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P. J. DELAY.

ROLLING MILL FOR MANUFACTURING ROUND BARS, &c.

No. 594,333. Patented Nov. 23, 1897.

Fig. 1.

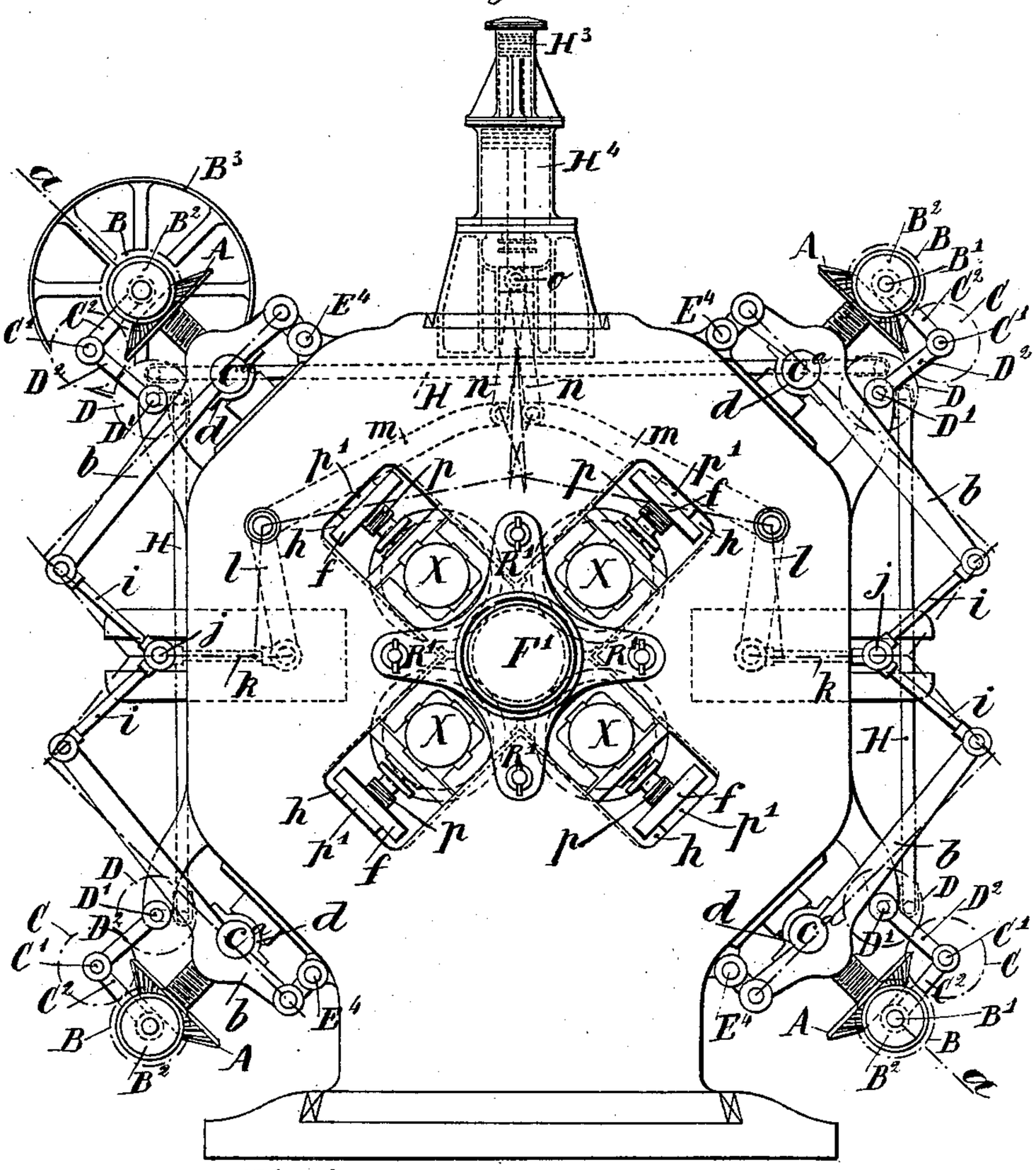


Fig. 4.

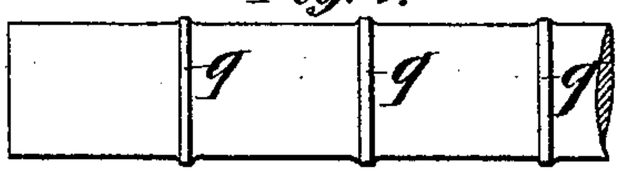


Fig. 5.

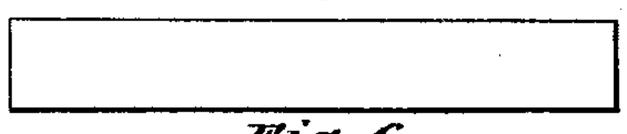


Fig. 6.

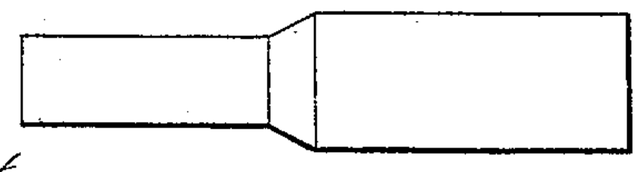


Fig. 7.

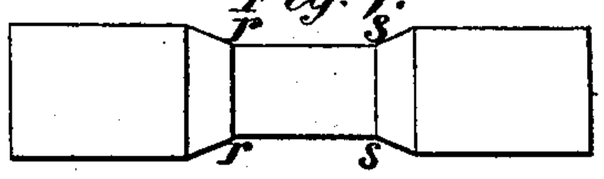


Fig. 8.

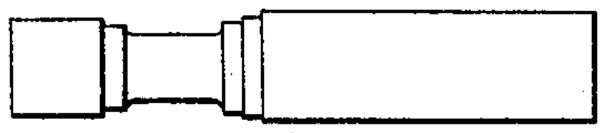
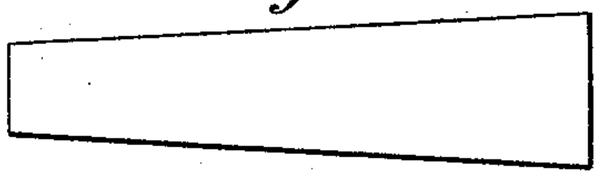


Fig. 9.



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ROLLING MILL FOR MANUFACTURING ROUND BARS, &c.

No. 594,333. Patented Nov. 23, 1897.

Fig. 1a.

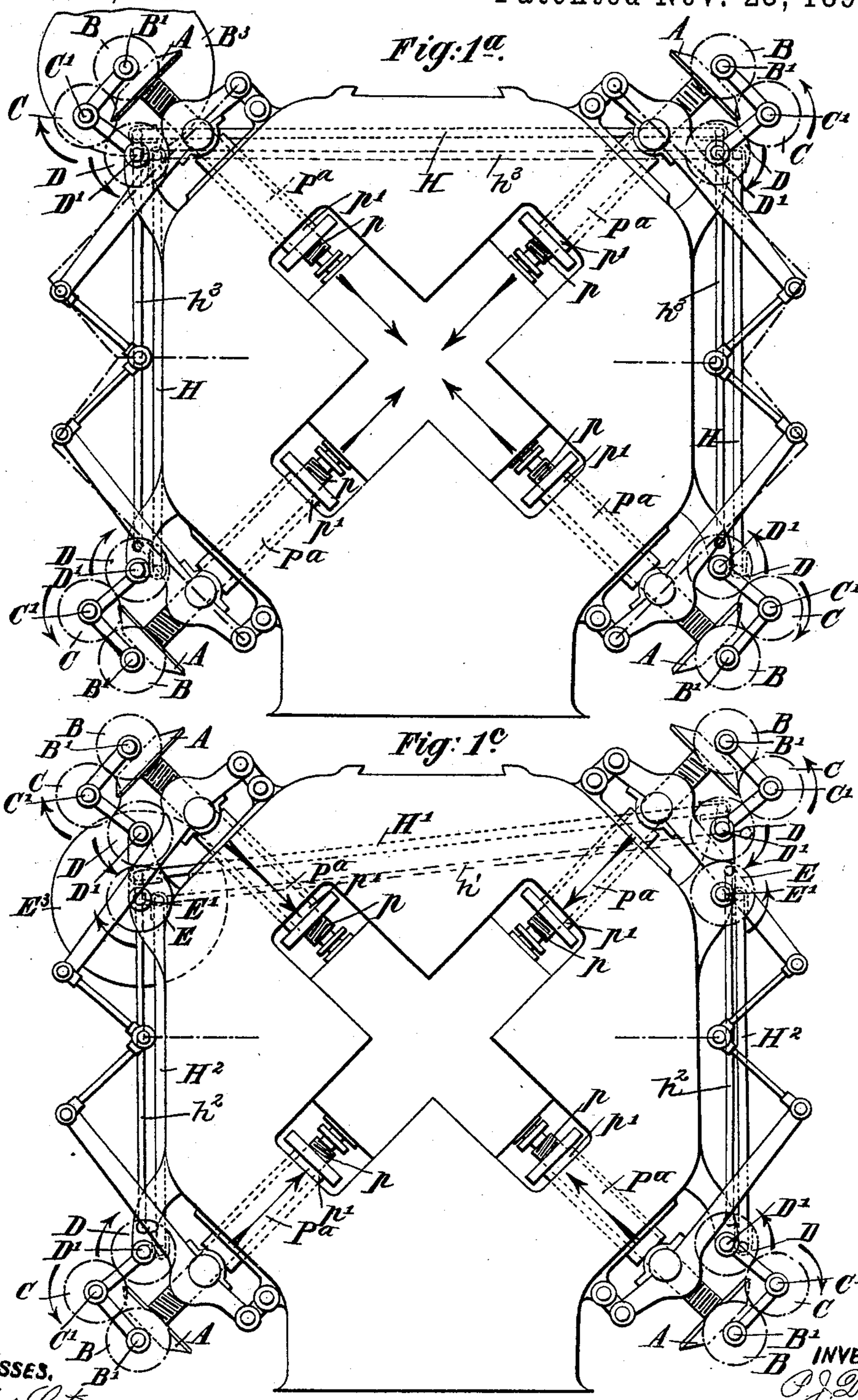

Fig. 1c.

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ROLLING MILL FOR MANUFACTURING ROUND BARS, &c.

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Fig: 1b.

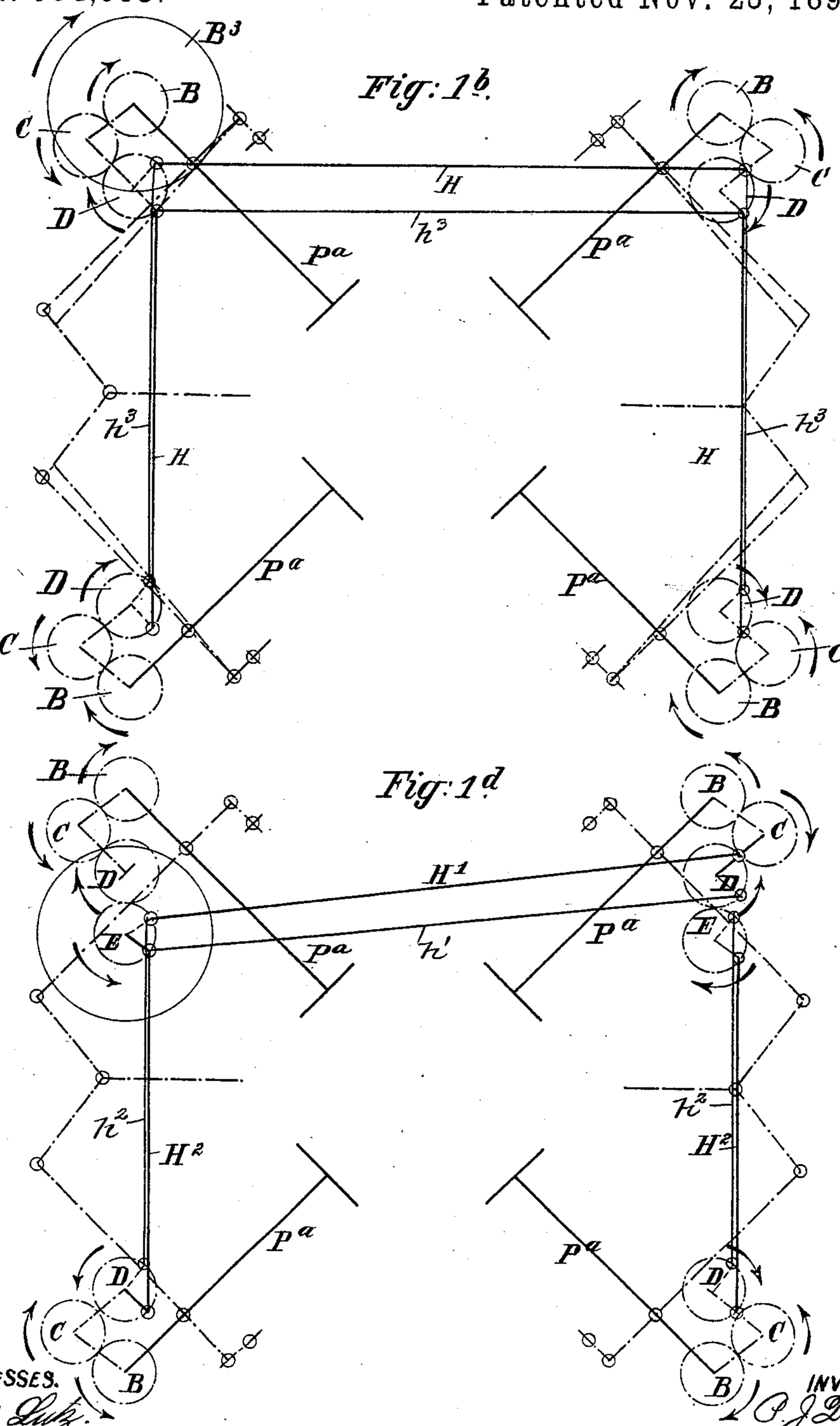

Fig: 1d.

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ROLLING MILL FOR MANUFACTURING ROUND BARS, &c.

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Fig. 2.

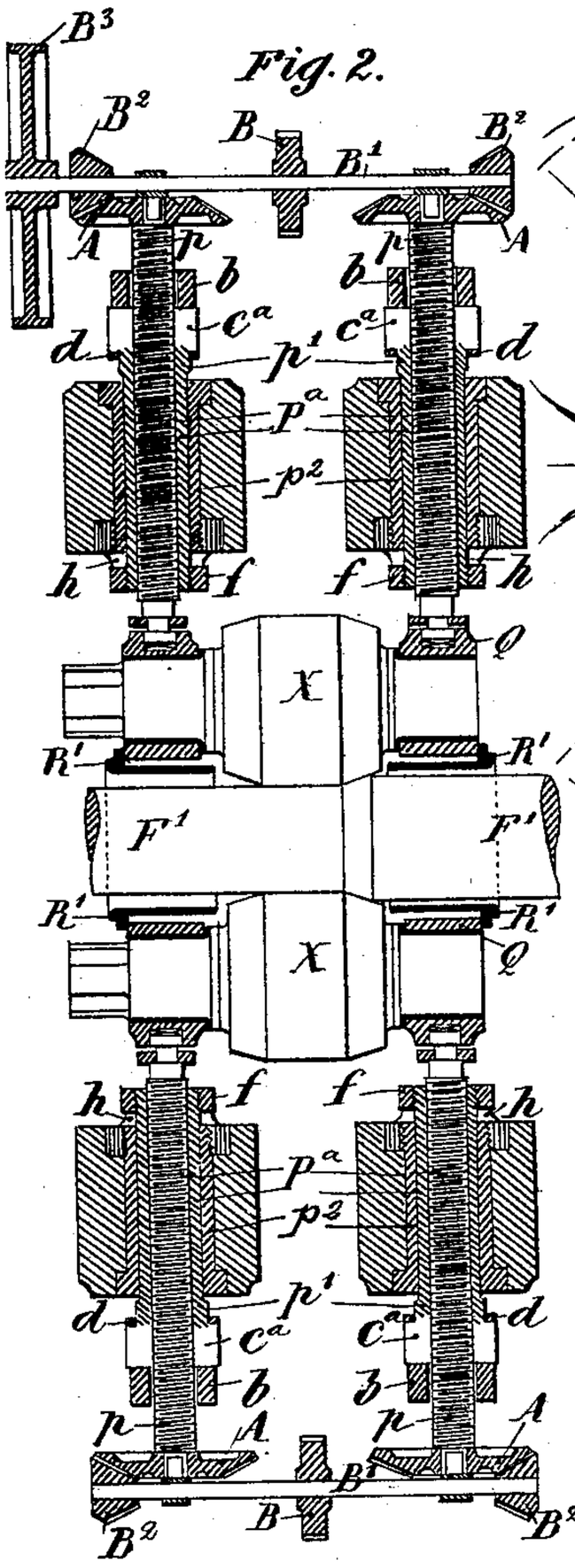


Fig. 3.

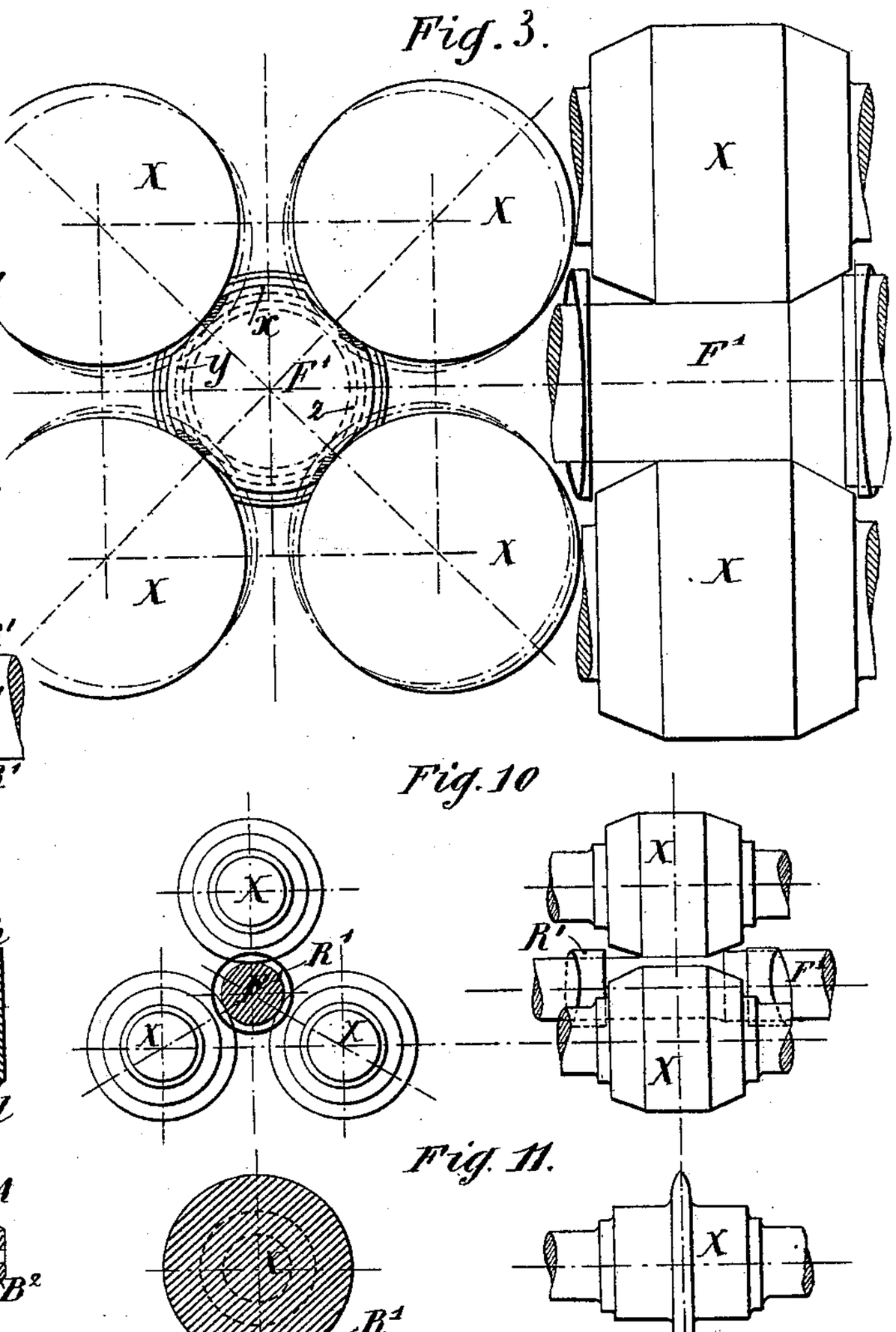
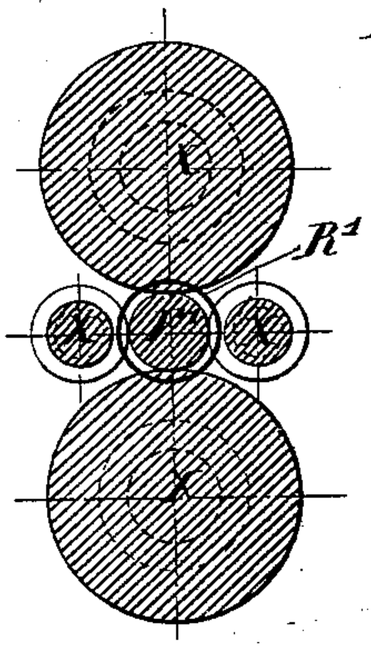
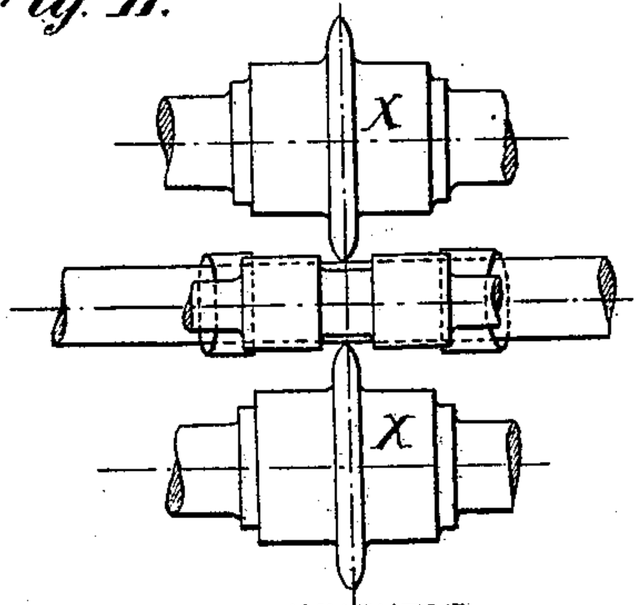


Fig. 10

Fig. 11.





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ROLLING MILL FOR MANUFACTURING ROUND BARS, &c.

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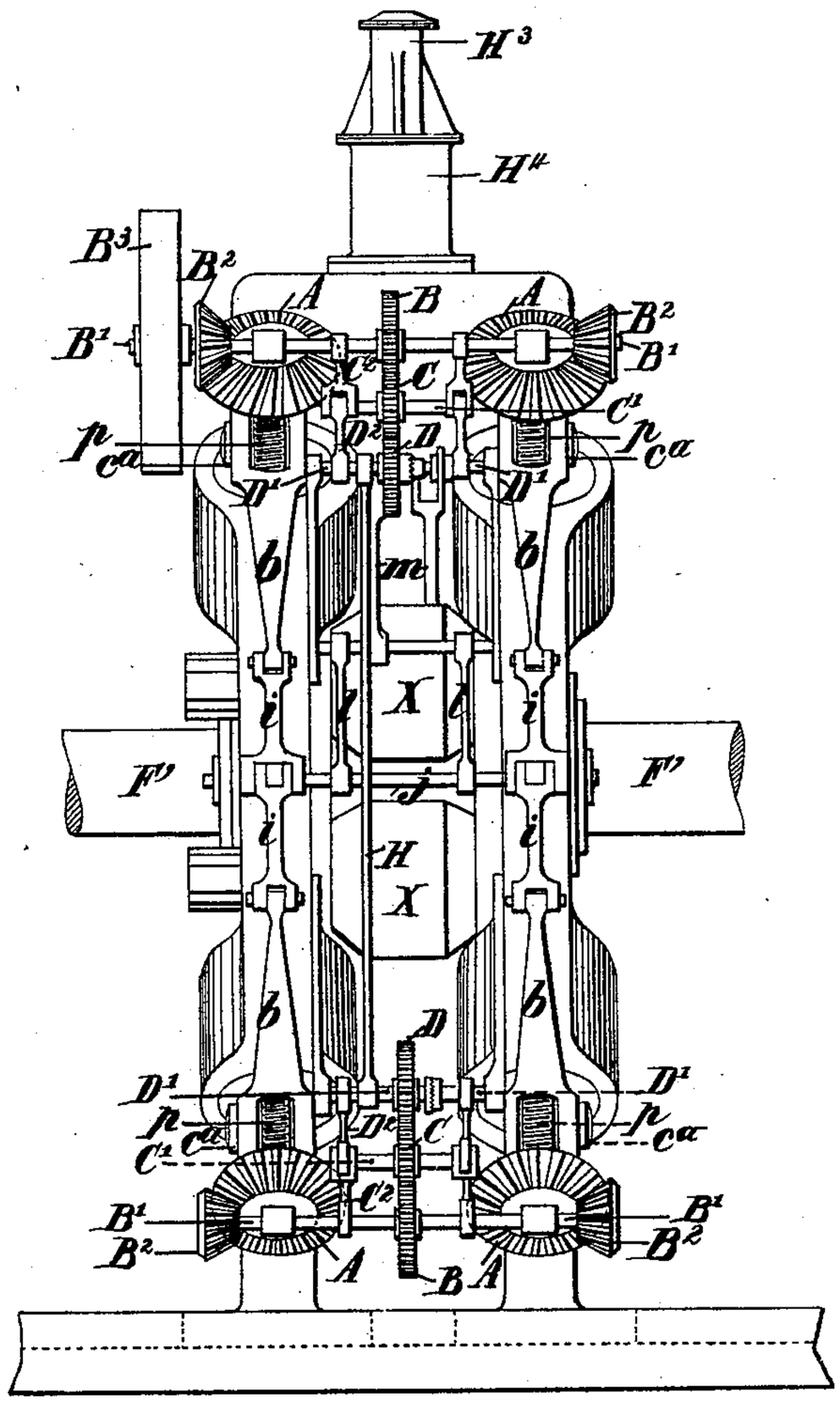
Fig. 12.



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ROLLING MILL FOR MANUFACTURING ROUND BARS, &c.

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Fig. 13.

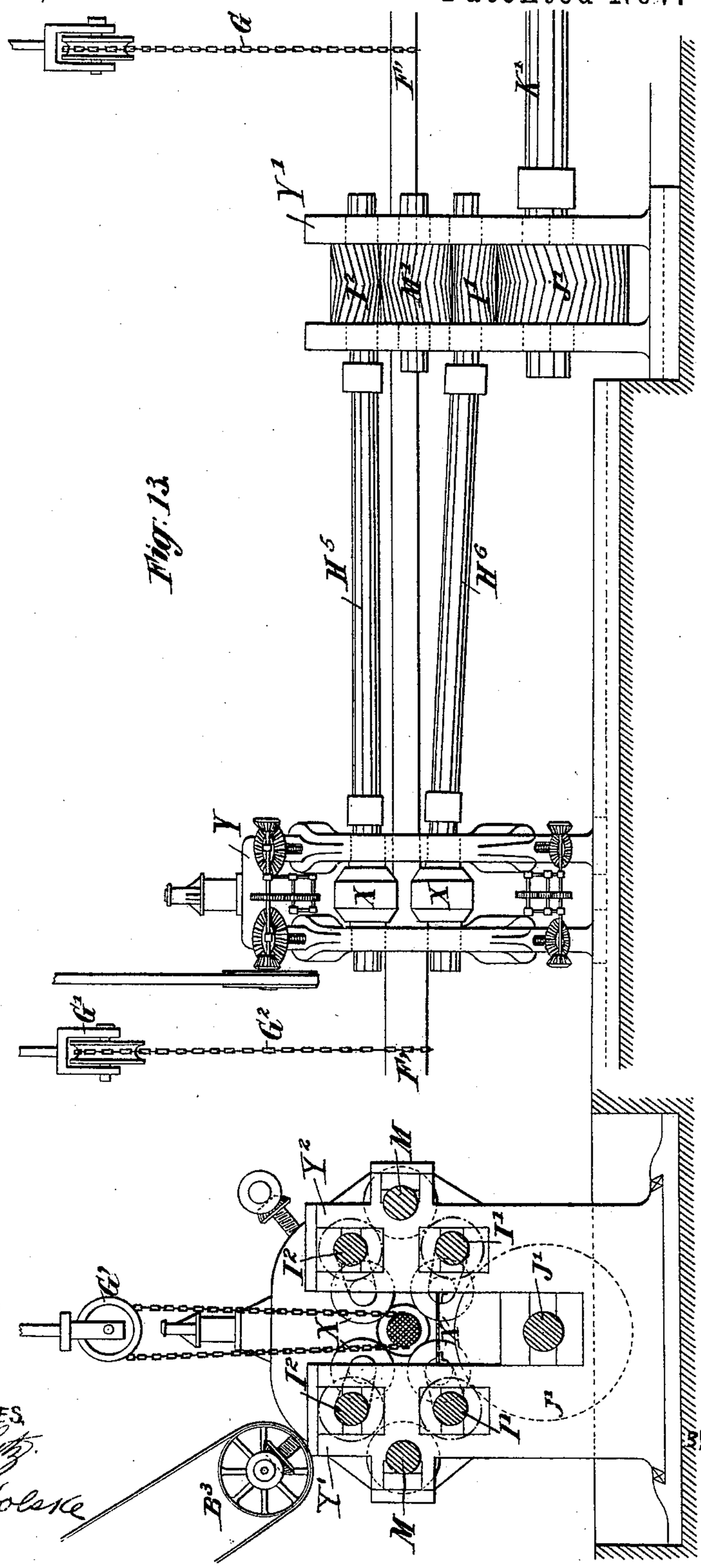

Fig. 14.

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ROLLING MILL FOR MANUFACTURING ROUND BARS, &c.

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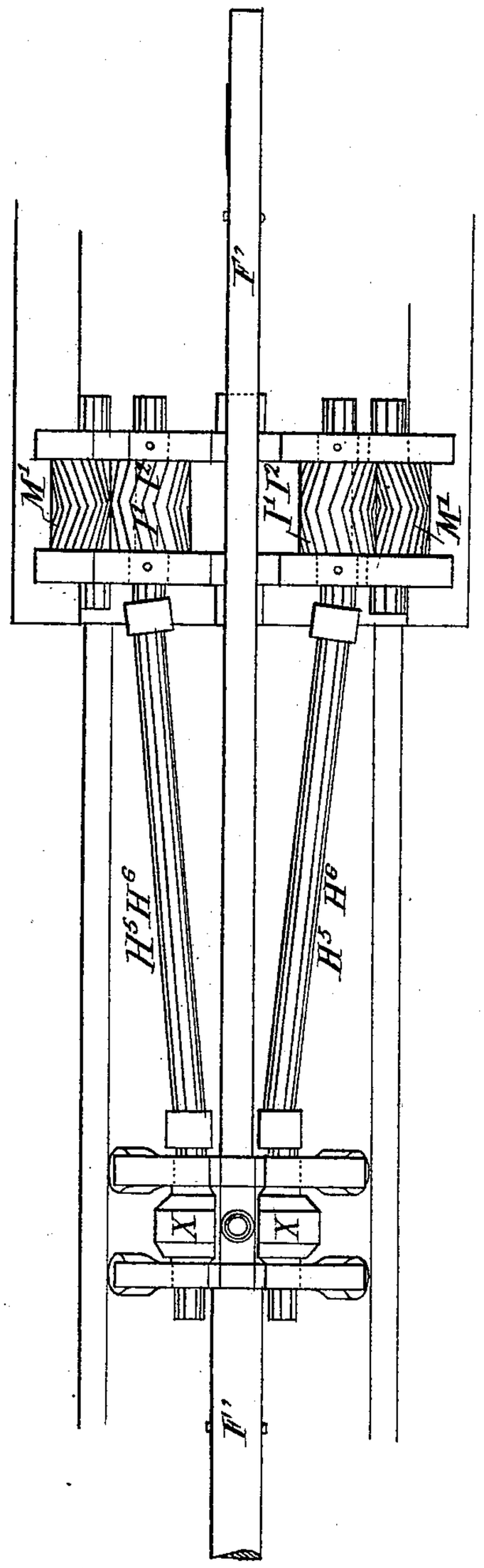

Fig. 15.

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ROLLING MILL FOR MANUFACTURING ROUND BARS, &c.

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Fig. 16.

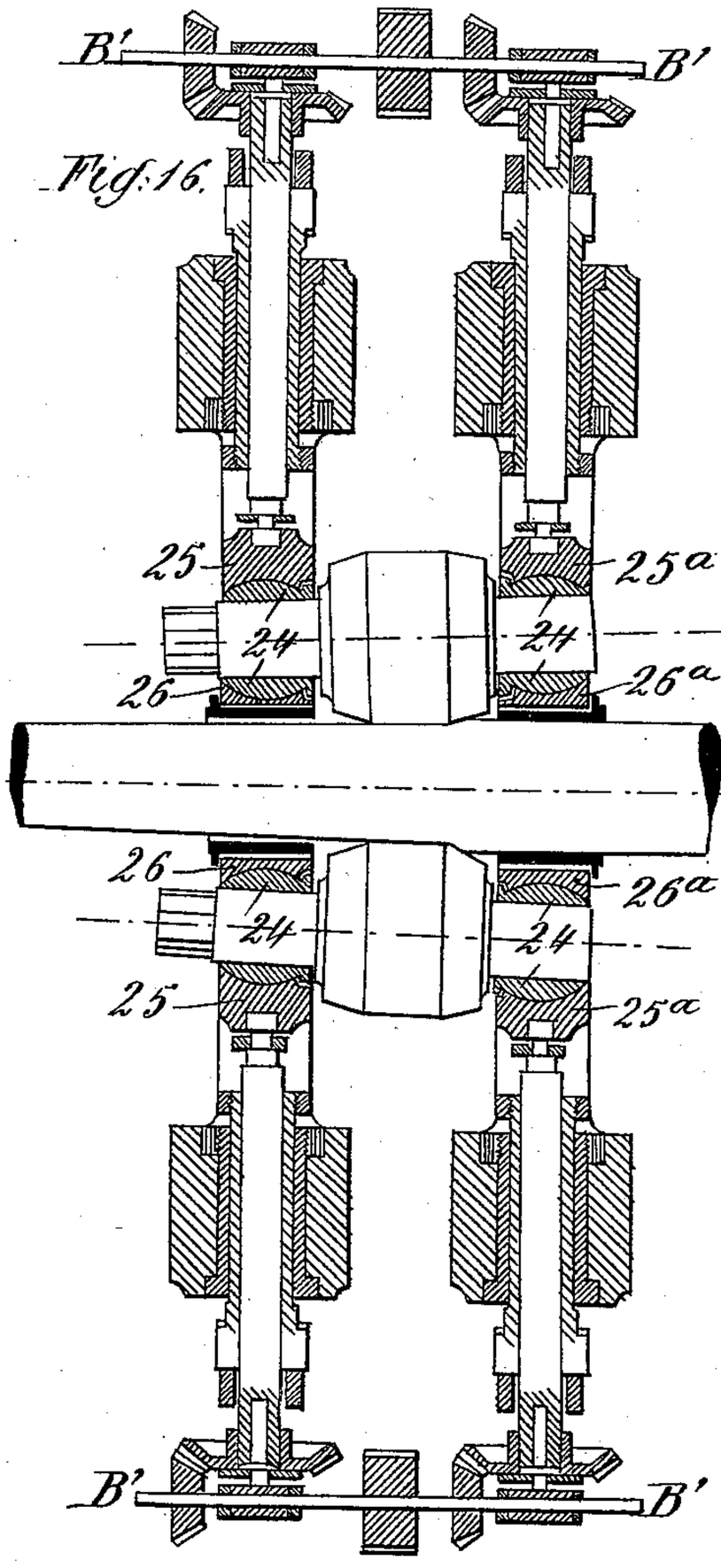

Fig. 17.

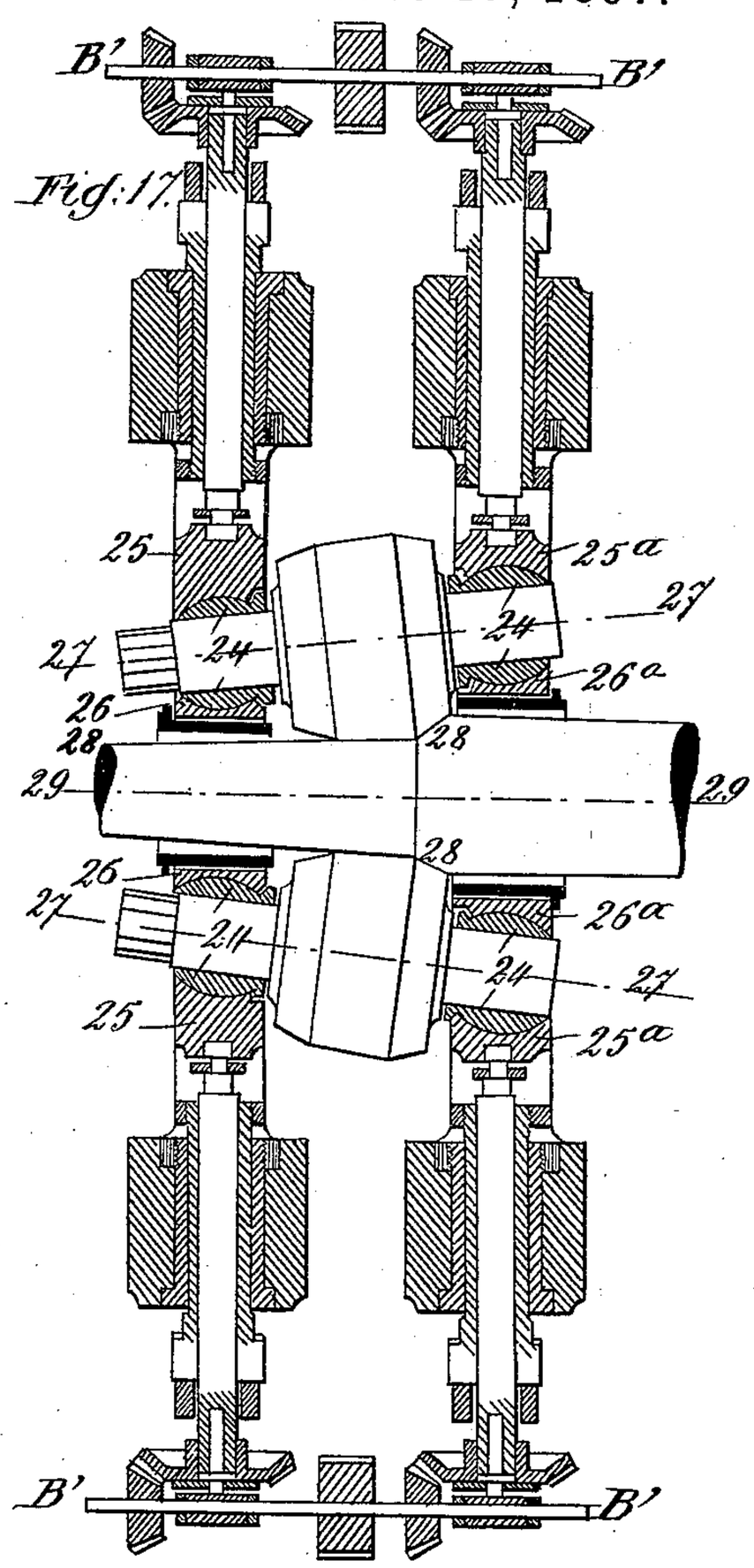

Fig. 22a.

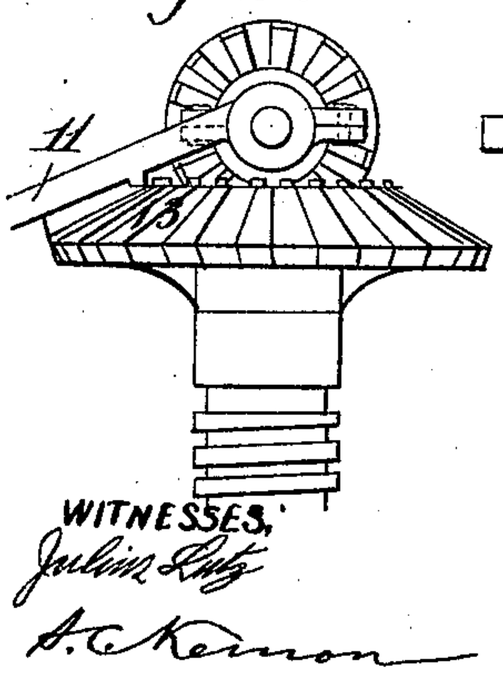

Fig. 22.

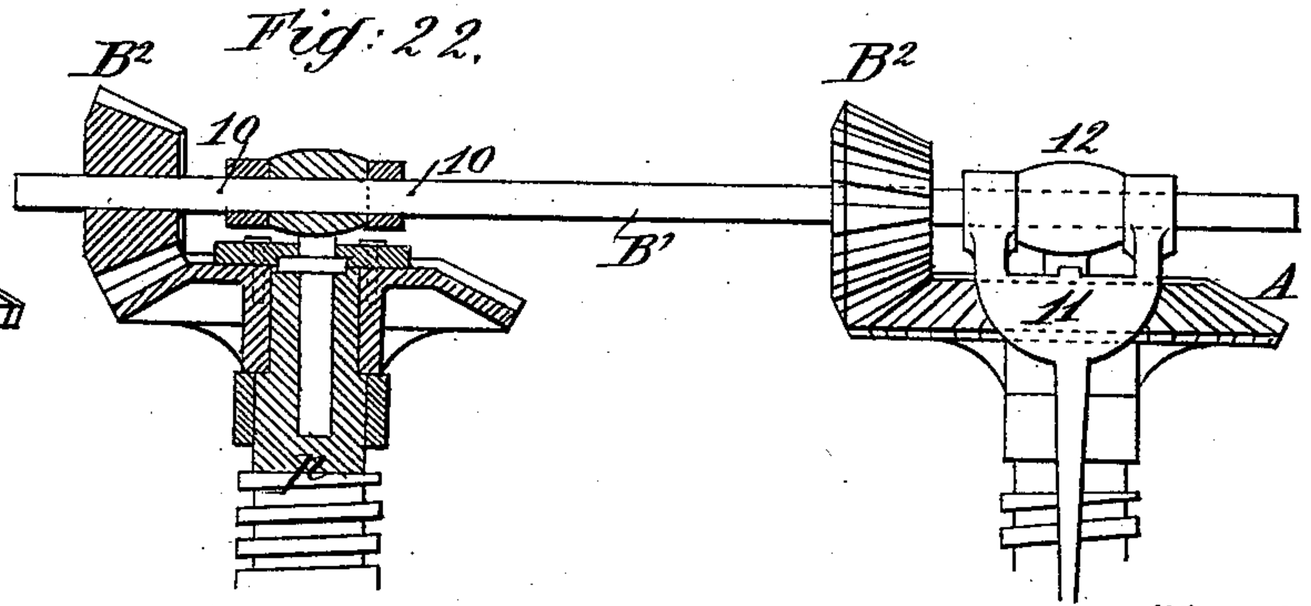

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Fig: 18.

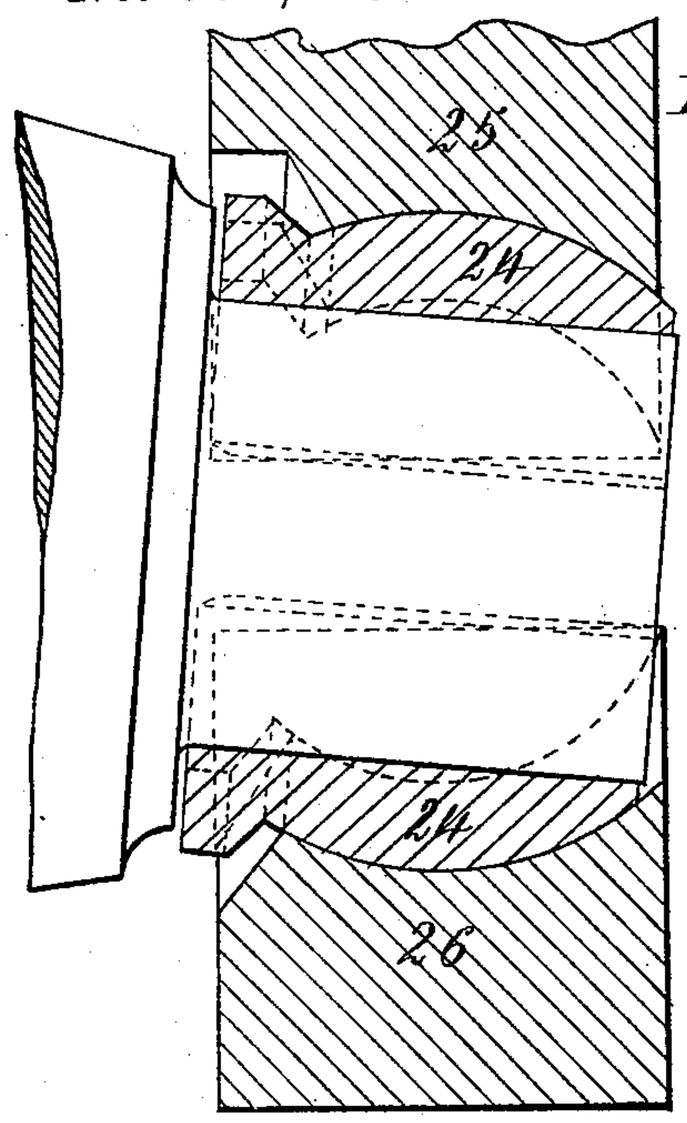

Fig: 18a.

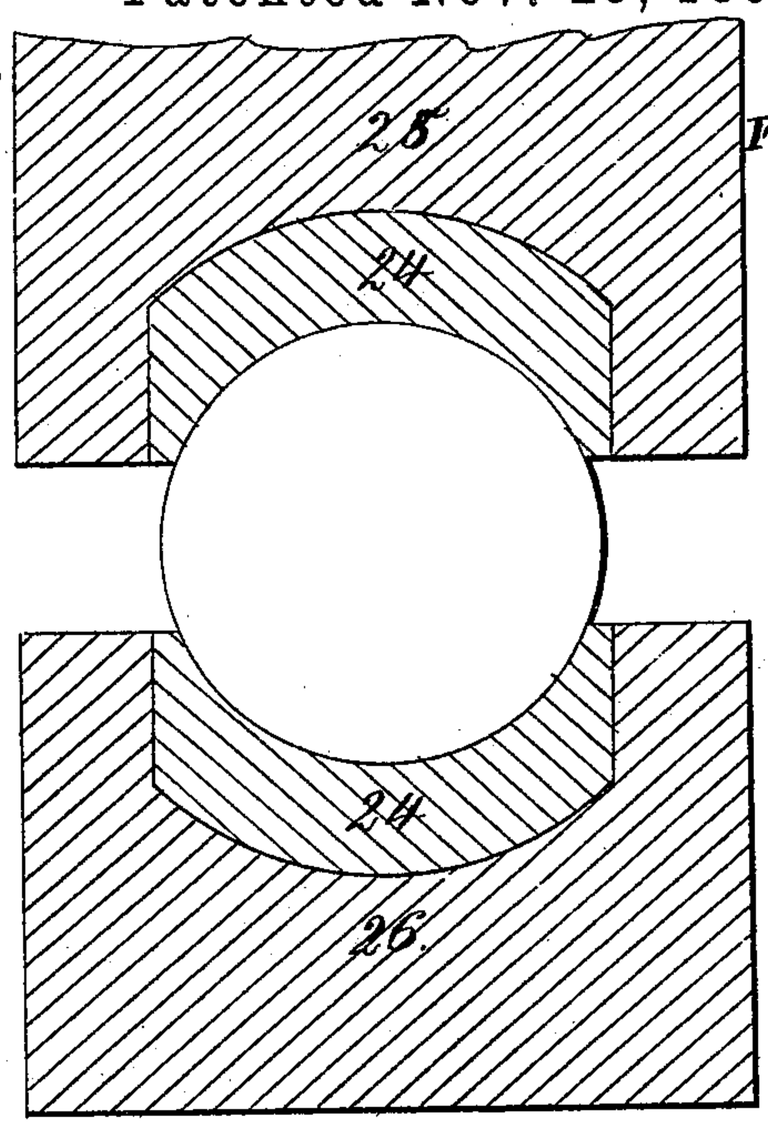

Fig: 19.

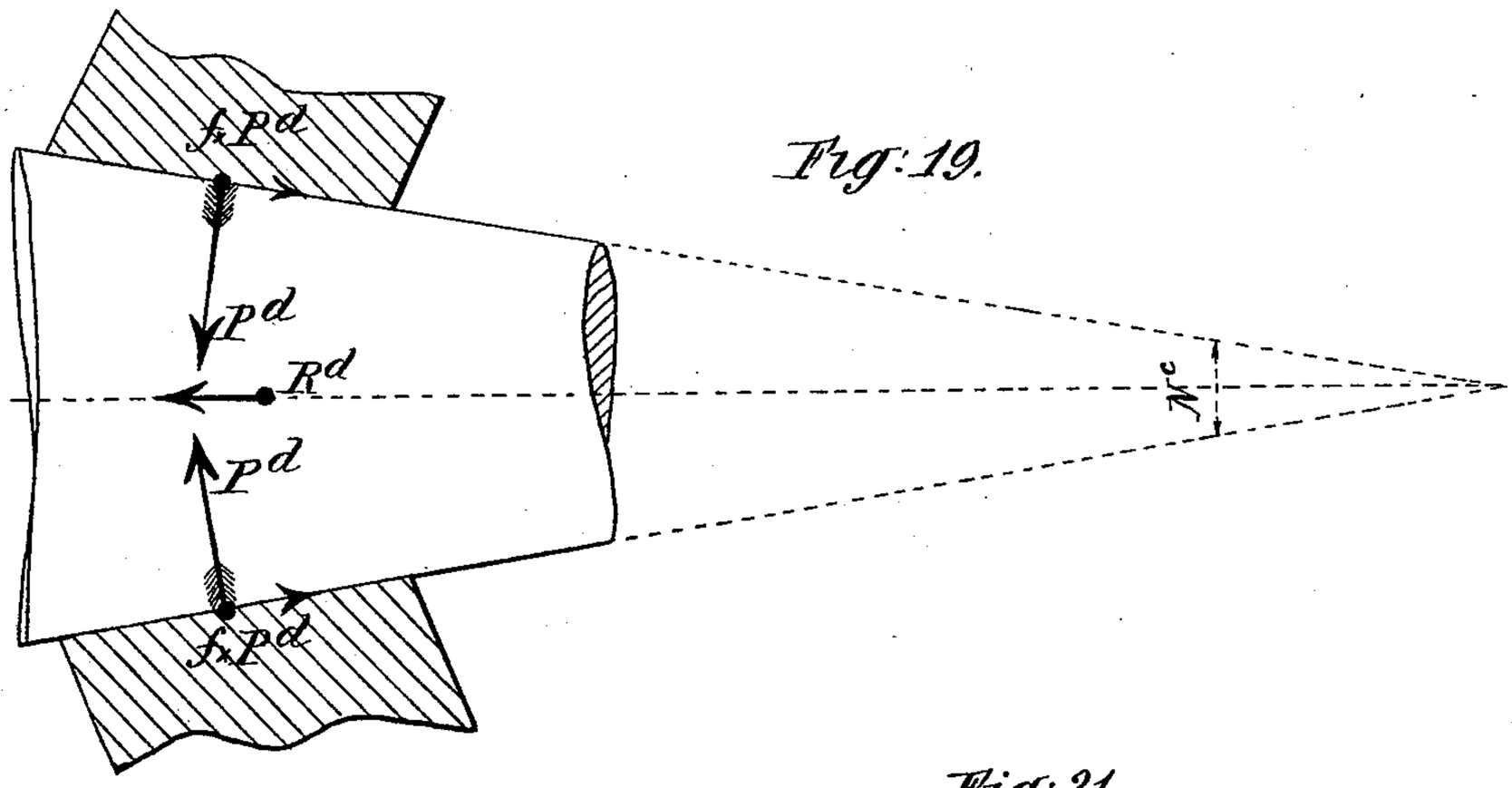

Fig: 20

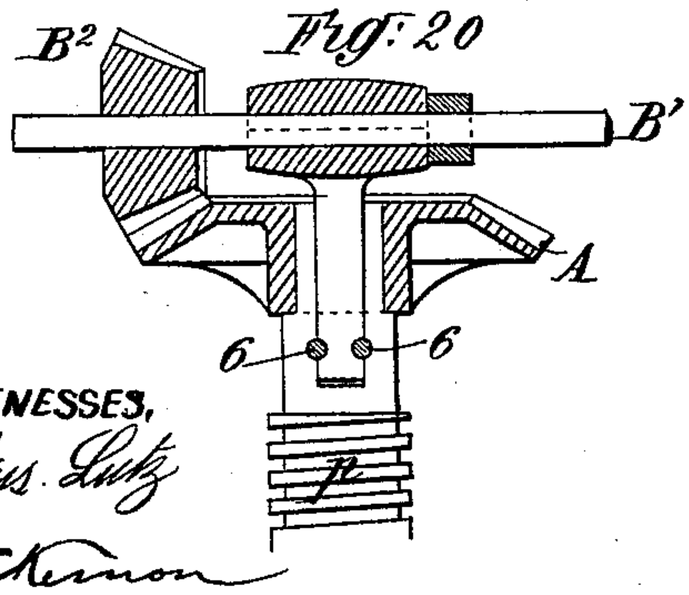

Fig: 21

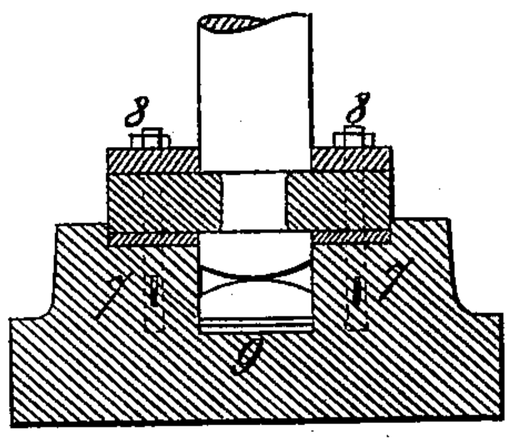

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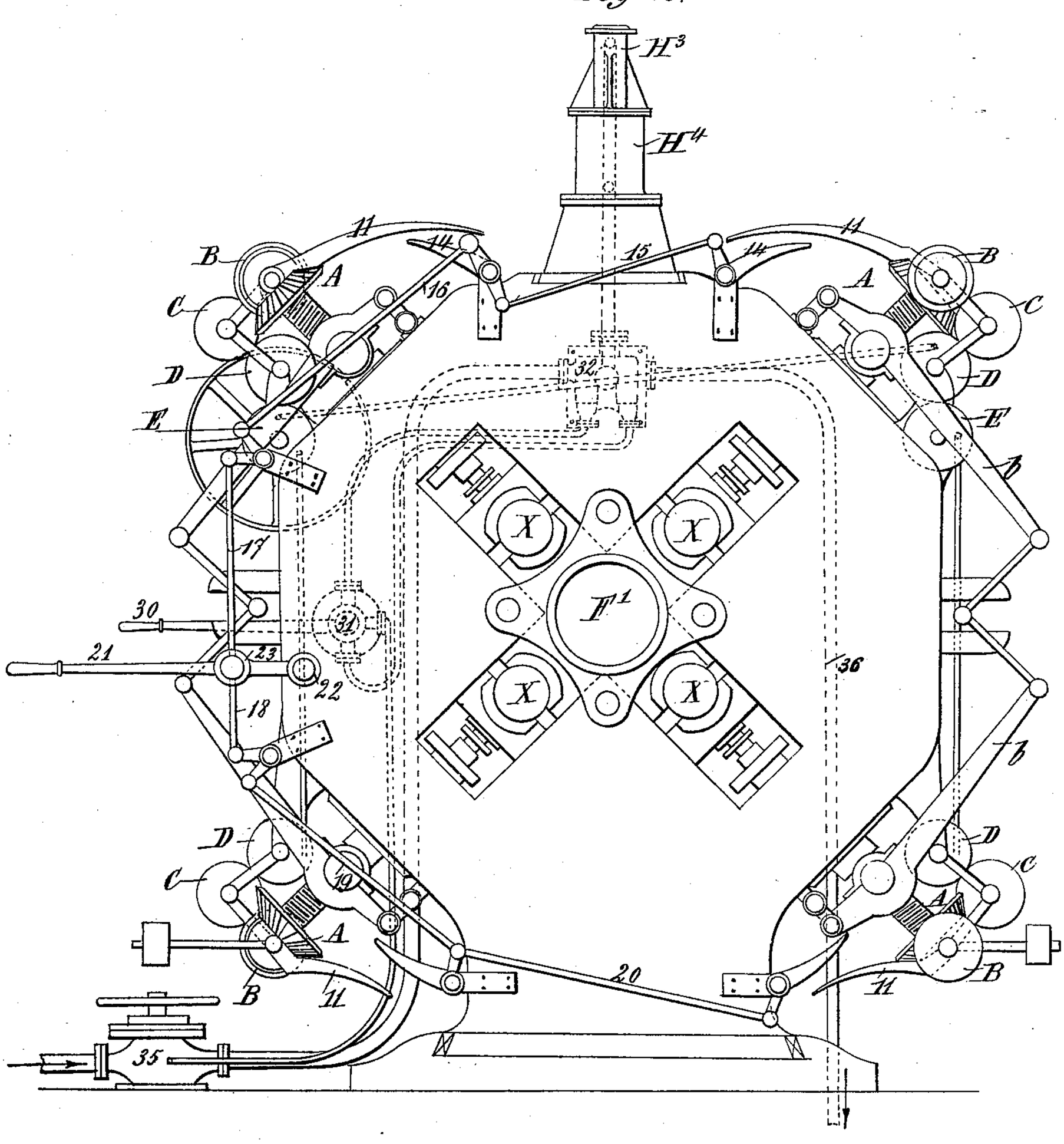
Fig. 23.



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ROLLING MILL FOR MANUFACTURING ROUND BARS, &c.

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Fig: 24.

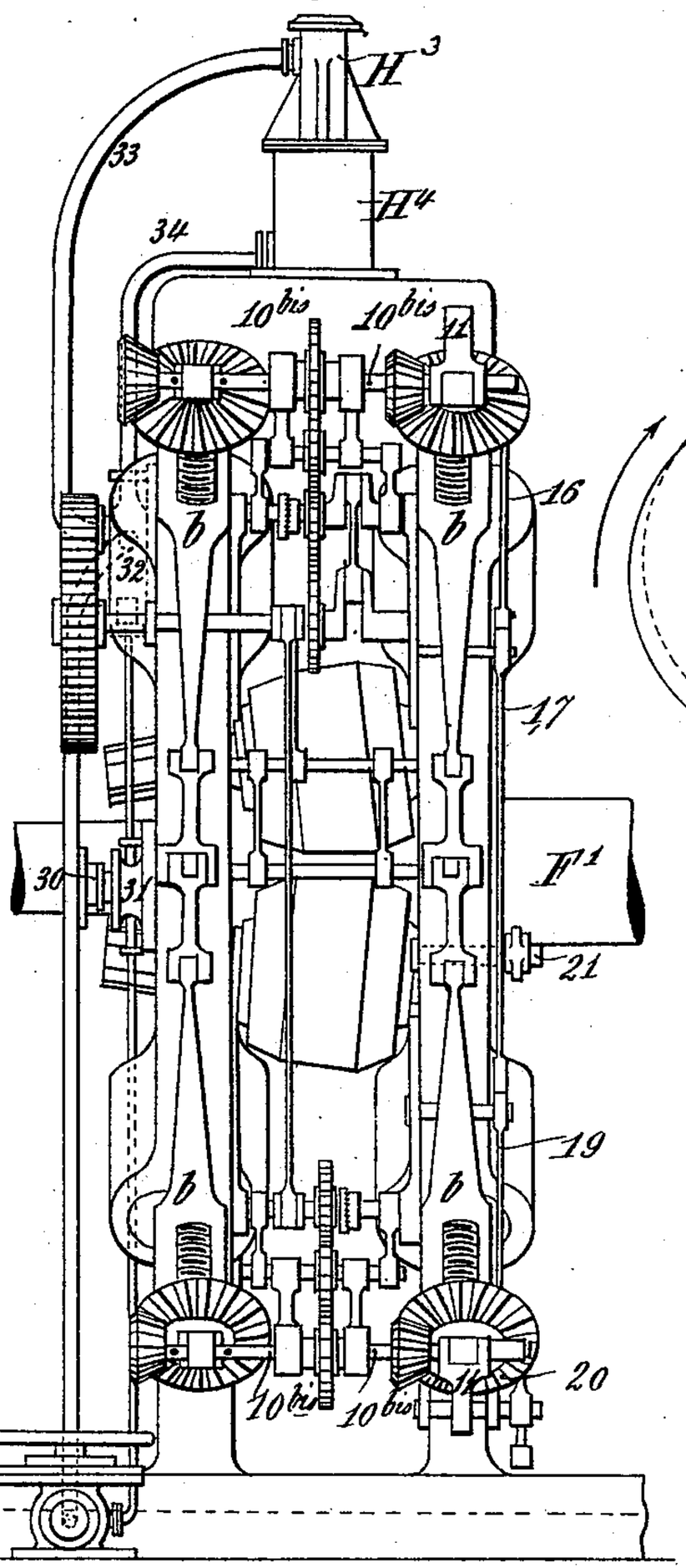
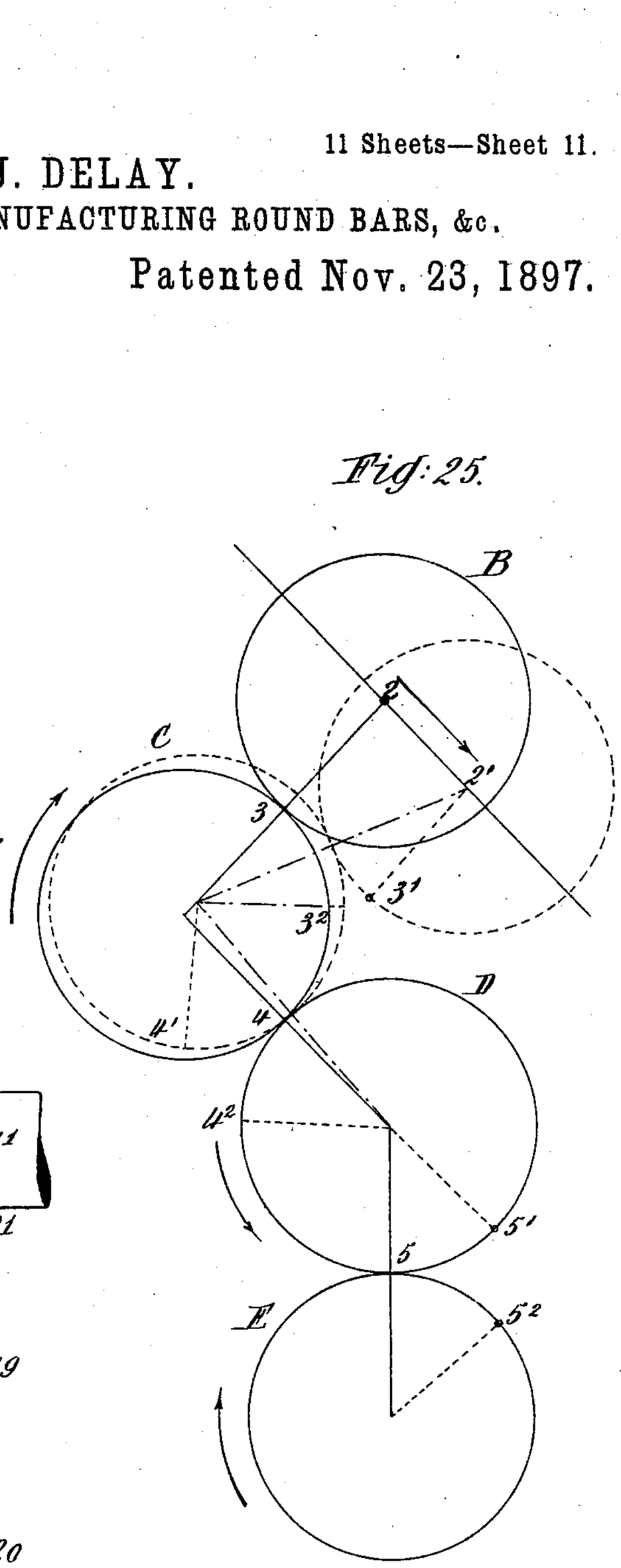


Fig: 25.



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UNITED STATES PATENT OFFICE.

PAUL JEAN DELAY, OF BOUCAN, FRANCE.

ROLLING-MILL FOR MANUFACTURING ROUND BARS, &c.

SPECIFICATION forming part of Letters Patent No. 594,333, dated November 23, 1897.

Application filed February 28, 1896. Serial No. 581,131. (No model.) Patented in France July 17, 1895, No. 248,957.

To all whom it may concern:

Be it known that I, PAUL JEAN DELAY, a citizen of the Republic of France, residing at Boucan, Department of Baues-Pyrénées, France, have invented an Improved Rolling-Mill for the Manufacture of Round Bars or the Like, (for which I have obtained a patent in France, No. 248,957, dated July 17, 1895,) of which the following is a specification.

The object of the present invention is to obtain with a rolling-mill rods, bars, or other articles of circular cross-section and rectilinear longitudinal axis. Such articles have been manufactured hitherto by means of a stamp-hammer or a press, or where ordinary rolling-mills have been employed it has been necessary to provide a large variety of parts to suit the numerous forms or classes of articles to be produced. As examples, I may cite straight shafts or axles for machines and vehicles, propeller-shafts for steamships, conical pivots as employed in some hoisting devices, straight shafts of varying diameter for stationary engines, &c.

The invention will be fully described hereinafter and the features of novelty pointed out in the claims.

Reference is to be had to the accompanying drawings, in which—

Figure 1 is an end elevation of the machine with the parts in the position they occupy at the outset of the operation. Figs. 1^a and 1^b are diagrams corresponding to Fig. 1, showing the operating parts in two positions, Fig. 1^a illustrating the first movement of the blank-compressing parts or slides, which movement is obtained by hydraulic pressure through the medium of levers, while Fig. 1^b indicates the second movement corresponding to the tightening and adjusting operation of the slides by means of the screw mechanism, which will be fully described hereinafter. Figs. 1^c and 1^d are diagrammatic elevations representing a slightly-modified form of the screw mechanism in two positions corresponding to those illustrated in Figs. 1^a and 1^b. Fig. 2 is a broken sectional elevation taken on the line *a a* of Fig. 1. Fig. 3 is a diagram illustrating the action of the rollers in end elevation and side elevation. Figs. 4 to 9 illustrate various kinds of work which may be produced with my improved machine. Fig. 10 is a diagram (end view and side elevation) of a modified arrangement of rollers. Fig. 11 is a diagram (cross-section and side elevation) of another modification. Fig. 12 is a side elevation of the machine shown in Fig. 1. Figs. 13, 14, and 15 are views showing the general arrangement of parts in side elevation, longitudinal section, and plan, respectively, said views showing particularly the mechanism for rotating the rollers, for supporting the blank, and for feeding it forward. Figs. 16 and 17 are sectional elevations similar to Fig. 2, illustrating the arrangement of parts for obtaining conical articles. Figs. 18 and 18^a are a longitudinal section and a transverse section, respectively, both on an enlarged scale, of a ball-and-socket joint employed in the construction shown in Figs. 16 and 17. Fig. 19 is a diagrammatic section illustrating the action of the rollers on the blank. Fig. 20 is an enlarged detail view showing, in sectional elevation, a mechanism for adjusting the rollers toward or from the blank. Fig. 21 is a similar view showing adjusting means applied to the bearings receiving the ends or trunnions of the rollers. Fig. 22 is a view similar to Fig. 20, showing another mechanism for the same purpose. Fig. 22^a is an end view of the mechanism shown in Fig. 22. Fig. 23 is an end elevation corresponding to Fig. 1 of the construction illustrated by the diagrams Figs. 1^c and 1^d. Fig. 24 is a side elevation corresponding to Fig. 12 of the machine represented in Figs. 1^c, 1^d, and 23; and Fig. 25 is a diagram illustrating the movement of the gear-wheels.

Like letters of reference denote like parts in all the views.

I will first describe in detail a rolling-mill provided with four cylinders or rollers whose axes are parallel to that of the blank to be worked, said rollers being of equal diameters and located at equal distances from each other as well as from the center of the blank. All these rollers are operatively connected to move in the same direction, their circumferential rates of speed being equal. The blank in its initial shape is of circular cross-section.

After describing the construction above referred to as a type of my invention I will indicate modifications which may be made when it is desired to alter the direction of the rollers' axes, their number, or the number of

rollers driven. One feature, however, remains unaltered—viz., the manner of tightening or moving the rollers against the blank. This feature I consider a characteristic of the machine.

F′ designates the blank to be worked.

X denotes the balanced rollers. Their periphery is formed of a cylindrical portion and of a conical portion connecting each end to the trunnions. The latter are received in bearings Q, mounted to slide in radial slots provided in the casing, said slots, as shown, being arranged at an angle of ninety degrees to each other.

The bearings Q are connected to the ends of adjusting-screws *p*, more fully described hereinafter, in such a manner as to permit said screws to turn within the socket provided for their reception in the bearings, Figs. 1, 2, and 21.

Sleeves R′ protect the bearings Q against the heat radiating from the blank and against the oxids, scraps, &c., which may fly off said blank.

The screws *p* engage movable nuts *p′*, each of which is provided at its outer end with two projecting pins c^a, engaged by strong levers *b*, by means of which the rollers X may be forced against the blank. Furthermore, that part of the frame through which pass the said nuts *p′* is provided with a sleeve p^2, having a smooth inner surface, so that the nuts may slide in a radial direction with as little friction as possible.

Caps *d* are provided to make the levers *b* practically integral with the pins c^a, so that any movement of the levers will be communicated directly to the nuts *p′* and screws *p*. At its inner end each of the nuts *p′* receives another nut *f*, chiefly for the purpose of preventing the nuts *p′* from falling out of their sockets when the levers *b* are removed. For the sake of conciseness I will hereinafter designate by the character P^a the slide formed by the movable nut *p′* in conjunction with the screw-rod *p*. (See Figs. 1^a and 1^c.)

All the movable nuts *p′* are connected by means of levers and links *b i k l m n* and connecting-pivots *j o*, Figs. 1 and 12, which work from fulcrums E^4 on the frame and are operatively connected at *o* to a piston-rod actuated by two single-acting hydraulic pistons H^3 and H^4. The cylinder H^3 (see Figs. 23 and 24) is in constant communication, at its upper end only, with a supply of water by means of the valve 35 and the tube 33.

The cylinder H^4 receives the water only at its lower end. Water is admitted by means of a cock or valve 31, having a key or handle 30. The cock allows the water to proceed to a distributer 32, which communicates with the cylinder H^4 by means of the tube 34. The waste water escapes through a tube 36, and according to the position of the cock 30 water is either admitted to the cylinder H^4 or escapes therefrom.

To make the description and drawings more readily intelligible, I have omitted from several views the mechanism for actuating the screws *p* and the slides P^a. It is understood that the screws *p* cannot turn when the levers *b* are actuated by the pistons in the cylinders H^3 and H^4. The mechanism for actuating the screws and slides is shown best in Figs. 23 and 24 and will be fully described hereinafter.

By actuating one or the other of the pistons contained in the cylinders H^3 and H^4, I cause the four rollers to move simultaneously and the same distance toward or from the blank. The pressure will cause the rollers to deform the blank by penetrating into the same, Fig. 3, and owing to their rotary movement they will progressively compress the blank on its entire circumference. After one-fourth of a rotation the portion *x* will have been rolled. If the application of pressure is continued, the portions *y* and *z* will be rolled successively, and this operation will continue as long as the piston contained in the cylinder H^4 has not reached the end of its stroke. When nearing the end of the operation, the thickness of material to be worked by the rollers will decrease gradually, and since said rollers bear on the blank with a constant pressure and rotate against it as long as desired they will finally work the blank into a regular shape. When this result has been obtained, pressure is discontinued in the cylinder H^4 and applied in the cylinder H^3, so that the rollers moving outwardly to their initial position release the blank completely.

As illustrated by Figs. 13, 14, and 15, the blank F′ is supported at its front and rear ends by two chains G^2, which pass under it and over pulleys G′. During the compression the blank will rotate, causing a similar movement of the pulleys G′. When the rollers are removed from contact with the blank, the latter will be supported by the chains G^2. The pulleys G′ are connected to overhead travelers or carriages of suitable construction, according to the weight and character of the work. A rotary movement is imparted to the rollers by means of the driving extension K′, which actuates the gear-wheels J′ I′ M′ I^2. The pinions I′ and I^2 are connected to the rollers by means of sleeves and extensions H^5 and H^6. The latter are of sufficient length to permit of their assuming various inclinations and actuating the rollers in any position they may be adjusted to.

It will be observed that a free space is left between the frames Y Y′ and Y′ Y^2 for the purpose of allowing the blank and its supporting-chains to travel freely therein. It will therefore be understood that if the rollers have first been set at such a distance from each other that the blank may be freely moved between them longitudinally by means of the usual overhead carriage from which the said blank is suspended it will be easy to feed the blank forward by means of said carriage or traveler after the blank has been

rolled for a part of its length—that is, the feeding of the blank may be accomplished in the same manner that is customary when working bars or the like with a steam-hammer or a press.

By compressing successively adjacent portions of the blank a finished product like that shown in Fig. 4 will be obtained, the collars *q* affording a means of readily ascertaining if the amount of feed between two successive compressions has been too great.

The above-described movement of the rollers is quick and powerful, since it depends only on the force and speed which can be obtained with a piston.

In order to obtain a longer stroke and a precise adjustment by means of the screws *p*, the screws are connected in pairs by pinions, shafts, gear-wheels, connecting-rods, and pulleys permitting of setting all the screws in motion at the same time. A more detailed illustration of these movements is given in Figs. 1^a and 1^b of the drawings, Figs. 1^a and 1^b being diagrams corresponding in Fig. 1 in two positions—that is to say, Fig. 1^a illustrates the first movement, corresponding to the operation of the slides by hydraulic pressure and through the medium of the levers, while Fig. 1^b indicates the second movement, corresponding to the tightening and adjusting operation of the slides by means of the screw mechanism, which shall presently be fully described.

Figs. 1^c and 1^d represent a slightly-modified form of the screw mechanism in two positions corresponding to those illustrated in Figs. 1^a and 1^b.

The screw mechanism, Figs. 1, 1^a, 1^b, and 2, consists of bevel-wheels A, secured, respectively, to the ends of the screws *p* and engaging with other bevel-wheels B^2. The latter are connected in pairs by means of shafts B′, loosely mounted on the ends of the screws *p*. Each shaft B′ carries at its central portion a toothed wheel B, engaging a gear-wheel C, meshing into a similar wheel D. The gear-wheels D are mounted either loosely or rigidly on their shafts D′. One of the shafts B′ carries the driving-pulley B^3. The shafts D′ rotate in bearings permanently attached to or stationary on the frame or casing, all of the said shafts D′ being balanced and connected together by rods or links H. The gear-wheels D may be made fast on the shafts D′ by means of clamps, friction-cones, or the like. The length of the links D^2 C^2, connecting the shafts B′ C′ D′, is constant; but the angles formed by the lines connecting the centers of B′ C′ D′ are variable according to the position of the shafts B′, which, owing to the particular construction described, are compelled to move on straight lines leading from them to the center of the machine.

Fig. 1^a indicates the direction in which the gear-wheels turn, while the eight slides P^a move under the action of the levers, at which juncture the gear-wheels D will have become loose upon their shafts. The links remain stationary. It will be seen that the four toothed wheels D, corresponding to the eight slides, will turn, two and two, in opposite directions. When the slides are moved outwardly, the reverse rotary movement will take place. By restoring at this moment the connection between the shafts D′ and the gear-wheels D and by rotating the gear-wheels through the medium of the driving-pulley B^3 the position shown in Fig. 1^b will be arrived at. It will be observed that all the gear-wheels B rotate in the same direction. Therefore by cutting all the screws at the same pitch and making their threads left-hand or right-hand, as required, they may be caused to advance or recede in unison and the same distance.

In Fig. 1^a the pulley B^3 and the bevel-wheels do not turn. The levers cause the four pistons or slides P^a to simultaneously move toward the center of the apparatus. The wheels D are loose upon their crank-shafts and may rotate freely without affecting the links or rods H. The wheels C and D make a short rotary movement, since the wheel C must turn on the wheel B, which cannot turn on its axis, but moves bodily in a radial direction. When the slides P^a move outward, the gear-wheels C and D return to their original positions. To overcome the dead-centers, I prefer to use in addition to the links H a second set of links h^3, connected to second cranks on the shafts, the cranks being set ninety degrees apart.

In Fig. 1^b the gear-wheels D are rigid with the crank-shafts D′, and consequently with the links H. In this case the levers are stationary, the pawls are thrown off, and the gears A can turn under the influence of the pulley B^3.

Two distinct movements or operations are therefore obtainable. When the levers are in action, the driving-pulley B^3 is inactive and does not rotate, and when the slides are to be moved radially by the rotation of said pulley the levers are stationary.

The arrangement represented in Figs. 1^c and 1^d differs from the one just described in its being supplemented by two additional toothed wheels E, secured to the shafts E′, which rotate in bearings permanently fixed to the casing or frame. In these figures the primary set of connecting rods or links is designated as H′ H^2 and the secondary set (at ninety degrees to the primary set) is lettered *h′* h^2.

In Fig. 25 I have indicated diagrammatically the movement of the gear-wheels B C D E when actuated by the piston H^4. Owing to the construction above referred to the point 2 moves inwardly to the position 2′ on the straight line connecting the point 2 to the center of the apparatus. The point 3 of the gear-wheel B moves to 3′, parallel to the line 2 2′, since when the pistons are used for moving the slides P^a the screws *p*, and consequently the gear-wheels A B^2 B, cannot rotate. This movement involves a rotation of the gear-

wheel C and a shifting of its center. The point 3 comes to the position 3^2. Similarly the points 4 and 5 move to 4′ 4^2 and 5′ 5^2, respectively.

Fig. 1ᶜ indicates the direction of the movement of all the gear-wheels during the inward movement of the slides P^a when actuated by the levers *b*. It will be seen that all the shafts linked together by connecting-rods move in the required direction. The slides thus can move, although the gear-wheels are keyed or otherwise rigidly secured on their shafts. During such movement the gear-wheels and the connecting-rods will turn to a predetermined extent, with the exception of the gear-wheels B B^2 A. The angles B′ C′ D′ will vary. Assuming the slides to be stationary, if the pulley B^3 is rotated it will be seen that two of the gear-wheels B will turn in the same direction and the other two in the opposite direction. It will be evident that if the screw-threads have the same pitch and are partly right hand and partly left hand the screws *p* will be fed inward or outward in unison and the same distance. By adding the gear-wheel E, I therefore obtain the advantage of being able to rigidly secure all the gear-wheels on their shafts.

Whether one or the other of the above-described mechanisms is employed it is sufficient, in order to effect a second compression when the slides P^a have reached the end of their stroke and the first rolling or compression has been effected, to move the slides outwardly, raise the locking-lever 11, adjust the screws *p* inward by means of the pulley B^3 a distance equal to the stroke of the slides P^a, and put the locking-lever 11 back to its original position. The slides may then again be moved inward by means of the levers *b*, and a second reduction of diameter equal to the stroke of the slides P^a may be obtained on the blank. This operation may be repeated several times. The screws may thus be extended so long as they do not bend under the compressing strain to which they are subjected, a condition which it is easy to fulfil. This extensibility of the screws secures a very considerable stroke for the machine, and while sufficient in extent the stroke will also be perfectly precise, as upon the slides reaching the limit of their strokes the rollers carried thereby will be able to force their way into the body of the blank only to the extent to which the screws have been tightened, the extent of reduction or compression being thus adjustable to a nicety. By such means the blank may reliably be reduced to the desired dimensions and not beyond the limit predetermined.

The driving-pulley B^3 receives motion in either direction, or, if preferred, in one direction only, by any convenient or well-known devices which I have not deemed necessary to illustrate.

In order to adjust the rollers to the same distance from the center, I may employ the mechanism shown in Fig. 20. Upon the removal of the pins 6 6 the shaft B′ is raised so as to move the gear-wheels B^2 and A out of mesh. Then the gear-wheel A and the screw are turned to the desired extent, and the parts, including the pins 6 6, are put back to their former position. If the desired movement is too considerable and involves too great an inclination of the shaft B′, I adopt the mechanism represented in Fig. 21, which shows the connection of the screw *p* to the sleeve Q. The bolts 8 are loosened and washers 7 and 9 of appropriate thickness are put in.

For the purpose of connecting the shaft B′ to the screw *p* I may also employ the mechanism shown in Fig. 22. I remove the pins 10 10, Fig. 22, and 10^{bis}, Fig. 24, then slide the shaft B′ in its bearings to bring the pinions B^2 and A out of engagement with each other, and adjust the rollers as above described.

I may also use for adjusting the rollers any one of the mechanisms ordinarily employed for this purpose in sheet-metal-rolling mills.

In order to prevent the screws from turning during the movement of the slides, I provide the locking-lever 11, Fig. 22, one end of which is free, while the other end is formed with a fork provided at its ends with two sleeves, which are adapted to slide on the shaft B′ and for a part of their length engage the teeth of the wheel A and their extensions, so as to make any independent movement of the screws *p* impossible as long as the lever 11 is in its locking position.

When it is desired to turn the screws, the levers 11 are raised by means of the handles 14, Fig. 23, through the medium of the connecting-rods and cranks 15 16 17 18 19 20. The movement will be effected by means of the lever 21, fulcrumed at 22 and pivotally joined at 23 to the connecting-rods 17 and 18.

I will now describe by way of example a few of the shapes that can be produced with my improved rolling-mill. In order to obtain a cylindrical shaft, such as shown in Fig. 5, the rollers will first be spaced sufficiently to allow the blank to move freely between them. Then by means of the handle 30 and of the carriage from which the blank is suspended the latter will be compressed or rolled successively in all its parts. Thereupon the slides P^a will be moved away from the blank, the gear-wheels A will be unlocked, the screws *p* adjusted inward to the required extent, the wheels A locked again by means of the levers 11, and the blank will again be rolled by successive portions in its entire length, this operation being repeated until the diameter of the blank shall have been reduced to the desired dimension.

In order to produce a shaft like that shown in Fig. 6, a cylindrical piece of uniform diameter in its entire length is produced to begin with, and then one end only of the shaft is rolled. The conical portion connecting the

two cylindrical portions of unequal diameters is produced by the inclined or conical portion of the rollers X.

Pieces like that represented in Fig. 7 will be produced if the interval *r s* is equal at least to the length of the straight or cylindrical portions of the rollers.

When more delicate shapes are to be formed, such as shown in Fig. 8, the rollers will be shaped accordingly with grooves or flutes.

My improved rolling-mill may also be employed when the axes of the rollers converge toward a point on the axis of the blank. In this case conical shafts may be produced.

When the angle formed by the axes of the rollers is small, I may employ the arrangement shown in Fig. 16, in which the rollers are of a uniform diameter on the whole length of their working surface. For this purpose I provide balls 24, Fig. 18, held in casings or sockets 25 26 25^a 26^a, Figs. 16, 17, and 18. By employing washers of different thicknesses for each end of the roller its axis will be inclined as desired, while leaving the shaft B′ horizontal. The apparatus will be operated as above described.

When it is desired to produce shafts of greater conicity, the rollers will have a conical surface, as shown in Fig. 17. Balls and sockets 25 26 25^a, of suitable thickness, will be provided to keep the shaft B′ horizontal. It will be observed that the tangential velocities of the rollers and of the blank will be equal when the axes 27 27, 28 28, and 29 29 converge toward the same point. I may also employ the means now used for adjusting the rollers in rolling-mills for producing pieces of trapezoidal cross-section, such as used for the armors of men-of-war.

After each compression of a section of the blank it will be necessary to adjust the screws inward or outward, according to the direction in which the blank is to be fed, a distance corresponding to the conicity and to the longitudinal movement to be given to the conical piece to be rolled. It is understood that the blank is rolled by sections, a longitudinal movement taking place between each two compressing or rolling operations, as described. In this case the addition of the gear-wheel E will be advantageous, since it will avoid the necessity of frequently locking and unlocking the shafts D′ and the gear-wheels D.

It will be obvious that the inclination which can be given to the rollers is limited by the character of the construction described. In addition thereto, however, there is a limit imposed by the physical conditions of the operation, since when the rollers are inclined at a greater angle than a predetermined maximum angle the blank instead of being compressed by them will slip longitudinally. (See Fig. 19.) The motive forces are represented by P^d. They give rise to a friction amounting to $f \times P^d$ and to a reaction R^d. This reaction increases with an increase in the inclination of the rollers, and the blank will slip between the rollers when the coefficient of friction between the blank and the rollers will be equal to tg. $\frac{N^c}{2}$.

The number of rollers employed should be at least three. With this number smaller cylindrical pieces can be produced than with four rollers of the same diameter. Fig. 10 shows the arrangement of three rollers.

As nearly as possible the rollers should be equally spaced from each other and from the center of the apparatus. I may also rotate only some of the rollers, as is sometimes done in the manufacture of certain articles with ordinary rolling-mills.

As shown in Fig. 11, I may at the same time produce a piece of varying diameter and press with two rollers only. The two small rollers will serve as guides and the large ones will produce a circular groove or incision by compressing the blank, permitting of its being readily divided.

A hollow blank may be worked by inserting therein a mandrel, as is done in the manufacture of some articles forged, with a steam-hammer or a press. Blanks of polygonal cross-section originally may also be worked with my rolling-mill.

Instead of chains for suspending the blank I may employ loosely-mounted supporting-rollers.

It will be understood that according to circumstances I may employ only one of the two modes of moving the rollers, (hydraulic pressure and screw mechanism.)

Having thus described my invention, I claim as new and desire to secure by Letters Patent—

1. A rolling-mill, comprising a series of rollers surrounding a central space adapted to receive the blank, slides carrying the said rollers and arranged to move radially in the frame of the machine, the rollers being carried bodily by the slides so that during the movement of the slides the axes of the rollers remain parallel to their original positions, means for moving said slides radially with the rollers, and means for rotating the rollers while they are being moved inward against the blank, substantially as described.

2. A rolling-mill, comprising a series of rollers surrounding a central space adapted to receive the blank, slides mounted to move radially in the frame of the machine and carrying the said rollers bodily, so that during the movement of the slides the axes of the rollers remain parallel to their original positions, a set of levers fulcrumed on the frame and connected to the slides to move the same in unison, and means for rotating the rollers while they are being moved inward against the blank, substantially as described.

3. A rolling-mill, comprising a series of rollers surrounding a central space adapted to receive the blank, slides carrying said rollers and mounted to move toward and from the

said central space, the rollers being carried bodily by the slides so that during the movement of the slides the axes of the rollers remain parallel to their original positions, a connection between all of said slides to compel them to move in unison, and means for rotating the rollers while they are being moved inward against the blank, substantially as described.

4. A rolling-mill, comprising a series of rollers surrounding a central space adapted to receive the blank, slides mounted to move radially and carrying said rollers, said slides consisting of nuts having guided movement in the frame of the machine, and radial screws carried by said nuts and connected to the bearings of said rollers, substantially as described.

5. A rolling-mill, comprising a series of rollers surrounding a central space adapted to receive the blank, slides mounted to move radially and carrying said rollers, said slides consisting of nuts having guided movement in the frame of the machine, and screws carried by said nuts and connected to the bearings of said rollers, a connection between all of the nuts to cause them to slide in unison, and a connection between all of the screws to cause them to turn in unison, as and for the purpose set forth.

6. A rolling-mill, comprising a series of rollers surrounding a central space adapted to receive the blank, slides mounted to move radially in the frame of the machine, a connection between said slides whereby they are compelled to move in unison, mechanism for moving said slides, radially-arranged rotatable supports having a screw connection with said slides and carrying bearings for said rollers, and adjusting mechanism connected to all of said supports to rotate them in unison, substantially as described.

7. A rolling-mill, comprising a series of rollers surrounding a central space adapted to receive the blank, slides mounted to move radially in the frame of the machine, a connection between said slides whereby they are compelled to move in unison, mechanism for moving said slides, radially-arranged rotatable supports having a screw connection with said slides, bearings having a swivel connection to the inner ends of the said supports and receiving the journals of said rollers, and adjusting mechanism connected to all of said supports to rotate them in unison, substantially as described.

8. A rolling-mill, comprising a series of rollers surrounding a central space adapted to receive the blank, slides mounted to move radially in the frame of the machine, a connection between said slides whereby they are compelled to move in unison, mechanism for moving said slides, radially-arranged rotatable supports having a screw connection with said slides and carrying bearings for the said rollers, toothed wheels mounted on said supports, gear-wheels rotatably mounted on the frame, links pivotally connected with each other and with said toothed wheels and gear-wheels, motion-transmitting wheels carried by the links at their connecting-points and engaging the said toothed wheels and gear-wheels, and a connection between all of said gear-wheels to cause them to turn in unison, substantially as described.

9. A rolling-mill, comprising a series of rollers surrounding a central space adapted to receive the blank, slides mounted to move radially in the frame of the machine, a connection between said slides whereby they are compelled to move in unison, mechanism for moving said slides, radially-arranged rotatable supports having a screw connection with said slides and carrying bearings for the said rollers, toothed wheels mounted on said supports, gear-wheels rotatably mounted on the frame, links pivotally connected with each other and with said toothed wheels and gear-wheels, motion-transmitting wheels carried by the links at their connecting-points and engaging the said toothed wheels and gear-wheels, supplemental wheels journaled in the frame and engaging sundry of the said gear-wheels, and a connection between said supplemental wheels and the gear-wheels to cause them to turn in unison, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

PAUL JEAN DELAY.

Witnesses:

ERNEST DOT D'WALT,

FERNAND O. DESBARAT.