop on the tool carrier for coöperating with the rectifying stops.

31. The combination of a spindle carrying head, a plurality of spindles mounted therein, a plurality of cross tool carriers, a rectifying stop for each spindle corresponding to each tool carrier, and an adjustable stop on each tool carrier for coöperating with the corresponding series of rectifying stops.

32. The combination of a spindle carrying head, a plurality of spindles mounted therein, a cross tool carrier, a rectifying stop on the spindle head for each spindle, and a cooperating stop on the tool carrier.

33. The combination with a plurality of work spindles of a plurality of tool carrier, an operating cam for advancing each tool carrier, and connections between each cam and its tool carrier adjustable to vary the speed with which the carrier is moved by the cam and adjustable to vary the point to which the carrier is advanced with any given speed.

34. The combination with the work spindle, of a tool carrier, a cam for advancing the tool carrier, a lever operated by the cam, a block mounted on the lever for adjustment toward and from its pivot, and a link adjustable in length connecting the block and tool carrier.

35. The combination of a spindle head, a plurality of spindles mounted therein, indexing mechanism therefor, tool carriers, operating devices therefor, and mechanism for stopping the operating devices for the tool carriers during the indexing.

36. The combination of a spindle head, a plurality of spindles mounted therein, tool carriers, cams and connections for operating the tool carriers, indexing mechanism and means for stopping the cams during the indexing.

37. The combination of a spindle head, a plurality of spindles mounted therein, tool carriers, cams and connections for operating the tool carriers, driving mechanism for the cams, indexing mechanism, and mechanism for throwing the cam driving mechanism out of operation and the indexing mechanism into operation.

38. The combination of a spindle head, a plurality of spindles mounted therein, tool carriers, cams and connections for operating the tool carriers, driving mechanism for the cams, indexing mechanism, mechanism for throwing the cam driving mechanism out of operation and the indexing mechanism into operation, and for throwing the indexing mechanism out of operation and the cam-driving mechanism into operation.

39. The combination of a spindle head, a plurality of spindles mounted therein, tool carriers, cams and connections for operating the tool carriers, mechanism controlled by the indexing mechanism for stopping the indexing mechanism and starting the cams, and mechanism controlled by the cam operating mechanism for stopping the cams and starting the indexing mechanism.

40. The combination of a spindle head, a plurality of spindles mounted therein, indexing mechanism, tool carriers, cams for operating the tool carriers, driving mechanism for the cams, a trip on a tool carrier, devices controlled by the trip for disconnecting the cam driving mechanism and starting the indexing mechanism, and devices on the indexing mechanism for controlling the stopping of the indexing mechanism and the reconnecting of the cam driving mechanism.

41. The combination of a spindle carrying

head, a plurality of work spindles mounted therein, a cross tool carrier to which the spindles are successively presented, rectifying devices constructed and arranged to so limit the advance of the tool as to bring it into the same relation to each of the spindles.

42. The combination of a spindle carrying head, a plurality of spindles mounted therein, gears mounted on the spindles, an annular gear surrounding and engaging said gears and coöperating bearing surfaces on the annular gear and spindles.

43. The combination of a spindle carrying head, a plurality of spindles mounted therein, gears mounted on the spindles, bearing devices on the spindles having their surfaces in the pitch surface of the gear, an annular gear surrounding and engaging said gears and a bearing surface on the gear engaging the bearing surface on the spindles.

44. The combination of a spindle carrying head, a plurality of spindles mounted therein, gears mounted on the spindles, an annular gear surrounding and engaging said gears, and provided with a bearing surface in the pitch surface of the gear and cooperating bearing devices having their bearing surfaces in the pitch surfaces of the gears on the spindles.

In witness whereof, I have hereunto set my hand, this 6th day of December, 1905.

WILLIAM S. DAVENPORT.

In the presence of—
FRANK MANSUR,
GEORGE D. HAYDEN.