No. 799,088. PATENTED SEPT. 12, 1905.

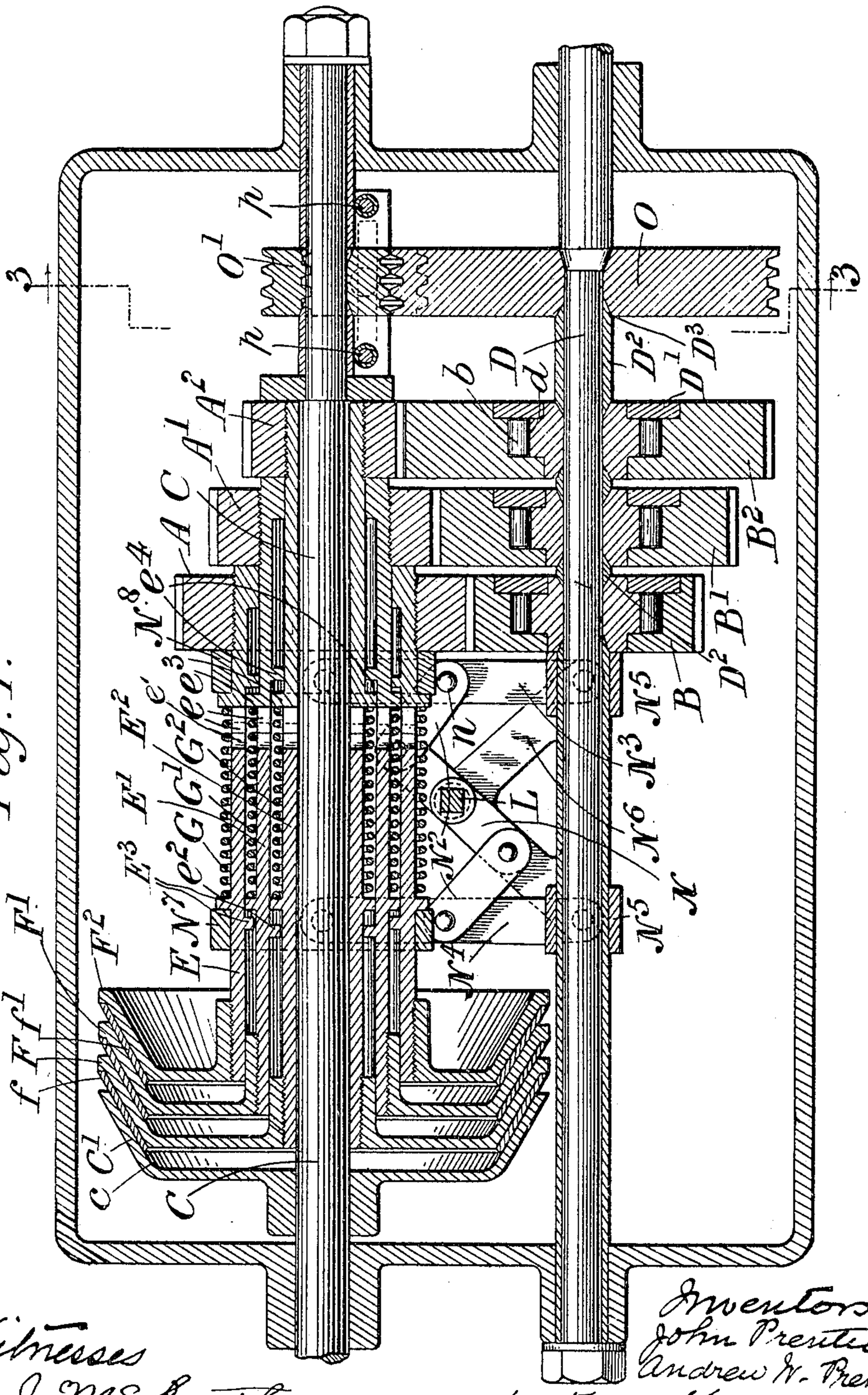
J. & A. W. PRENTICE.

VARIABLE SPEED GEARING.

APPLICATION FILED AUG. 3, 1903.

8 SHEETS—SHEET 1.

Fig. 1.



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8 SHEETS—SHEET 2.

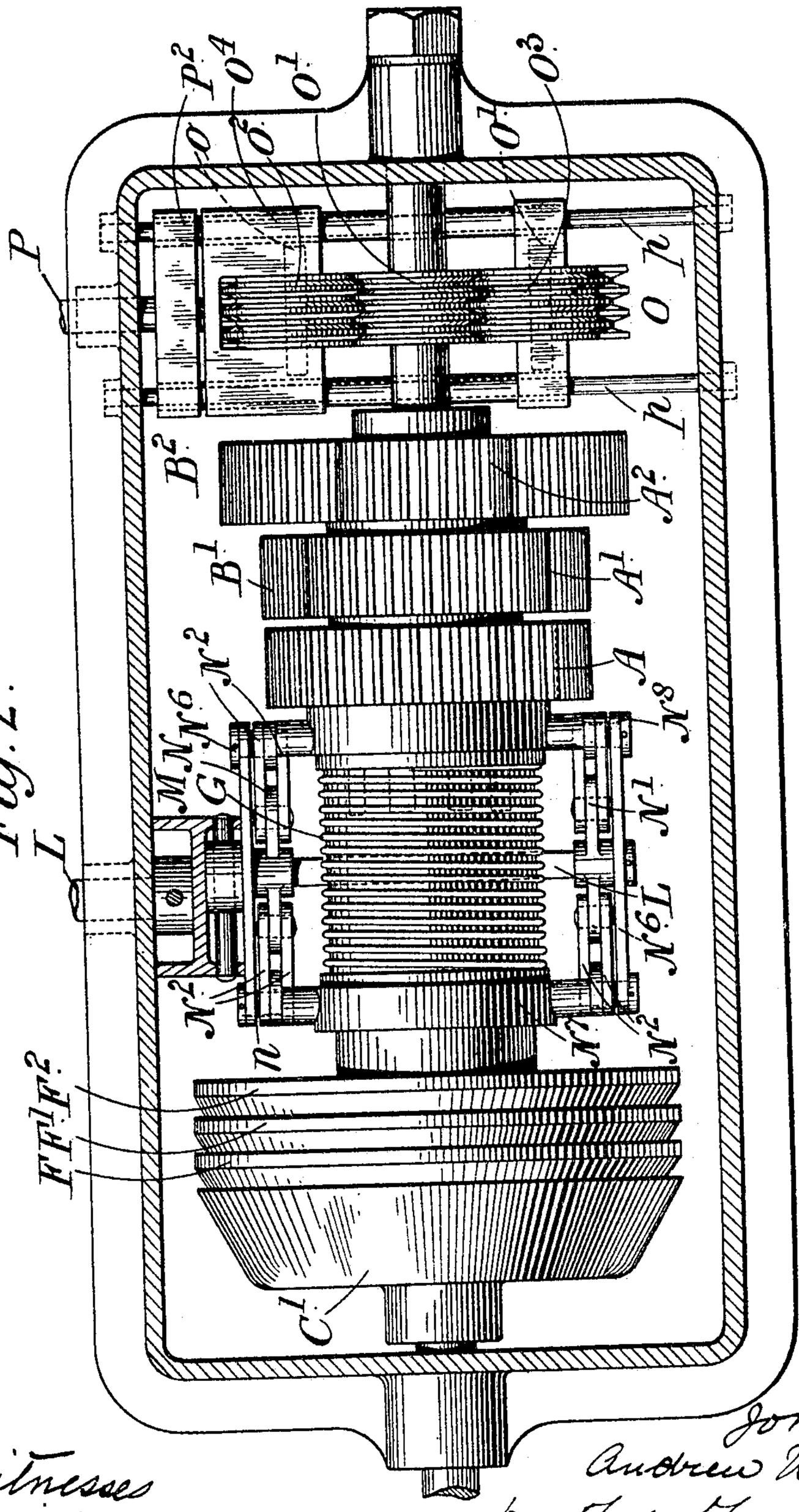

Fig. 2.

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8 SHEETS—SHEET 3.

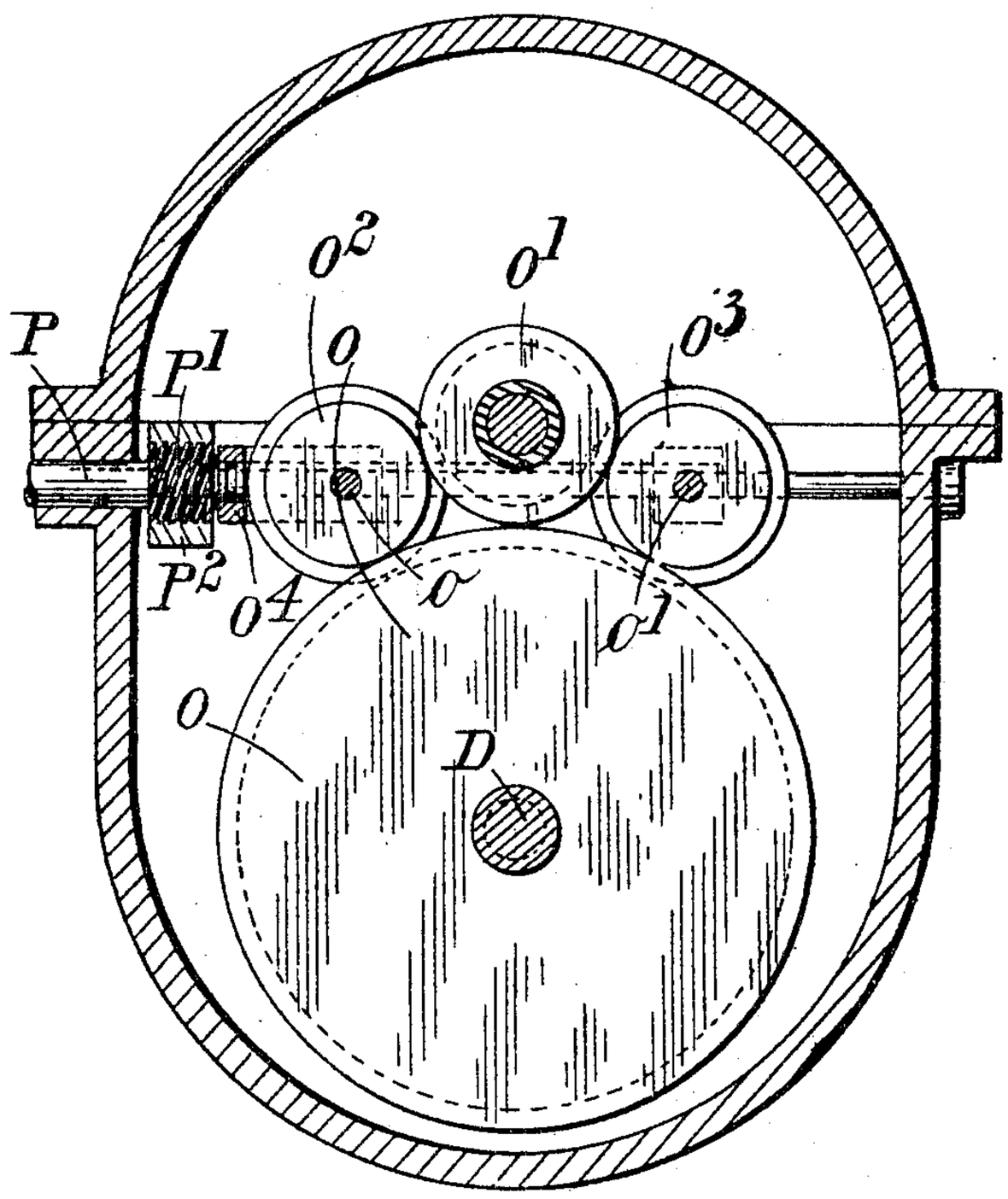

Fig. 3.

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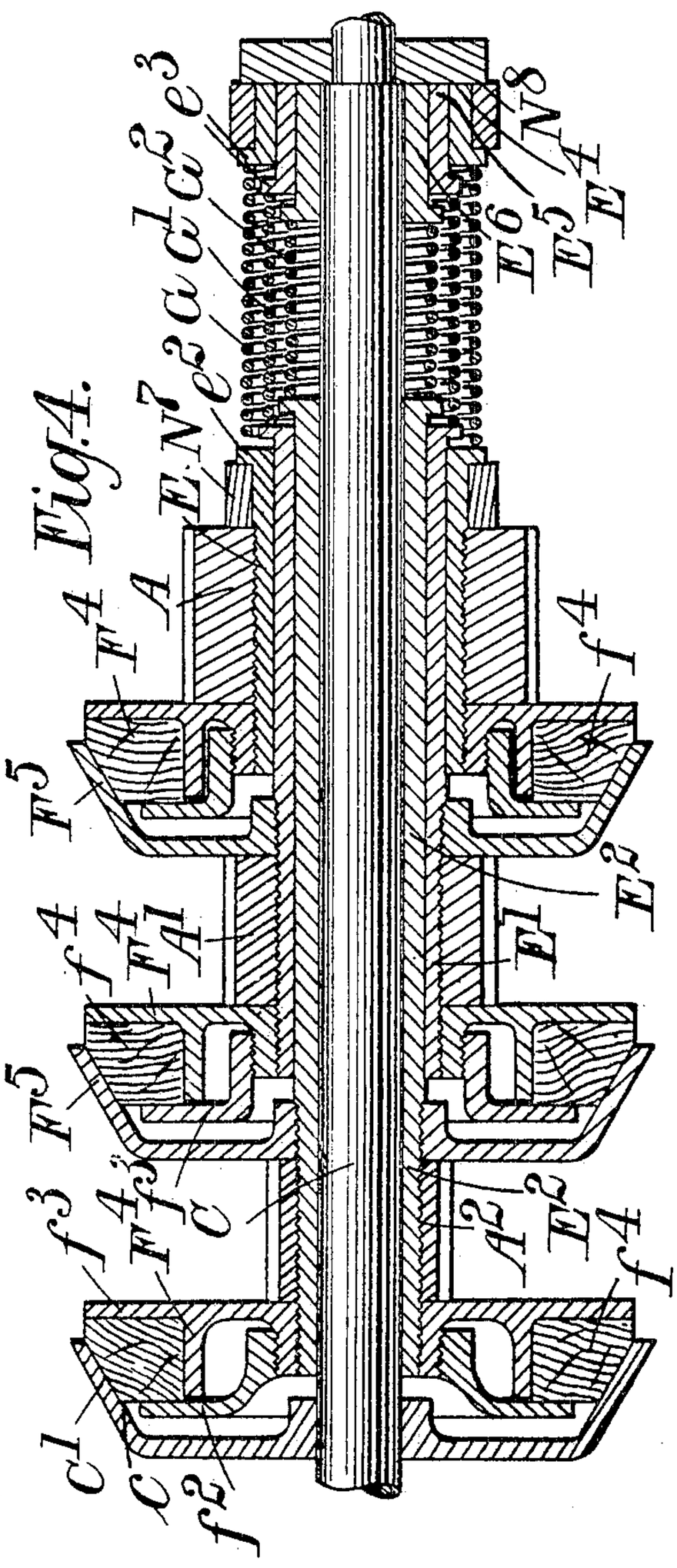
8 SHEETS—SHEET 4.

Fig. 4.



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8 SHEETS—SHEET 5.

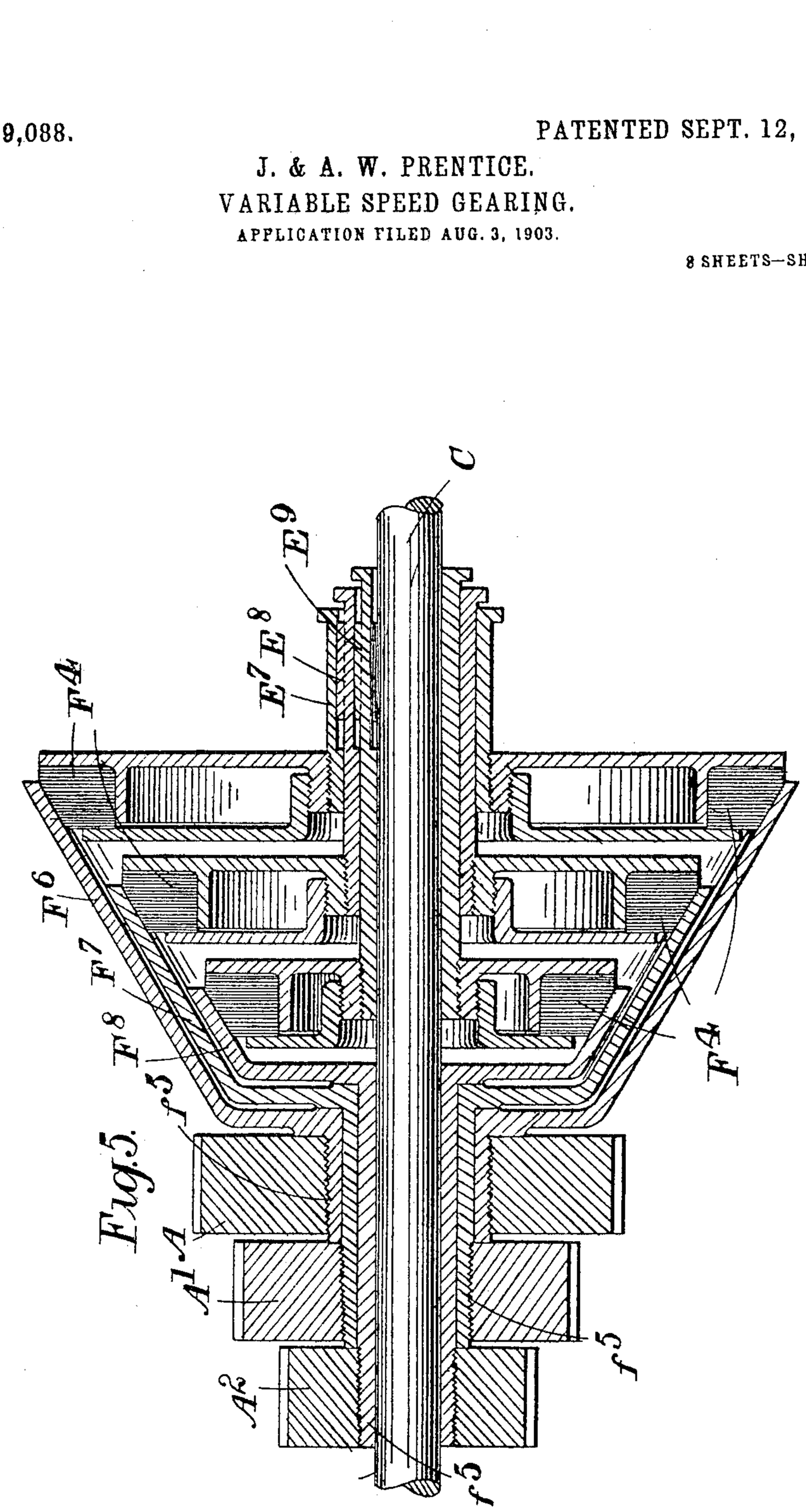

Fig. 5.

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8 SHEETS—SHEET 6.

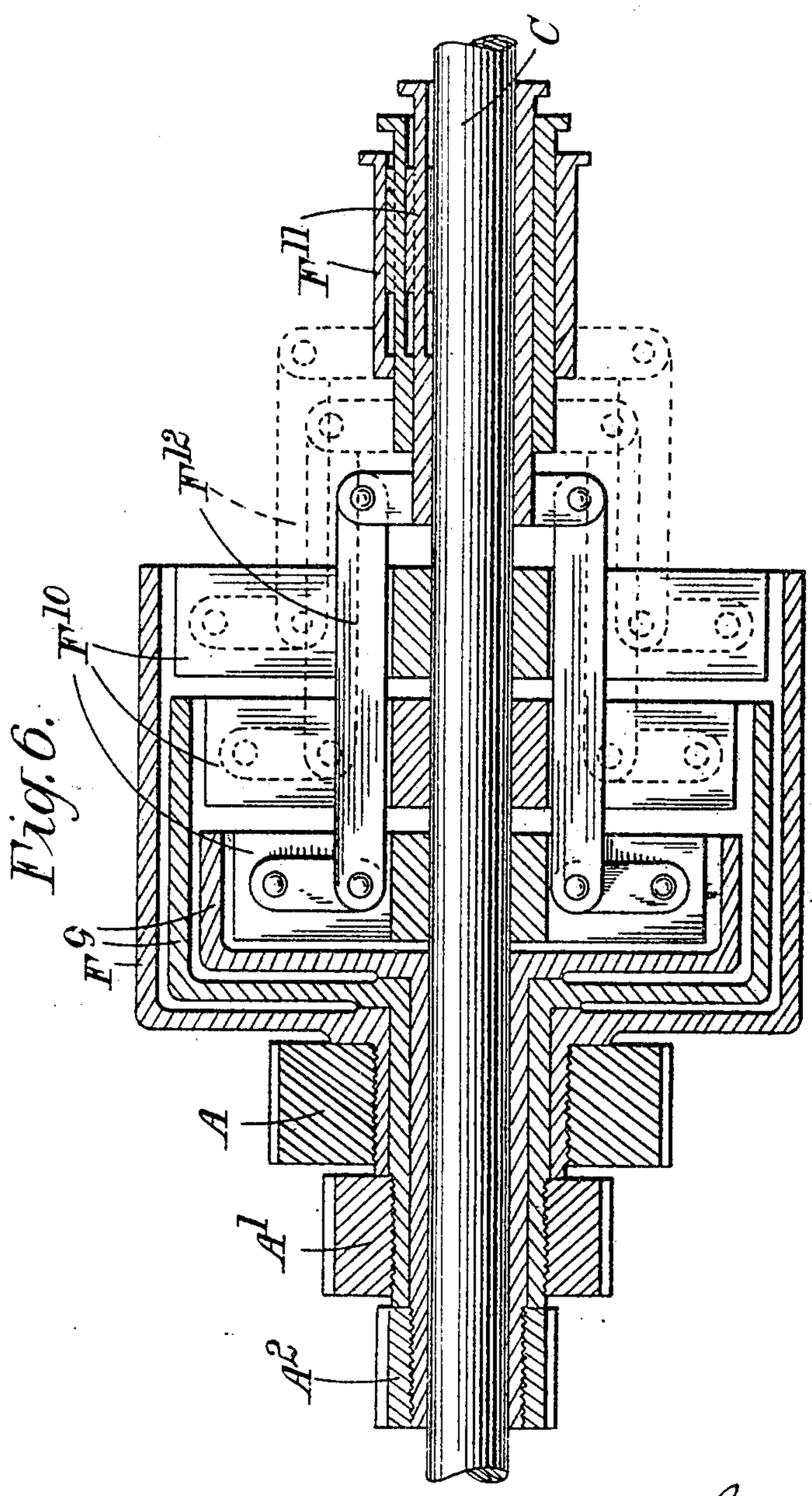

Fig. 6.

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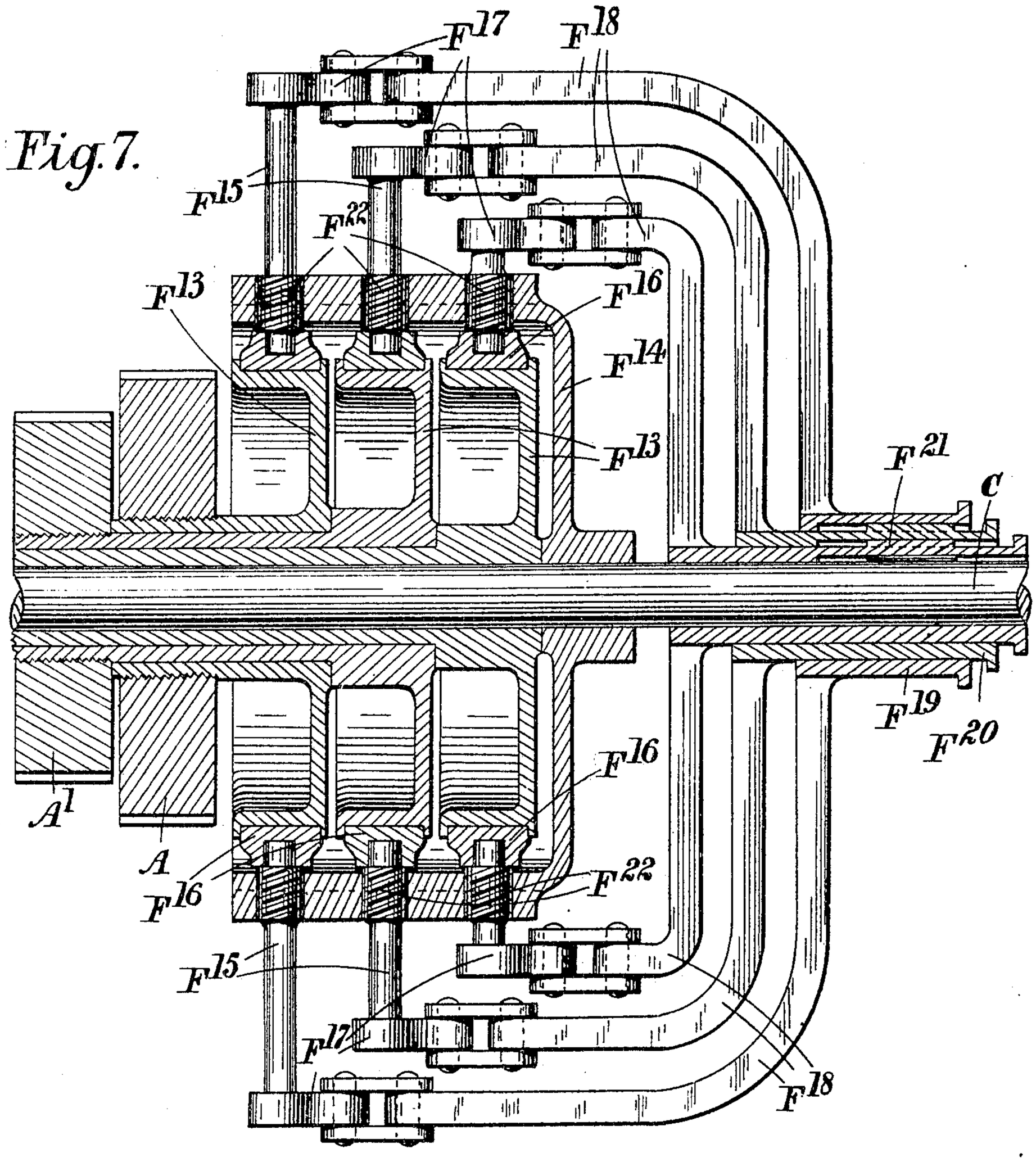
8 SHEETS—SHEET 7.

Fig. 7.



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8 SHEETS—SHEET 8.

Fig. 8.

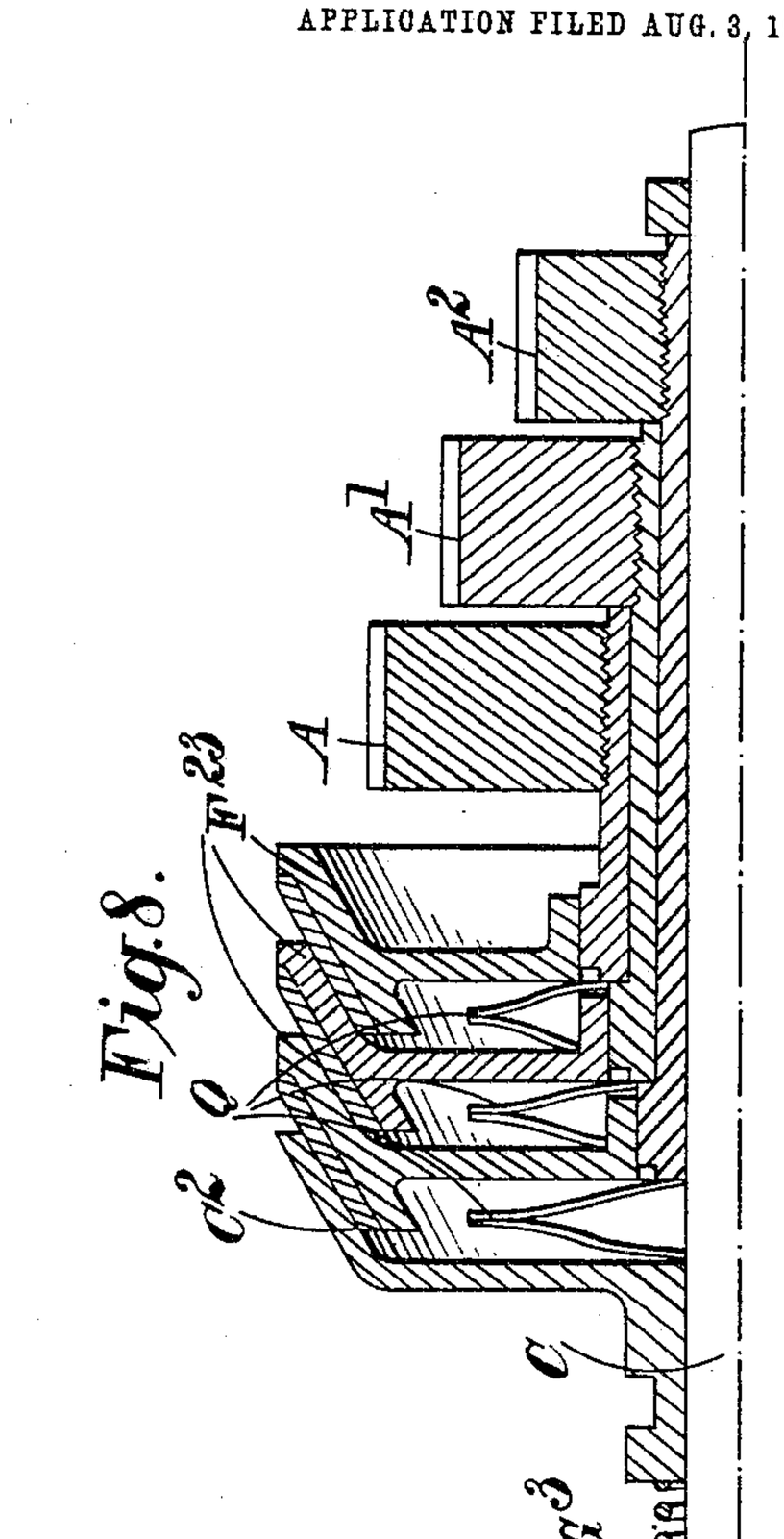
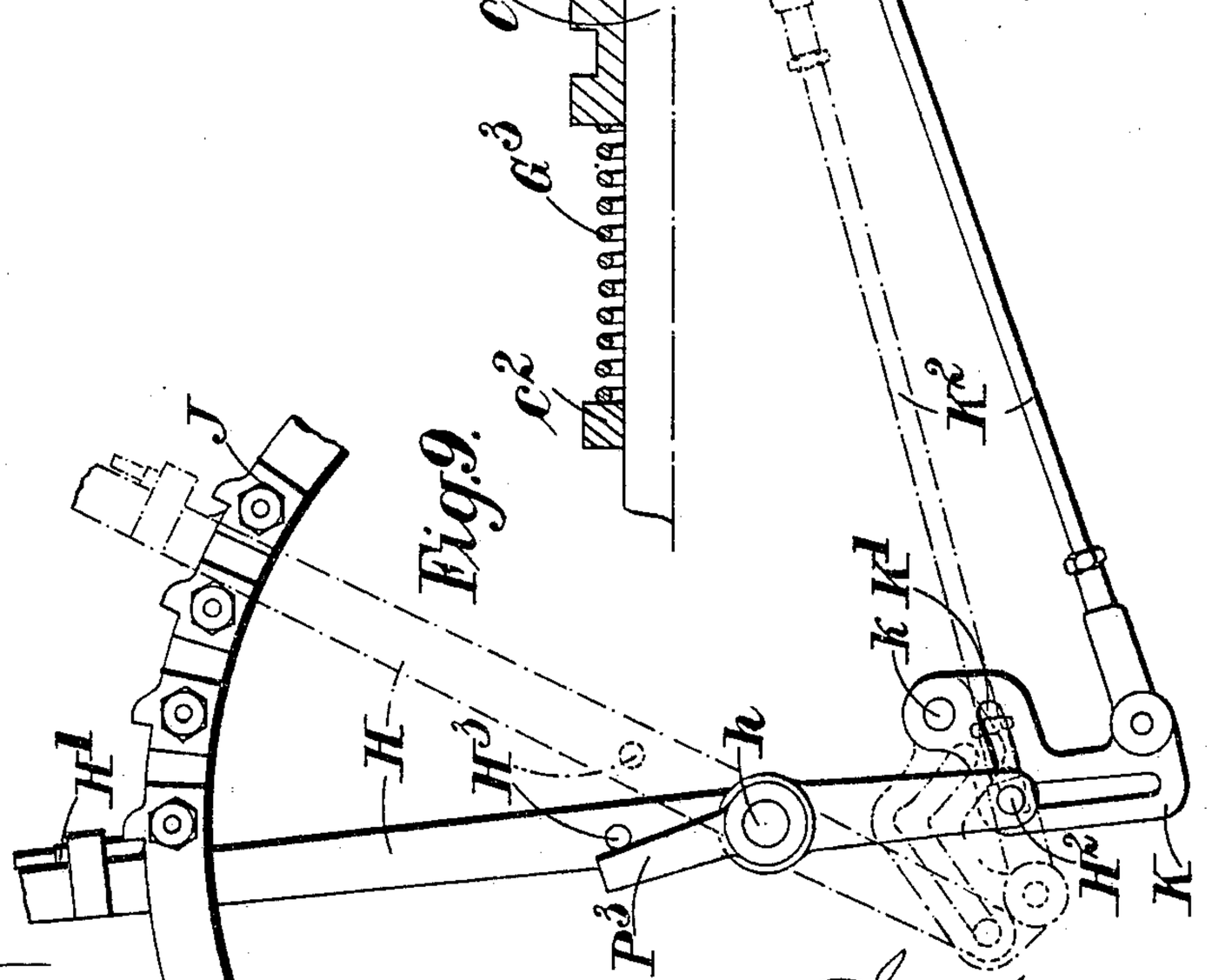


Fig. 9.



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UNITED STATES PATENT OFFICE.

JOHN PRENTICE AND ANDREW W. PRENTICE, OF LANARK, SCOTLAND.

VARIABLE-SPEED GEARING.

No. 799,088. Specification of Letters Patent. Patented Sept. 12, 1905.

Application filed August 3, 1903. Serial No. 168,056.

To all whom it may concern:

Be it known that we, JOHN PRENTICE and ANDREW WESTON PRENTICE, subjects of the King of England, residing at Lanark, Scotland, have invented certain new and useful Improvements in or Relating to Variable-Speed Gearing, of which the following is a specification.

This invention relates to variable-speed gearing, and has for its chief object to enable the changes of speed of the driven shaft or member to be made without necessitating the disengagement of the intermeshing gear wheels or pinions, thereby enabling the increase or decrease of speed to be accomplished without bringing sudden stress upon the driving-shaft, and consequently avoiding sudden shocks to the mechanism.

According to this invention a stepped series or set of gears or toothed pinions is mounted on the driving or driven shaft or member, and means are provided for connecting the gears together and one of them to the driving-shaft, and a corresponding set of gears is mounted on the driven shaft, so as to intermesh with the gears of the driving-shaft. Means are also provided whereby each gear on the driven shaft is automatically connected to its shaft or disconnected therefrom, according as a higher-speed pair of gears is disengaged or brought into action.

Conveniently the gears mounted on the driving-shaft are provided with double friction-clutches, by which they can be connected together and one of them to a corresponding friction-clutch fast on the driving-shaft, and the gears on the driven shaft are provided with clutches which are operative in one direction only. One friction-surface of the first gear on the driving-shaft can be connected directly to the friction-surface on the shaft, and the other surface can be engaged by one of the clutch-surfaces on the next gear when the latter is operated, a third gear being clutched to the second, and so on with all the gears of the series. When a pair of gears of high speed comes into operation, the previously-operating gears are, as above stated, not disengaged; but the gear on the driven shaft is automatically disconnected therefrom by its "free-wheel" clutch.

The friction-clutches or the gears on the driving-shaft are controlled by a single handle or lever, which operates them successively by a movement in one direction to gradually increase the speed, a movement of the handle in the opposite direction giving a gradual diminution of speed. A further movement of the handle in this latter direction operates the reversing mechanism. The clutches may be operated positively in both directions, or they may be operated in one direction by the handle and returned by springs.

Referring to the drawings, Figure 1 is a sectional elevation, Fig. 2 a plan, and Fig. 3 a section on the line 3 3 of Fig. 1, of one form of gearing constructed in accordance with this invention. Figs. 4, 5, 6, 7, and 8 are sectional elevations of modified constructions, and Fig. 9 is a side elevation of the controlling handle or lever.

Like letters indicate like parts throughout the drawings.

Referring more particularly to Fig. 1, the driving-pinions A A′ A^2 are mounted loose on the driving-shaft C and gear with corresponding pinions B B′ B^2 on the driven shaft D. The pinions A A′ A^2 are secured to concentric sleeves E E′ E^2, which carry at their other ends conical friction-drums F F′ F^2, respectively secured to the sleeves E E′ E^2. A corresponding friction-drum C′ is secured to the shaft C and adapted to engage by its inner surface *c* with the external friction-surface *f* of the drum F, of which the inner surface *f*′ is in turn engaged by the external friction-surface of the drum F′, and so on with the remaining drums. The sleeves carrying the friction drum and gears are made in two parts, as shown, so that part of the sleeve carrying the friction-drums can move axially and relatively to the part carrying the gear. The two parts of the sleeve are connected together by a telescopic coupling, consisting of teeth *e e*′, formed on the meeting ends of the two parts and intermeshing with each other. A facing of leather, wood, or other appropriate material may, as shown, be attached to the external surface of each drum to form a friction or bearing surface. Around the sleeves are disposed springs G G′ G^2, which lie between collars e^2 e^3, formed on the separate parts of the sleeve and adapted to constantly press their respective friction-drum into contact with its neighbor. On the inner surface of each sleeve is formed an internal rib or projection E^3, which after the sleeve E has been moved to disengage its friction-drum comes against the collar e^2, formed on the exterior of the adjacent sleeve E′, and a further movement of the sleeve E causes its internal projection E^3 to come against the collar e^2 on the

sleeve E^2, so as to cause it to disengage its friction-drum. The sleeve E^2, which takes a bearing on the shaft C, has attached to its free end the lowest-speed pinion A^2, the intermediate-speed pinion A′ being attached to the sleeve E′, while the highest-speed pinion A is carried on the outermost sleeve E. When the gears are operated, the spring G^2, surrounding the sleeve E^2, first moves its clutch F into engagement with the clutch C′ on the shaft giving the slowest speed of which the gear is capable. A further movement of the controlling-lever causes the sleeve E′ to move axially, the clutch F′ engaging with its outer surface the internal friction-surface of the drum F, which remains in contact by its outer surface with the friction-drum C′, so that the intermediate speed is obtained, and a still further operation causes the sleeve E to move to engage the friction-drum F^2 with the drum F′, the gear then giving its highest speed. The driven pinions or gear-rings B B′ B^2 are provided with free-wheel clutches, or clutches operative in one direction only, and preferably these are in the form of pawls *b*, which engage with ratchet-teeth *d*, formed on hubs D′, secured to the driven shaft D. Conveniently these hubs are made fast on the driven shaft by means of sleeves D^2, which have tapered split ends D^3, which enter openings in the hubs from each side and secure them to the shaft. An operating-handle H is pivoted to a stationary support at *h* and adapted to move over a quadrant J, which is notched for the various speeds obtainable. H′ is a sliding catch carried by the handle H and adapted to engage with the various notches on the quadrant. At its lower end the lever H has a projection or pin H^2, adapted to move in an L-shaped slot K′ in a plate K. The plate K is pivoted at *k* and has pivoted to it an adjustable link K^2, the other end of which is pivoted to a crank L′ on the operating-shaft L. As shown in Fig. 2, the shaft L is mounted at right angles to the driving and driven shafts and is made in two parts connected together by an Oldham or similar coupling M. The inner part of the shaft L passes through the gearing and carries at opposite sides of the shaft C levers N N′, which have pivoted to their opposite ends links N^2, which are in turn pivoted to rods N^3 N^4. The rods N^3 N^4 are pivoted at one end to sliding bearings N^5, mounted loosely on the shaft D and connected together by triangular or other plates N^6, which support the opposite ends of the inner part of the shaft L. The links N^2 are pivoted at a point *n* intermediate of the ends of the rods N^3 N^4, which at their upper ends are pivoted to sleeves or collars N^7 N^8, of which the collar N^7 embraces the part of the outermost sleeve carrying the clutch-surface and the collar N^8 the part of the sleeve carrying the pinion.

The controlling-handle shown in Fig. 9 (which view is taken from the opposite side to that of the gearings illustrated in the other views of the drawings, so that the positions of the shafts L and P are reversed) is in the position it assumes when all the friction-clutches are disengaged and no driving action is taking place. In this position the springs G G′ G^2 or their equivalent are compressed, and if the controlling-lever be now moved in the direction of the arrow the pin H^2 moves in the straight arm of the slot K′ and causes the plate K to rotate on its pivot, thereby operating the crank L′ and rotating the controlling-shaft L. This latter shaft in rotating causes through the link mechanism above described the collars N^7 and N^8 to move apart, permitting the spring G^2 to first expand, thereby putting the lowest-speed clutch into operation. The two remaining driving-pinions A A′ are still out of action, their corresponding pinions B B′ being idle on the shaft D by means of their free-wheel clutches. A further movement of the lever next permits the spring G′ to expand and the intermediate gear comes into operation, while a still further movement causes a higher-speed gear to operate, and so on till all the clutches are in engagement.

When the shaft L is rotated to withdraw the high-speed clutch, the two collars N^7 N^8 are caused to approach each other and bearing against the external collars e^2 e^3 on the sleeve E compress the spring G and withdraw the drum F^2 from engagement with the drum F′. When this takes place, the pinion A ceases to rotate or rotates idly, as the pinion A′ now acts as the driving-pinion, its corresponding pinion B′ being automatically clutched to the driven shaft, while the pinion B is automatically released by its free-wheel clutch from the driven shaft. A further operation of the controlling-lever causes the projection E^3 on the inner surface of the sleeve E to come against the external collar e^2 on the sleeve E′, the collar e^3 on the other part of the sleeve coming against another internal collar e^4 on the other part of the sleeve E. The gear is now running at its lowest speed, and a further movement of the controlling-lever causes the sleeve E′ to slide along and bring its internal collar e^3 against the external collar e^4 of the sleeve E^2, the collar e^3 of which bears against a corresponding collar e^4 on the sleeve E′.

Wear is conveniently taken up automatically, since the pivots of the rods N^3 N^4 are rigidly connected together by the plate N^6, which also prevents these pivots varying their distance from the inner part of the shaft L. The inner part of the shaft L and the mechanism connected thereto can thus move bodily along the shafts D and C, and the coupling M permits this motion to take place without interfering with the operating-lever H, which is connected to the outer part of the shaft L.

The reversing mechanism conveniently comprises a pinion O, fixed to the shaft D, and a

pinion O′, carried on the shaft C. With these pinions mesh idle pinions O³, which are mounted on opposite sides of the shaft. One of the pinions is mounted on a spindle *o*, carried in a frame O⁴, to which is connected in such a manner that it can rotate therein the inner end of a shaft P. On the shaft P is formed a quick screw-thread P′, which gears with a corresponding screw-threaded part P² on a frame carrying the other pinion O³, which is mounted on a short spindle *o*′, carried therein. These frames slide on supports *p*, and when the shaft P is rotated in one direction the two frames are drawn together to cause the idle pinions to gear with the pinions O O′, and when the shaft is rotated in the opposite direction the pinions are moved apart to put the reversing mechanism out of action.

Conveniently the reversing mechanism is operated by the lever H, which carries for this purpose a projection H³, adapted to engage with an arm or trigger P³ on the shaft P. When the lever is in the position that all the friction-clutches are out of engagement, a further movement to the left causes the pin H³ to come against the projection P³ and rotate the shaft P, as above described.

Although the gear above described is designed to give three forward speeds, it is to be understood that by adding other pinions provided with clutches on the driving-shaft and corresponding pinions on the driven shaft other speeds can be obtained.

Referring now to the modification shown in Fig. 4, the pinions A A′ A² are mounted on the concentric sleeves, as in the previous example; but the clutches are made in two parts and mounted at the opposite sides of the pinions, the sleeves in this case each being made in a single part in place of in two parts, as in the previous example. Mounted on the shaft C is a plate C′, having an internal conical friction-surface *c*, and with it engages the external friction-surface *f*⁴, carried by the sleeve of the pinion A². Secured to the sleeve E² at the opposite side of the pinion from the friction-surface F⁴ is a plate F⁵, having an internal friction-surface, with which engages the external friction-surface of the clutch F⁴, carried by the sleeve E′ of the pinion A′, and the sleeve E′ also carries at the opposite side of the pinion a friction-clutch F⁵, with which engages the friction-clutch F⁴, carried by the sleeve E of the pinion A. According to this example the springs G G′ G² are mounted between the ends of their respective sleeves and the ends of the collars mounted loosely on the shaft C. The sleeves or rings N⁷ N⁸, already described, are mounted, respectively, on the outermost sleeve E and on the outermost collar E⁴. Under normal conditions the clutches F⁴, carried by the various sleeves, are in engagement with the clutches F⁵ on the neighboring sleeves, the clutch F⁴ on the end sleeve or lowest speed being in engagement with the clutch C′ on the driving-shaft, the gear being now in position to give its highest speed. When the controlling-handle is moved, the shaft L is rotated and through the connecting mechanism causes the collar N⁷, which bears against the external collar *e*² of the sleeve E, to compress the spring G and at the same time withdraw the clutch F⁴ of the sleeve E, thereby throwing the pinion A out of action and with it the corresponding pinion B on the driven shaft, which is automatically released by its free wheel. A further operation of the controlling mechanism causes the collar *e*² on the sleeve E and the collar *e*³ on the sleeve E⁴ to approach each other and bear against the collars *e*² and *e*³ on the sleeves E′ and E⁵, respectively. This withdraws the clutch F⁴ and the sleeve E′, carrying the intermediate-speed pinion A′, and therefore disengaging the pinion B′ from the driven shaft, so that the gear now runs at its lowest speed. A still further operation of the controlling-lever withdraws the low-speed clutch on the sleeve E², so that no driving motion takes place through the gear. In order that the pinions A A′ A² may slide with their sleeves without being disengaged from their corresponding pinions B B′ B² on the driven shaft, these first-mentioned pinions are made of different lengths, as shown clearly in Fig. 4. In withdrawing the various gears the springs G G′ G² are compressed, so that when the controlling-lever is moved in the opposite direction the springs are released successively and in such manner that the clutch F⁴ of the low-speed gear first engages with the clutch C′ on the driving-shaft, the intermediate-speed gear being brought into operation by a further movement and finally the highest-speed gear. Conveniently the friction-clutches F⁴ consist of two plates *f*² *f*³, which retain between them blocks of wood *f*⁴, which rest on a flange on a plate *f*², which is screwed to the sleeve, and the plate *f*³ is screwed to the plate *f*². The outer edge of the block *f*⁴ is tapered to correspond with the internal friction-surface of the clutch F⁵.

In the modified construction shown in Fig. 5 the pinions A A′ A² are mounted on hubs or sleeves *f*⁵ of conical clutch members F⁶ F⁷ F⁸, respectively. These friction-clutches are mounted coaxially and are of different lengths, so that each succeeding clutch extends beyond the other, as shown. Coacting clutch members F⁴, similar in construction to those already described with reference to Fig. 4, are adapted to engage with the respective clutches F⁶ F⁷ F⁸. The clutch F⁴, which engages with the clutch F⁸, connected to the pinion A², is carried by a sleeve E⁹, which is mounted on the shaft C and connected to it by a groove-and-feather coupling, so that the sleeve can slide axially on the shaft, but is constrained to rotate with it. Mounted concentrically on the sleeve E⁹ is a sleeve E⁸, connected to the sleeve E⁹ by a groove-and-feather coupling,

and a third sleeve E^7 is mounted on the sleeve E^8, to which it is connected in a similar manner. In this case the springs G G′ G^2 bear against the ends of the sleeve E^7 E^8 E^9, which are acted upon by the springs and by controlling mechanism in a similar manner as the sleeves E E′ E^2 are acted upon in the foregoing examples. The sleeves E^7, E^8, and E^9 may be made in two parts, as described in the first example with reference to Figs. 1 to 3 or as described with reference to Fig. 4.

A further modification is illustrated in Fig. 6, in which expanding clutches are employed. In this case the pinions A A′ A^2 are mounted on the hubs of concentric drums F^9, which extend beyond each other, the innermost drum being the shortest. Within each drum and fixed on the driving-shaft are expanding clutches F^{10}, carried by sleeves F^{11}, which are mounted concentric upon each other and connected by a groove-and-feather coupling or other connection, permitting the sleeves to move axially relatively to each other, but causing them to rotate together. The innermost sleeve F^{11} is connected by a groove-and-feather coupling to the shaft C, and between each sleeve F^{11} and its corresponding expanding clutch F^{10} is disposed crank mechanism F^{12}, so that as each sleeve is moved axially relatively to the others the mechanism F^{12} causes the clutch F^{10} to expand and engage its corresponding drum F^9 or to be disengaged from it, according as the sleeve is moved to the right or to the left.

In the construction shown in Fig. 7 collapsing or contracting friction-clutches are employed instead of expanding ones, as above described. According to this construction the pinions A A′ A^2 are mounted on concentric sleeves carrying brake-drums F^{13}. Mounted loosely on the shaft C is a cylinder F^{14}, through which a series of studs F^{15} project and carry at their inner ends blocks F^{16}, adapted to engage with the various drums F^{13}. The studs which engage with the drum F^{13} of the pinion A carry at their outer ends cranks F^{17}, the other ends of which are connected to arms F^{18} on a sleeve F^{19}. Similar cranks and arms are provided on the studs F^{15}, which are adapted by their blocks F^{16} to engage with the drums connected to the pinions A′ A^2, and these cranks are connected in turn to arms on the sleeves F^{20} F^{21}. The sleeve F^{21} is connected to the shaft C by a groove-and-feather coupling, and the sleeves F^{20} F^{19} are connected to each other in a similar manner. The arrangement is that when one of the sleeves is moved axially relatively to the other it operates, through its arms F^{18} and crank F^{17}, one of the series of studs passing through the drum F^{14}. This causes the studs F^{15} to rotate, and these are provided with a quick screw-thread F^{22}, passing through a correspondingly-screw-threaded pinion in the drum F^{14}, causing the blocks F^{16} to be compressed against their corresponding drum F^{13}, thereby locking one of the pinions A, A′, or A^2 to the driving-shaft C.

In the construction shown in Fig. 8 the pinions A A′ A^2 are mounted on concentric sleeves which are free to rotate relatively to each other and to the driving-shaft C. On the opposite ends of the sleeves are carried friction-drums F^{23}, which are capable of moving axially on the sleeves, but are constrained to rotate with them and which have internal and external friction-surfaces. The friction-drum C^2 is mounted on a shaft C so that it is free to move axially thereon, but rotates constantly with the shaft. Between the boss of the frame C^2 and a stop or shoulder c^2 on the shaft is disposed a spring G^3. Between each pair of drums is mounted a plate-spring Q, which tends to force the drums away from each other. Assuming the parts to be in the position shown in the drawings, all the clutches are in engagement, so that the pinion A is the driving-pinion and the gear is giving its highest speed. Should the clutch C^2 be moved to compress the spring G^3, then momentarily the spring Q between C^2 and drum of the pinion A^2 will expand, to be followed immediately by the expansion of the springs between the drums of the pinions A^2 A′; but the final expansion will rest with the springs between the drums of the pinions A′ and A, resulting in the pinion A being disconnected. A further compression of the spring G^3 will result in the pinion A′ being disconnected, and finally the pinion A^2 by a further compression of the spring G^3 will be released. When the spring G^3 is allowed to expand, the spring Q between the drums C^2 and C′ of the pinion A^2 will first be compressed, since the remaining springs Q will act in conjunction with the spring G^3 to give this result, and a further expansion of G^3 will result in the intermediate spring Q being compressed and the intermediate pinion A′ coming into action. The springs Q between the several gears are of unequal strength and so arranged that the clutches are successively actuated, as above described.

The action above described is due to the fact that the spring Q, controlling the friction-clutch of the outermost gear, has less resistance to act against than the other springs, and therefore expands first.

In all cases the speed obtained from the gearing is increased by bringing into action a friction-clutch connected to a pinion without disengaging the clutch which has hitherto been in operation, and the pinion on the driven-shaft gearing, with the pinion connected to the clutch, is automatically disconnected by means of a free wheel-clutch, a decrease of speed being obtained by disengaging the clutches successively.

What we claim as our invention, and desire to secure by Letters Patent, is—

1. In a variable-speed gearing, the combination with two shafts, a stepped series of gears, means for connecting one of the gears to one of said shafts, and means for connecting all the gears together successively, of a second stepped series of gears mounted loosely on the second shaft and meshing with the first series, and means for automatically connecting and disconnecting each gear of the second series and its shaft when a higher-speed pair is released and brought into action respectively.

2. In a variable-speed gearing, the combination with a driving member, a driven member, a stepped series of gears, means for connecting one of the gears directly to the driving member and means for connecting all the gears of the series together successively, of a second stepped series of gears intermeshing with the first series, and means for automatically connecting each driven gear to the driven member when the corresponding gear is connected to the driving member and automatically disconnecting it therefrom when its driving-gear is released.

3. In a variable-speed gearing, the combination with a driving member, a driven member, a stepped series of gears, means for connecting one of the gears directly to the driving member, means for connecting all the gears of the series together successively, and controlling means for operating the connecting means, of a second stepped series of gears intermeshing with the first series, and means for automatically connecting each driven gear separately to and disconnecting it from the driven member respectively when a higher-speed pair is brought into or put out of action.

4. In a variable-speed gearing, the combination with a driving member, a driven member, a stepped series of gears, means for connecting one of the gears directly to the driving member, means for connecting all the gears of the series together successively, and controlling means for operating the connecting means, of a second stepped series of gears intermeshing with the gears of the first series, means for automatically connecting each driven gear separately to and disconnecting it from the driven member respectively when a higher-speed pair is brought into or out of action, and means for reversing the direction of motion of the driven member.

5. In a variable-speed gearing, the combination with a driving-shaft, a driven member, a stepped series of gears, means for connecting one of the gears directly to the driving-shaft, means for connecting all the gears of the series together successively, and controlling means for operating the connecting means, of a second stepped series of gears intermeshing with the first series, means for automatically connecting each driven gear separately to and disconnecting it from the driven member respectively when a higher-speed pair is brought into or out of action, means for reversing the direction of motion of the driven member, and means for operating the reversing means.

6. In a variable-speed gearing, the combination with a driving-shaft, a driven member, a stepped series of gears, means for connecting one of the gears directly to the driving-shaft, means for connecting all the gears of the series together successively, and controlling means for operating the connecting means, of a second stepped series of gears intermeshing with the first series, means for automatically connecting each driven gear separately to and disconnecting it from the driven member respectively when a higher-speed pair is brought into or out of action, means for reversing the direction of motion of the driven member, and means connected with the speed-controlling means for operating the reversing means.

7. In a variable-speed gearing, the combination with a driving-shaft, a driven shaft, a stepped series of gears, of means for connecting one of the gears directly to the driving-shaft, means for connecting all the gears together, a second stepped series of gears gearing with the first series and means operative in one direction only for automatically connecting each gear of the second series to and disconnecting it from the driven shaft when a higher-speed pair of gears is brought in or put out of action.

8. In a variable-speed gearing, the combination with a shaft, and a stepped series of pinions, of double friction-clutches connected to the pinions, a friction-clutch carried by the shaft, and means for moving the separate clutches into engagement with each other, and one of them with the friction-clutch on the shaft.

9. In a variable-speed gearing, the combination with a driving-shaft, and a stepped series of pinions, of double friction-clutches connected to each pinion, means whereby the clutches can move relatively to the pinions, a friction-clutch carried by the driving-shaft and adapted to engage with one of the pinion friction-clutches, and means for operating the friction-clutches.

10. In a variable-speed gearing, the combination with a driving-shaft, and a stepped series of pinions, of double friction-clutches connected to each pinion, a friction-clutch carried by the driving-shaft to engage with one of the pinion friction-clutches, means for moving the separate clutches into engagement with each other, and means for disengaging the clutches.

11. In a variable-speed gearing, the combination with a driving-shaft, and a stepped series of pinions, of a double friction-clutch carried by each pinion, a friction-clutch on the

driving-shaft to engage with one of the pinion friction-clutches, means for moving each clutch separately into engagement, means for disengaging each clutch separately, and means for taking up wear.

12. In a variable-speed gearing, the combination with a stepped series of pinions, of a sleeve connected to each pinion, a double friction-clutch on each sleeve, a driving-shaft, a friction-clutch on the driving-shaft to engage with one of the pinion friction-clutches, a spring pressing each clutch into engagement with its neighbor, and means for withdrawing the clutches substantially as described.

13. In a variable-speed gearing, the combination with a stepped series of pinions, of a double friction-surface connected to each pinion, a driving-shaft, a friction-surface on the shaft adapted to engage with one of the pinion friction-surfaces, a spring holding each pinion-clutch in engagement with another pinion-clutch, and lever mechanism for withdrawing the clutches successively.

14. In a variable-speed gearing, the combination with a stepped series of pinions, of a double friction-surface connected to each pinion, a driving-shaft, a friction-surface on the shaft adapted to engage with one of the pinion friction-surfaces, a spring holding each pinion-clutch in engagement with another pinion-clutch, lever mechanism for withdrawing the clutches successively and means connected with the lever mechanism for taking up wear.

15. In a variable-speed gearing, the combination with a stepped series of pinions, of a double friction-surface connected to each pinion, a driving-shaft, a friction-clutch on the driving-shaft to engage with one of the pinion friction-surfaces, springs forcing the friction-clutches into engagement, a controlling-shaft, and lever mechanism between the clutch and the controlling-shaft substantially as described.

16. In a variable-speed gearing, the combination with a stepped series of pinions, of a double friction-surface connected to each pinion, a driving-shaft, a friction-clutch on the driving-shaft to engage with one of the pinion friction-surfaces, springs forcing the friction-clutches into engagement, a controlling-shaft, lever mechanism between the clutches and the controlling-shaft and means connected with the lever mechanism for withdrawing the clutches successively substantially as described.

17. In a variable-speed gearing, the combination with a stepped series of pinions, of a double friction-surface connected to each pinion, a driving-shaft, a friction-clutch on the driving-shaft to engage with one of the pinion friction-surfaces, springs forcing the friction-clutches into engagement with each other, a controlling-shaft, a lever on the shaft, pivoted rods connected to the lever, and collars connected to the pivoted rods and engaging with the clutches to withdraw each clutch successively and compress the springs connected therewith substantially as described.

18. In a variable-speed gearing, the combination with a stepped series of pinions, of a double friction-surface connected to each pinion, a driving-shaft, a friction-clutch on the driving-shaft to engage with one of the pinion friction-surfaces, means whereby the friction-surface can move axially, springs for forcing the friction-surfaces into engagement with each other, a controlling-shaft, a lever on the shaft, pivoted rods connected to the lever, and collars connected to the pivoted rods and engaging with the clutches to withdraw each clutch successively and compress the springs connected therewith substantially as described.

19. In a variable-speed gearing, the combination with a stepped series of pinions, of a telescopic sleeve connected to each pinion, and each section thereof having an external collar, double clutch members on each sleeve, a driving-shaft, a friction-clutch on the shaft to engage with one of the pinion-clutches, a spring bearing against the external collars on each sleeve to force the clutches together, internal collars on the sleeve adapted to engage with the spring-retaining collars on another sleeve, a controlling-shaft, a lever on the shaft, pivoted rods connected to the lever, and collars connected to the pivoted rods and engaging with one of the sleeves to withdraw each clutch successively and compress the springs connected therewith substantially as described.

20. In a variable-speed gearing, the combination with a stepped series of pinions, of a sleeve connected to each pinion and made in two parts capable of relative axial movement, a spring disposed between collars on the separate parts, a double friction-clutch member mounted on each sleeve, external collars on each of the concentric sleeves, internal collars on each concentric sleeve adapted when the sleeve is moved axially to engage with the external collars on an adjacent sleeve, a controlling-shaft, a lever on the shaft, pivoted rods connected to the lever, and collars connected to the pivoted rods and engaging with the clutches to withdraw each clutch successively and compress the springs connected therewith substantially as described.

21. In a variable-speed gearing, the combination with a stepped series of pinions, of a sleeve connected to each pinion and capable of relative movement with regard to the pinion, a spring disposed between collars on the sleeve and a stationary part, a double friction-clutch member mounted on each sleeve, an internal collar on the concentric sleeve adapted when the sleeve is moved axially to engage the external collar on the adjacent sleeve, a controlling-shaft, a lever on the shaft, pivoted rods connected to the lever, a plate

connecting the shaft-bearings with the bearings of the pivoted rods, and collars connected to the pivoted rods and engaging with the clutch-sleeves to withdraw each clutch successively substantially as described.

22. In a variable-speed gearing, the combination with a stepped series of pinions, double friction-clutches connected to the pinions, a shaft, a friction-clutch carried by the shaft, means for moving the separate clutches into engagement with each other, and one of them with the shaft friction-clutch, of a second series of gears meshing with the first series, a driven shaft, and clutches operative in one direction only between each driven gear and the shaft substantially as described.

23. In a variable-speed gearing, the combination with a stepped series of pinions, double friction-clutches connected to each pinion, means whereby the clutches can move relatively to the pinions, a friction-clutch carried by the driving-shaft and adapted to engage with one of the pinion friction-clutches, and means for operating the friction-clutches, of a second series of gears meshing with the first series, a driven shaft, and clutches operative in one direction only between each driven gear and the shaft substantially as described.

24. In a variable-speed gearing, the combination with a stepped series of pinions, double friction-clutches connected to each pinion, a friction-clutch carried by the driving-shaft to engage with one of the pinion friction-clutches, means for moving the separate clutches into engagement with each other, and means for disengaging the clutches, of a second series of gears meshing with the first series, a driven shaft, and clutches operative in one direction only between each driven gear and the shaft substantially as described.

25. In a variable-speed gearing, the combination with a stepped series of pinions, a sleeve connected to each pinion, a double friction-clutch on each sleeve, a driving-shaft, a friction-clutch on the driving-shaft to engage with one of the pinion friction-clutches, a spring pressing each clutch into engagement with its neighbor, and means for withdrawing the clutches, of a second series of gears meshing with the first series, a driven shaft, and clutches operative in one direction only between each driven gear and the shaft substantially as described.

26. In a variable-speed gearing, the combination with a stepped series of pinions, each having a double friction-clutch connected thereto, a driving-shaft, a friction-clutch on the shaft adapted to engage with one of the pinion friction-clutches, a spring holding each pinion-clutch, in engagement with another pinion-clutch and lever mechanism for withdrawing the clutches sucessively, of a second series of gears meshing with the first series, a driven shaft, and clutches operative in one direction only between each driven gear and the shaft substantially as described.

27. In a variable-speed gearing, the combination with a stepped series of pinions, each having a double friction-surface connected thereto, a driving-shaft, a friction-clutch on the driving-shaft to engage with one of the pinion friction-surfaces, springs forcing the friction-clutches into engagement, a controlling-shaft, and lever mechanism between the clutches and the controlling-shaft, of a second series of gears meshing with the first series, a driven shaft, and clutches operative in one direction only between each driven gear and the shaft substantially as described.

28. In a variable-speed gearing, the combination with a stepped series of pinions, of a sleeve connected to each pinion and capable of axial movement, an external collar on the sleeve, a spring bearing against the external sleeve, a double friction-clutch mounted on each sleeve, the internal collar on each sleeve adapted when the sleeve is moved axially to engage with an external collar on the adjacent sleeve, a controlling-shaft, a lever on the shaft, pivoted rods connected to the lever, sleeves on the rods adapted to engage with collars on the outermost concentric sleeve, a plate connecting the shaft-bearings with the bearings of the pivoted rods, a second series of gears meshing with the first series, a driven shaft, clutches operative in one direction only between each gear and the driven shaft, an operating-lever, a pivoted slotted plate, a projection on the lever engaging with the slot in the plate, and a crank connected to the lever and to the controlling-shaft substantially as described.

29. In a variable-speed gearing, the combination with a stepped series of pinions, of a sleeve connected to each pinion and capable of axial movement, a spring bearing against the external collar on the sleeve, a double friction-clutch mounted on each sleeve, an internal collar on each sleeve adapted when the sleeve is moved axially to engage with the external collar on the adjacent sleeve, a controlling-shaft, a lever on the shaft, pivoted rods connected to the levers, sleeves on the rods adapted to engage with collars on the outermost concentric sleeve, a plate connecting the shaft-bearings with the bearings of the pivoted rods, a second series of gears meshing with the first series, a driven shaft, clutches operative in one direction only between each gear and the driven shaft, an operating-lever, a pivoted slotted plate, a projection on the lever engaging with a slot in the plate, a crank connected to the lever, a pinion on the driving-shaft, a pinion on the driven shaft, an idle pinion mounted in sliding bearings, a screw-threaded shaft connected to the idle-pinion-supporting frame, and

means connected with the speed-controlling lever for rotating the screw-threaded shaft substantially as described.

30. In a variable-speed gearing, the combination with a stepped series of pinions, of a sleeve connected to each pinion and capable of axial movement, an external collar on each sleeve, a spring bearing against the external collar on each sleeve, a double friction-clutch mounted on each sleeve, an internal collar on each sleeve adapted when the sleeve is moved axially to engage with an external collar on the adjacent sleeve, a controlling-shaft, a lever on the shaft, pivoted rods mounted on sliding sleeves and connected to the lever, sleeves on the rods, adapted to engage with collars on the outermost concentric sleeve, plates connecting the shaft-bearings with the bearings of the controlling-shaft, an operating-lever, a pivoted slotted plate, a projection on the lever engaging with the slot in the plate, a crank connected to the controlling-shaft, connected with the slotted plate, a second series of gears meshing with the first series, a driven shaft, clutches operative in one direction only between each driven gear and its shaft, a pinion on the driving-shaft, a pinion on the driven shaft, an idle pinion, sliding bearings for the pinion, a screw-threaded shaft connected with the idle-pinion-supporting frame, a crank on the screw-threaded shaft, and a projection on the controlling-lever adapted to engage the controlling-crank, substantially as described.

31. In a variable-speed gearing, the combination with a driving-shaft, a driven shaft, a series of driving members, and means for connecting all the driving members together and one of them to the driving-shaft, of a series of driven members, and means whereby each of the driven members is connected to its shaft only when its coöperating member on the driving-shaft is acting as the driving member.

32. The combination of a shaft, a plurality of gears loosely mounted on said shaft and each corresponding to a certain speed, a plurality of friction-clutches for connecting said gears with the shaft, each of said clutches including a member adapted to move longitudinally of the shaft, and means for rendering one of said clutches operative and then rendering other of said clutches operative without opening that or those already operative.

33. The combination of a shaft, a plurality of gears loosely mounted on the shaft and each corresponding to a certain speed, friction-clutches for connecting said gears with the shaft, one member of each clutch being adapted to move longitudinally of the shaft relative to the other member thereof, means for moving the sliding member of one clutch into engagement with the other member of said clutch and then moving the sliding members of other of said clutches into operative position while retaining the clutch or clutches previously engaged in engagement.

34. The combination of a shaft, a plurality of gears loosely mounted on the shaft and each corresponding to a certain speed, a plurality of concentric clutches, each consisting of a male and female member one of which is adapted to slide longitudinally of the shaft, and means for engaging the members of one of said clutches and then engaging the members of other of said clutches while retaining in engagement that or those previously engaged.

35. The combination of a shaft, a plurality of concentric sleeves loosely mounted on the shaft and each having a gear fast thereon, each of said gears corresponding to a certain speed, a plurality of friction-clutches for connecting said sleeves to the shaft, and each having one member mounted on the shaft to move toward and from the other member longitudinally of the shaft while rotating therewith, and means for moving the sliding member of one clutch into position to connect one of said sleeves to the shaft and then rendering the other clutches successively operative while retaining the previously-engaged sleeve or sleeves in engagement with the shaft.

36. The combination of a shaft, a plurality of gears loosely mounted on the shaft and each corresponding to a certain speed, a plurality of friction-clutches each adapted to connect one of said gears to the shaft and each including a member adapted to slide longitudinally of the shaft relative to the other member, each of said clutches except the outermost being inclosed by one or more of the others, and means rendering one of said clutches operative and then rendering others thereof operative without disengaging that or those previously closed.

37. The combination of a driving-shaft, a driven shaft, a plurality of trains of gearing of different speeds, each having a member mounted on and adapted to be connected to or disconnected from each of said shafts, means for successively connecting said trains of gearing to the driving-shaft while retaining the train or trains previously engaged with said shaft in engagement therewith, means for connecting each train of gearing to the driven shaft, as said train is engaged with the driving-shaft, and means for automatically disconnecting each train of gearing from the driven shaft as a train of higher speed is connected with the driving-shaft.

38. The combination of a driving-shaft, a driven shaft, a plurality of trains of gearing of different speeds, each having a member mounted on and adapted to be connected to or disconnected from each of said shafts, friction-clutches, each including a member mounted to slide on the driving-shaft relative to the other member, for respectively connecting said

trains of gearing with said shaft, means for connecting each train of gearing to the driven shaft as said train is engaged with the driving-shaft, means for rendering one of said clutches operative and then rendering other of said clutches operative without releasing that or those previously rendered operative, and means for automatically disconnecting each train of gearing from the driven shaft as a train of higher speed is connected with the driving-shaft.

39. The combination of a driving-shaft, a driven shaft, a plurality of gears mounted loosely on the driving-shaft, a plurality of gears mounted loosely on the driven shaft and constantly meshing with the gears on the driving-shaft, friction-clutches, each adapted to connect one of said gears on the driving-shaft with said shaft, means for connecting each gear on the driven shaft with said shaft, as the associated gear is connected to the driving-shaft, means for rendering one of said clutches operative and then rendering others thereof operative without disconnecting that or those previously closed, and means for automatically disconnecting each gear on the driven shaft from said shaft as a gear of higher speed is connected with the driving-shaft..

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

JOHN PRENTICE.
A. W. PRENTICE.

Witnesses:
JOHN W. MCCALL,
HENRY LAING.