No. 745,953. PATENTED DEC. 1, 1903.

J. H. BARNARD.

APPARATUS FOR TRANSMITTING POWER.

APPLICATION FILED MAR. 8, 1902.

NO MODEL. 4 SHEETS—SHEET 1.

Fig. 1.

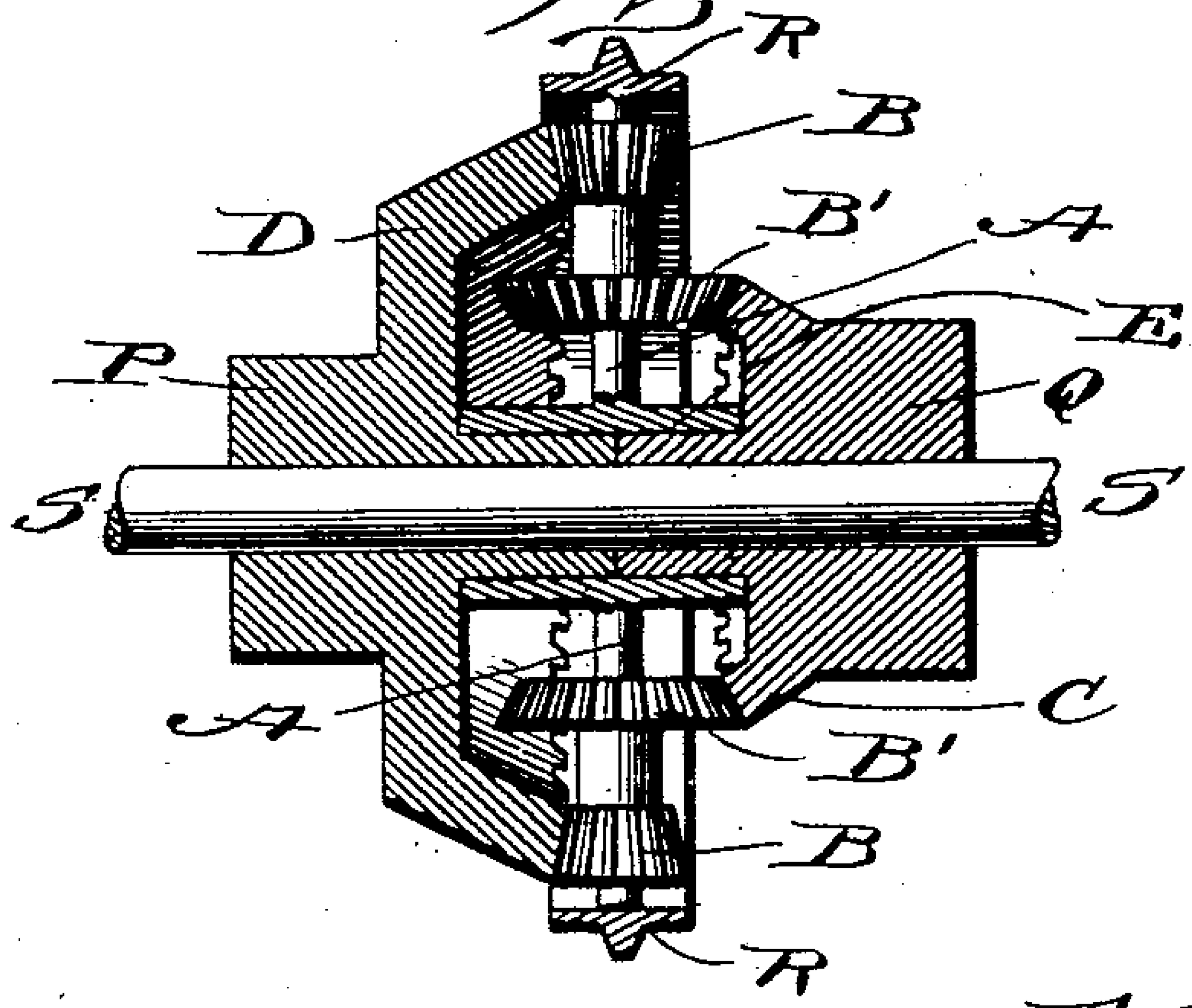


Fig. 2.

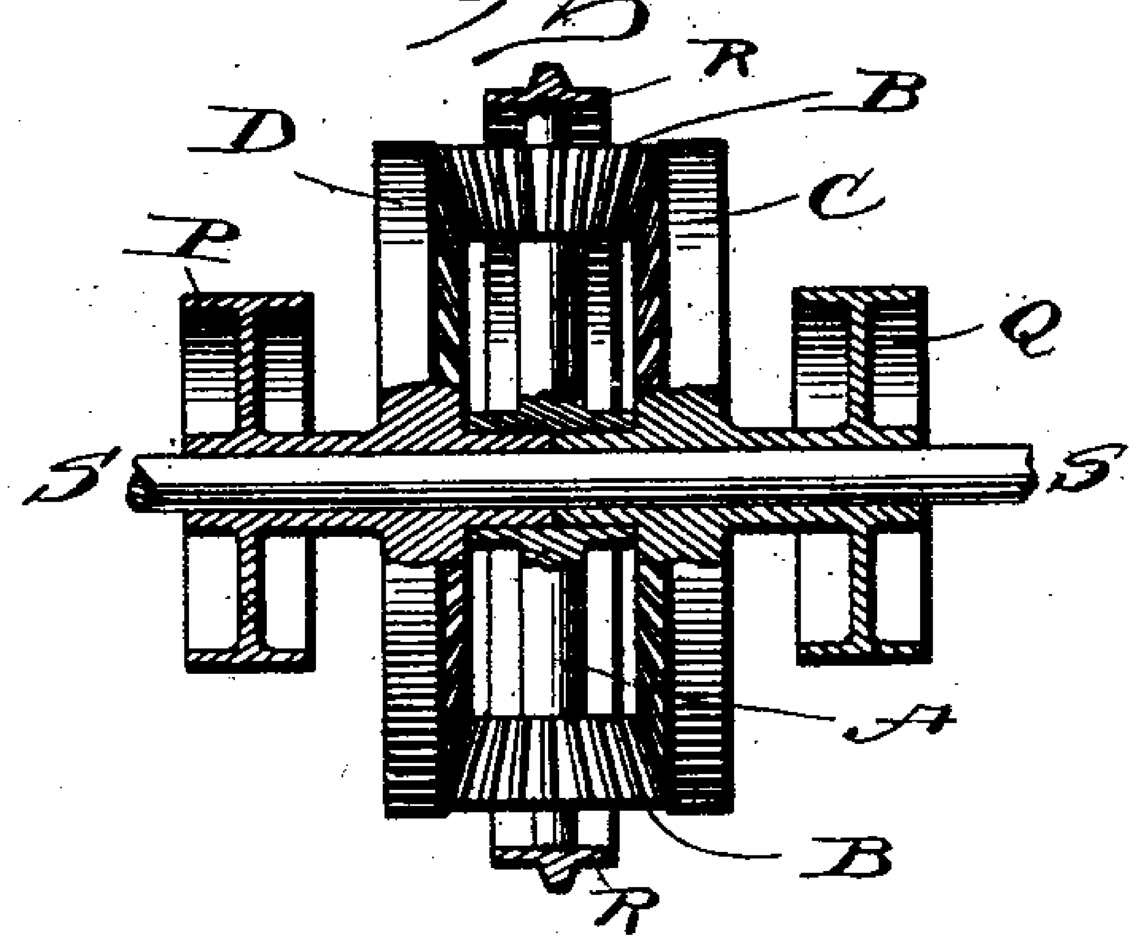


Fig. 3.

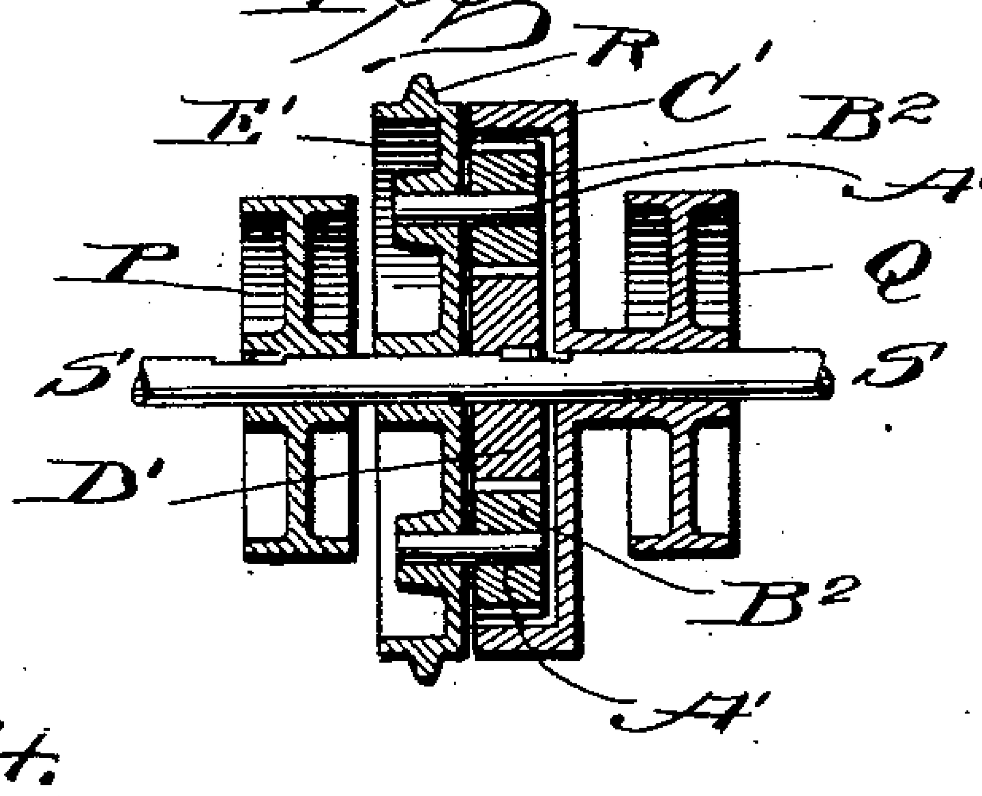


Fig. 4.

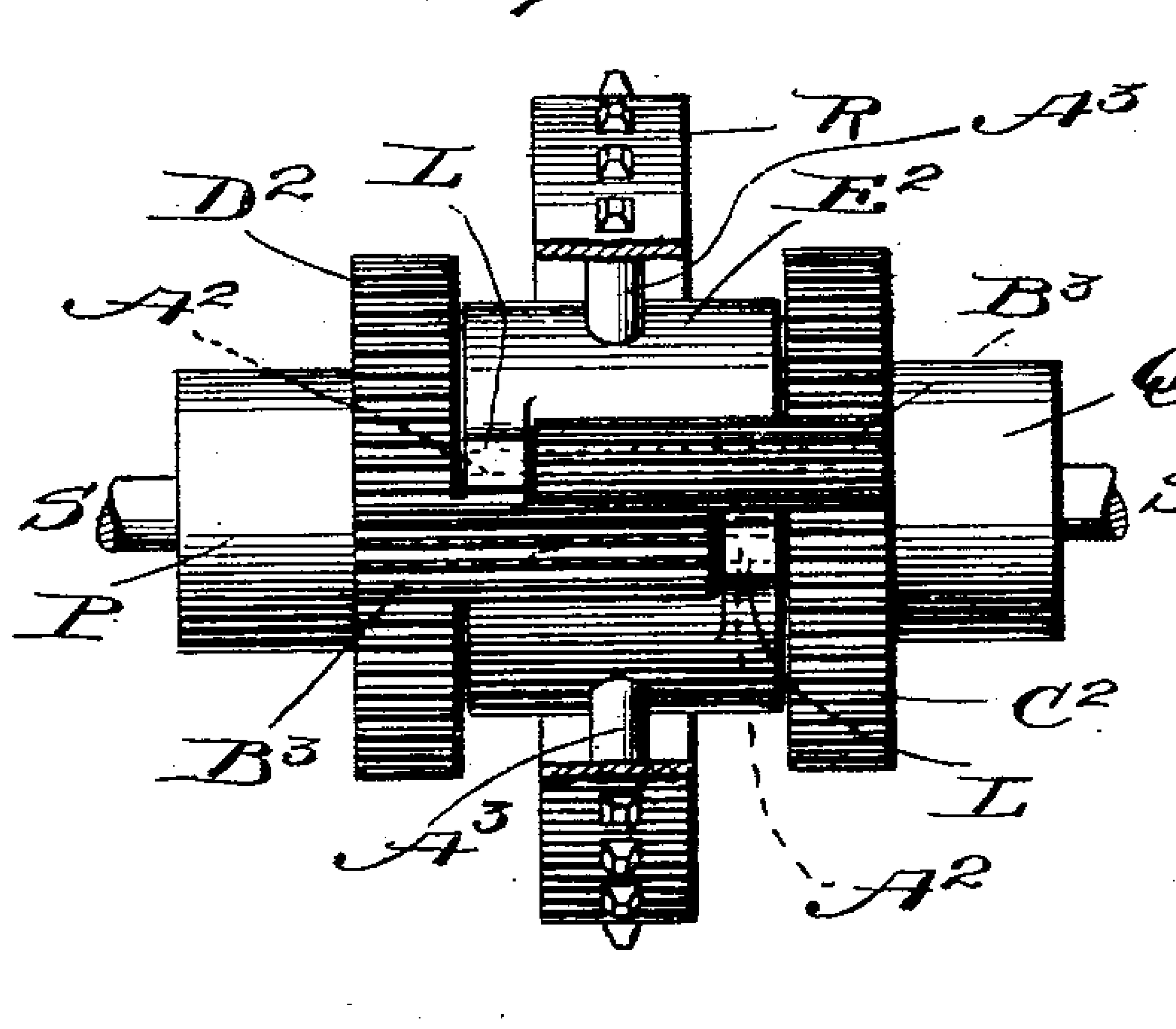
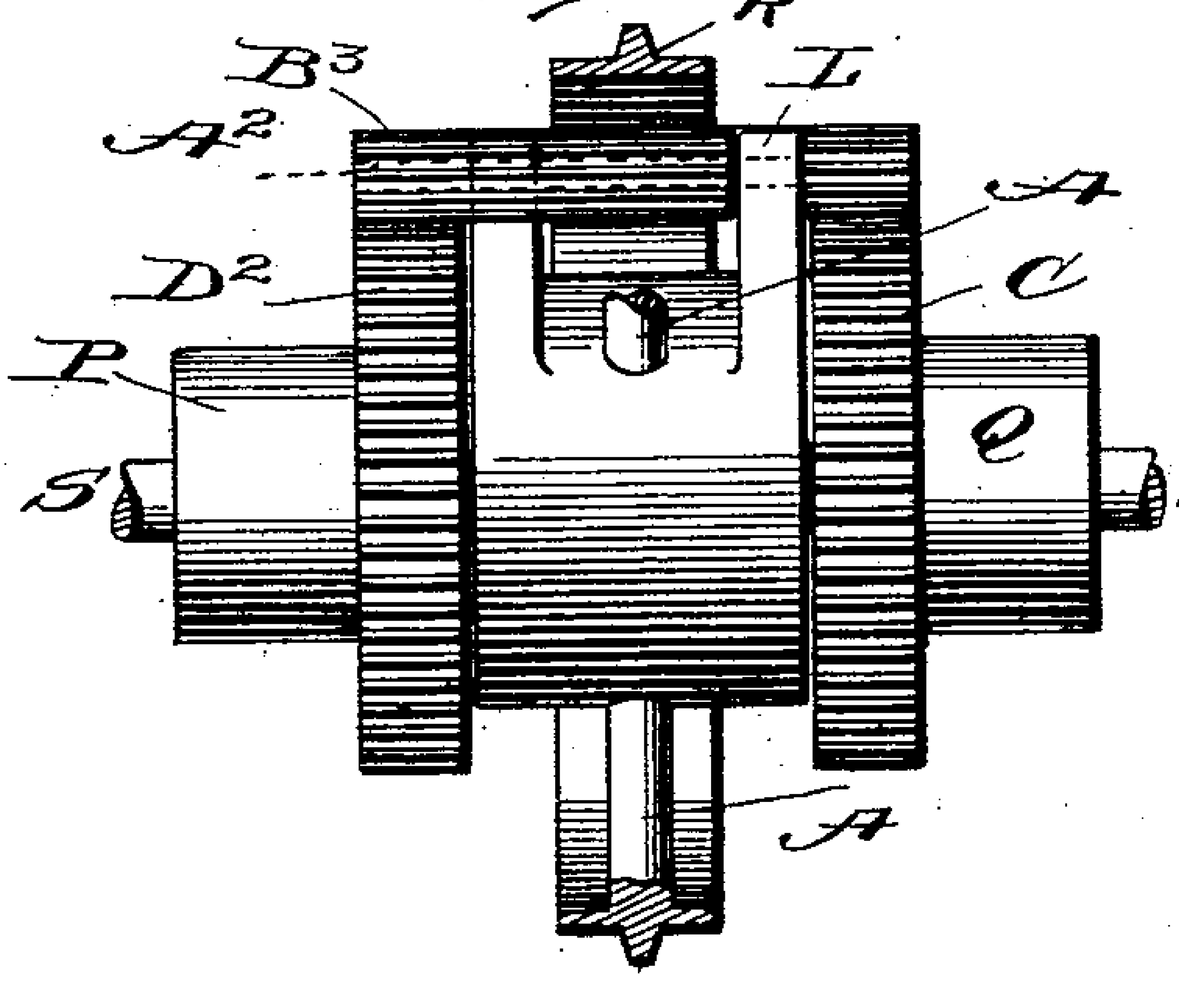


Fig. 5.



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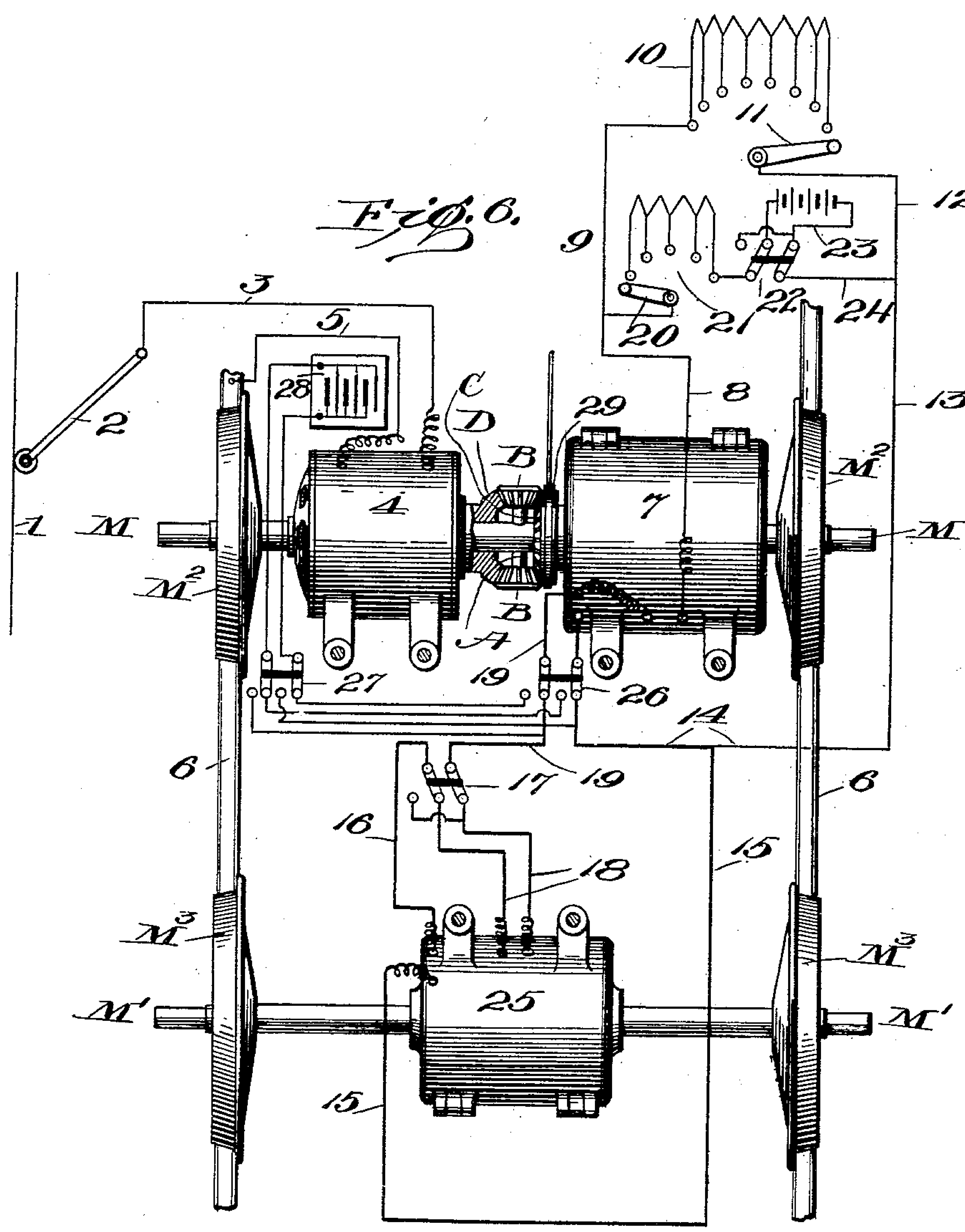
NO MODEL. 4 SHEETS—SHEET 2.

FIG. 6.



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NO MODEL. 4 SHEETS—SHEET 3.

Fig. 8.

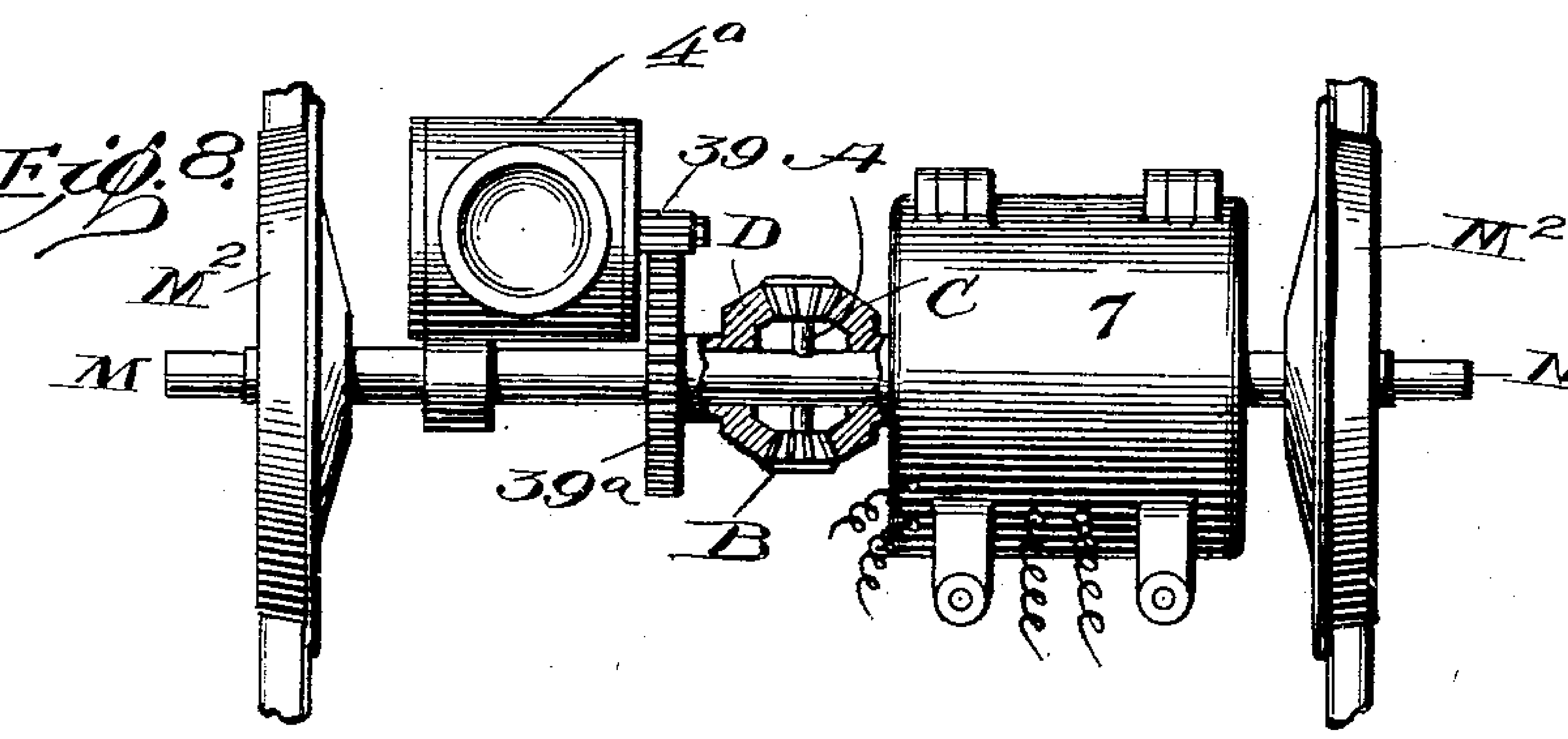
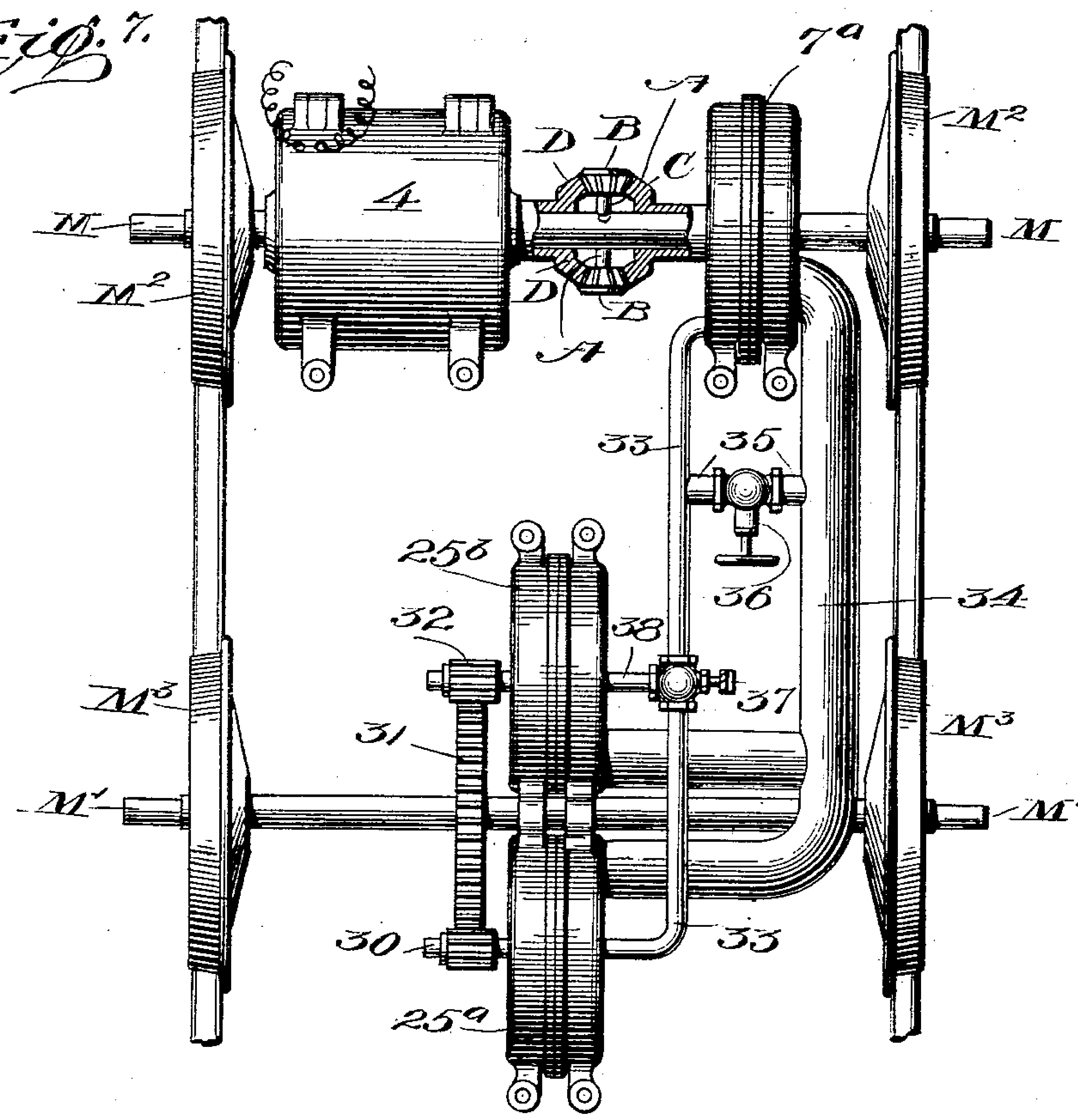


Fig. 7.



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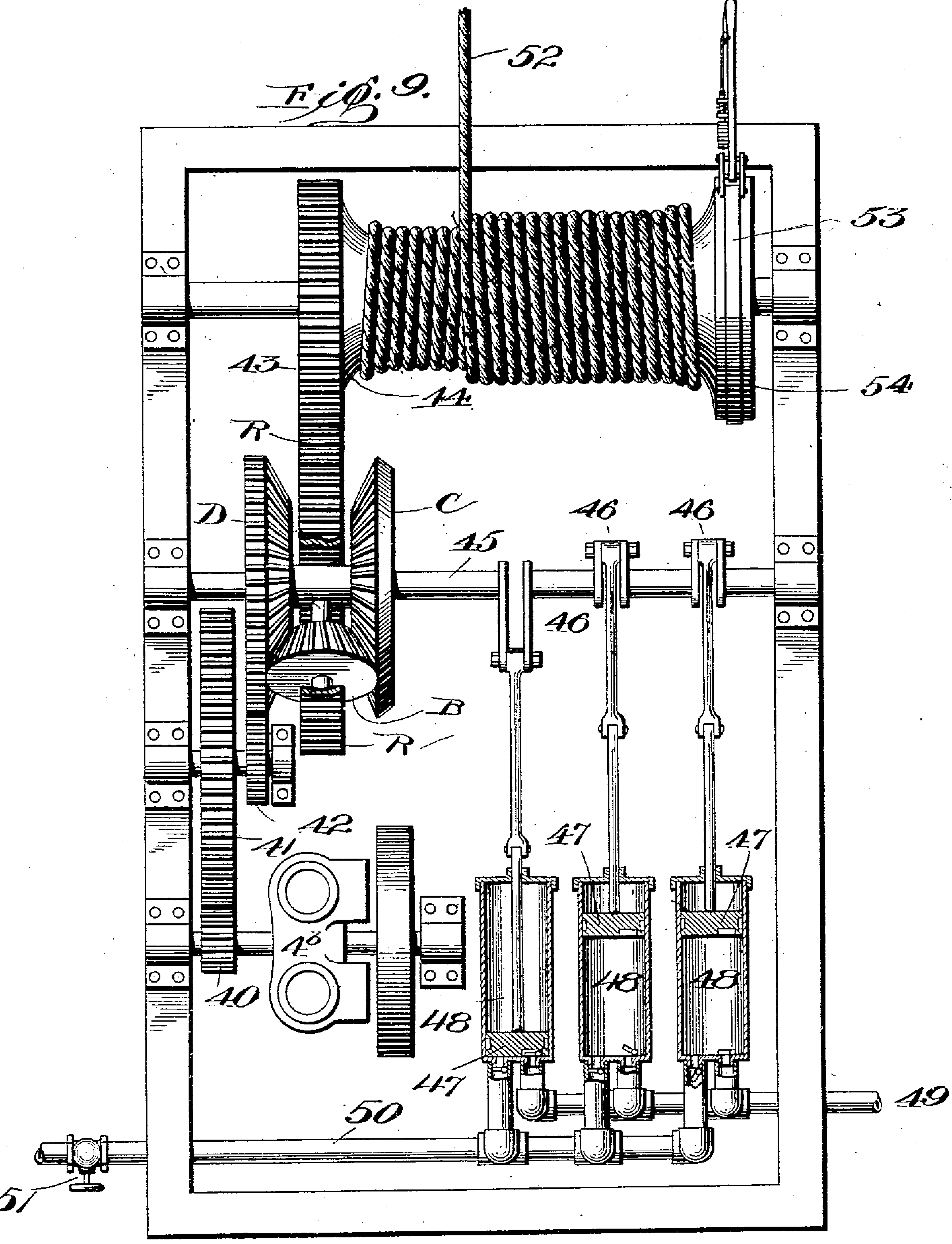
APPLICATION FILED MAR. 8, 1902.

NO MODEL. 4 SHEETS—SHEET 4.

Fig. 9.



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No. 745,953. Patented December 1, 1903.

UNITED STATES PATENT OFFICE.

JOHN HALL BARNARD, OF NEWARK, NEW JERSEY, ASSIGNOR OF ONE-HALF TO BENJAMIN ATHA, H. G. ATHA, H. B. ATHA, AND C. G. ATHA, OF NEWARK, NEW JERSEY.

APPARATUS FOR TRANSMITTING POWER.

SPECIFICATION forming part of Letters Patent No. 745,953, dated December 1, 1903.

Application filed March 8, 1902. Serial No. 97,277. (No model.)

To all whom it may concern:

Be it known that I, JOHN HALL BARNARD, residing at Newark, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Apparatus for Transmitting Power, of which the following is a full, clear, and exact description, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to means for transmitting power, and is especially adapted to utilize the principles broadly enunciated by me in my former application, Serial No. 79,624, filed October 23, 1901.

The object of my invention is to provide new and improved means for carrying out the process set forth in said application.

Further objects will appear from what is set forth in the following description.

My invention consists in certain novel arrangement and combination of parts, all of which will be understood from what is set forth in this specification and illustrated in the accompanying drawings, forming part thereof, and which is specifically covered by the claims at the end of this specification.

Referring now to the accompanying drawings for further understanding of my invention, when taken in connection with the description thereof, Figure 1 is a vertical elevation, partly in section, of a train of gears having two beveled gears of unequal diameters in the train loosely journaled on the same shaft. Fig. 2 is a similar view of a train of gears having two beveled gears of equal diameter in said train, both being loosely journaled on said shaft. Fig. 3 is an equivalent train, but of the spur-gear form. Fig. 4 shows still another arrangement of a train of gears of the spur-gear form. Fig. 5 shows the same arrangement as that shown in Fig. 4 with the parts, however, rotated through ninety degrees from the position shown in the prior figure. Fig. 6 shows one form of my invention in which an alternating-current motor is connected to drive the first member of such a train, the third member having connected thereto an electric generator, the other member being connected to the axle of the car, the current generated being transmitted to another motor, the electrical connections being shown. Fig. 7 shows an apparatus wherein an electric motor is used to drive one member, the balancing-load consisting of a pump utilized to restrain to any desired extent, another member to produce the desired effort in the remaining member, and means for transmitting the energy delivered to the pump to other useful purposes, in this instance to drive the other axle of the car. Fig. 8 shows a steam or other motor employed to drive the first member and an electric generator to restrain the third member for the same purpose as the pump in the prior illustration. Fig. 9 shows a winding-machine connected with one member of a differential train, a steam-engine causing rotation in another, and a pump employed to effect desired restraint upon the remaining member.

As trains of the planetary, epicyclic, or differential type are capable of many variations of forms, the first five figures are given to represent four typical forms as the basis of the mathematical argument underlying the design of all such mechanisms for general or specific purposes.

In the different views on the drawings the same reference character is used to indicate a similar part, and a letter or figure primed indicates a part performing a similar function though of different form from the part indicated by the letter or figure itself.

Referring now to the drawings, in Fig. 1 the parts lettered D and C are two beveled gears of unequal diameters mounted loosely on the shaft S. A sleeve E surrounds the hubs of these gears and carries the spindles A, upon which the beveled pinions B and B′, connected together by a sleeve, rotate in mesh with the gears D and C, respectively. These spindles also carry the rim R, which may be provided with gear or sprocket teeth on its outer surface, as shown, or may, if desired, be made smooth for an ordinary belt. The gears D and C have rigidly connected thereto the pulleys P and Q, so that to or from any one of these members power may be conveyed.

In Fig. 2 the gears D and C are shown as of equal diameters, and the pinions B and B′ are replaced by the pinions B B, which engage directly with the gears D and C.

In Fig. 3 I have shown a spur-gear D′ keyed to the shaft S. The pinions B^2 are mounted on spindles A′, projecting from the plate E′, which is loosely journaled on S. C′ is an internal gear loosely journaled on S, and the pinions B^2 engage with both D′ and C′. The plate E′ carries the rim R. The gear D′ is driven by power imparted to the shaft through the pulley P, keyed thereto, and C′ is provided, as before, with a pulley Q.

In the arrangement shown in Figs. 4 and 5, D^2 and C^2 are spur-gears, and E^2 is a cylinder which, as well as D^2 and C^2, is loosely journaled on the shaft S. The cylinder carries lugs L L, into which the spindles A^2 are set, carrying the pinions B^3, these pinions being engaged with each other and one of them in engagement with D^2 and the other with C^2. The spindles A^3 A^3 carry the rim R, and D^2 and C^2 are provided with pulleys or gears P and Q, respectively.

In all these five figures let b represent the diameter of B, B^2, or B^3; let b' represent the diameter of B′; let d represent the diameter of D, D′, or D^2, and let c represent the diameter of C, C′, or C^2; let n and n'' represent the angular movement in a given time of the part D (in any of its forms) and R, respectively, about the common axis, and n' represent the corresponding angular movement of C (in any of its forms) in the direction opposite to that of D. Then in the mechanisms shown in Fig. 1

$$n = n'' + (n'' + n')\frac{b}{d} \times \frac{c}{b'}, \text{ (equation 1.)}$$

In that shown by Fig. 2, $b = b'$ and $d = c$.

Hence $\frac{b}{d} \times \frac{c}{b'} = 1$ and equation 1 becomes

$$n = 2n'' + n', \text{ (equation 2.)}$$

In Fig. 3, $b = b'$.

Hence $\frac{b}{d} \times \frac{c}{b'} = \frac{c}{d}$ and equation 1 becomes

$$n = n'' + (n'' + n')\frac{c}{d}, \text{ (equation 3.)}$$

In Figs. 4 and 5

$$n = 2n'' + n', \text{ (equation 2.)}$$

Suppose now that the member D (in any of its forms) be driven from any source of power, that C (in any of its forms) be used to effect desired control, and that the rim R be connected with the machine to be driven at various speeds. It can then be seen that the value of n'', which is the speed of R, is dependent upon the relative values of n and n'.

Heretofore it has been customary to govern the speed of C by the restraint of a brake or by driving it from some source of power that may be governed in speed. The former method, as is set forth in my prior application, involves the loss in heat of exactly half the energy imparted to the driven member and incidentally requires that if this is to be continued for any length of time means must be supplied for dissipating the heat. The second means is complicated and in most instances must presuppose the former attainment of the object of this invention.

In any form of this system of gears it can be shown that the driven member tends to drive one of the other two and this second member tends to drive the third; that any resistance encountered by one of these latter two produces on the other a definite corresponding rotative force; that the measure of this force is the pressure on the point of communication multiplied by the distance of this point from the common axis of rotation. If, for instance, the member D (in any of its forms) exerts a pressure f on a pinion B, an equal pressure is produced on the member C (in any of its forms) where it engages B, and a pressure equal to the sum of these two is produced on the spindles A. Similarly, if C should be driven so that it exerts a pressure f on the pinions B an equal pressure f is produced on D and a pressure of 2^f on the spindles A, or if a pressure f is exerted on the pinions B by the spindles A, D, and C each feels a pressure $\frac{f}{2}$ where they engage B. Now, with D as the driven member, to obtain a given speed of rotation in R against a resistance r in the machine to be operated there must be applied to the spindles A a pressure F, which when measured at the extremity of the radius of R equals the product of r by the desired speed of the machine divided by the speed necessary in R. This determines the resistance that must be placed upon C measured at the point of its application to this member. Conversely, chosen resistances applied to C produce definite effort of rotation in R and resultant speeds in the driven machine. If, therefore, C is compelled to drive a governable load, it is only necessary to increase or diminish its amount to effect the desired resultant speed in the machine. Further, by choosing as such governable load one that will again give up the energy imparted to it it is possible to effect the desired control without material waste of energy. Loads of such character are pumps for gases or fluids and electric dynamos, for, as is well known, the former can be used to drive proper motors to accomplish immediate reconversion or can pump gases into accumulators or fluids to a height for future reconversion, and the current generated by dynamos can be reconverted into power by electric motors or conveyed into storage batteries for the later use.

In the Figs. 6, 7, and 8 a car is shown as the machine to be operated, in one case by a steam or gasolene engine and in the other two by an alternating-current electric motor, neither of which is readily controlled in speed.

In Fig. 6 the source of power is the alternating-current motor 4, attached to the member D of a differential gear, both being loosely journaled on the car-axle M. The balancing-load is a shunt-wound direct-current generator 7, attached to the member C of the differential gear, both of these also being loosely journaled on the car-axle M. The spindles A, carrying the pinions B, are rigidly attached to the axle and through it tend to drive the car-wheels M^2. The alternating-current motor 4 receives current from the trolley-wire 1 through the trolley 2 and the connecting-wire 3, returning it through the wire 5 and the track 6. To control the resistance which the direct-current generator 7 offers to the member C, its field-windings are in series with the resistance 10, with which they are connected through the wires 8, 9, 12, 13, and 14 and the switch 11 when the latter is not open. Capable of being substituted for the circuit composed of the wires 9 and 12, the resistance 10, and the switch 11 is an auxiliary circuit composed of the switch 20, the resistance 21, the pole-changing switch 22, the battery 23, and the wire 24, which is provided to allow the field to be built up more rapidly than if the residual magnetization were relied upon in first starting generation after a stoppage of current in this dynamo. The greater portion of the current produced by the dynamo 7 is led from one brush by the wire 19 and the pole-changing switch 17 to the series motor 25, attached to another axle M′, thence through the field-circuit 18 of this motor, the pole-changing switch 17, the armature-circuit 16 of this motor, and the wires 15 and 14 back to the other brush of the generator 7. In this arrangement the alternating-current motor is kept running at its designed speed in the direction in which the car is to move, being only stopped and reversed when the direction of the car is to be changed. Assuming now that the car is at rest, the motor 4 running at full speed, and the switches 11 and 20 are both "off," so that the field-circuit of the generator 7 is open, as no current is being generated in the local circuit the armature of 7 revolves idly, producing practically no resistance to the member C, hence no pressure on the spindles A. To start the car, the switch 20 is placed upon the first point of the resistance 21, so that the battery 23 slightly energizes the field of the generator 7, which causes its armature to produce a slight resistance to C. A consequent effort on the spindles A and the current generated causes the motor 25 to tend to revolve the axle M′ and its wheels M^3, assisting the effort of the wheels M^2 to overcome the inertia of the car. Moving the switch 20 farther to the right reduces the resistance to the battery-current, causing stronger effort on the car-wheels, until at last as the switch 20 reaches the last point of 21, where the battery produces its strongest effect, and having accomplished its functions the switch 20 is opened and switch 11 is simultaneously thrown to the left upon the first point of the resistance 10, and the generator 7 is thereafter self-exciting, and the effort on the wheels M^2 and M^3 is governed by the switch 11, which varies, by the resistance 10, the field strength of the generator 7. To stop the car, the switch 11 is opened, so that resistance is no longer offered to C and no current is generated to cause the motor 25 to drive the wheels M^3, and the car-brakes are applied. The car being at rest, to cause it to travel in the opposite direction the alternating-current motor is stopped and reversed in the ordinary way. The member C and the armature of the generator 7 are now run in the opposite direction, so the pole-changing switch of the battery is shifted, reversing the polarity when the switch 20 is closed. Hence the current produced flows in the former direction, and to make the motor 25 tend to rotate in the new direction its fields are reversed by shifting the pole-changing switch 17. Having made these reverses, the car is now operated as before described.

Connected with the circuits above described by the pole-changing switches 26 and 27 I show wires leading to a storage battery 28, which, while not essential to the propulsion and control of the car, may be often added to considerable advantage. Its use is as follows: When in running the power of the direct-current motor 25 is not required, or when standing with the brakes on the switch 26 may be thrown to the left, so as to send the current generated by 7 into the storage battery, adding to its charge. With this supply of energy available the full power of the alternating-current motor may be applied to the member of the differential connected with the car-axle by locking the member attached to the generator 7 by the brake 29 and the current from the storage battery be used in the direct-current motor 25 by throwing the switch 27 to the left and opening the switch 26. The regulation of the current from the storage battery to the motor 25 and the proper grouping of the cells for charging as described may be effected by the usual means for such purposes. In such a case as this it is seen that at times that the power derived from the prime mover may be stored; that during the times when the load is too heavy to be moved by the prime mover the stored or accumulated energy may be used in conjunction with the prime mover in the operation or propulsion of said load. It is to be understood, of course, from what has just been described that the stored or accumulated energy is to be properly regulated or controlled when assisting the prime mover.

Should several cars equipped as described be united in a train, the field-circuits of all may be led to all controllers, and the switches 11 and 20 of all but one being at "off" the train may be governed from that controller.

Fig. 7 shows the alternating-current motor 4 carried by the axle M. In this case the direct-current generator is replaced by a rotary pump 7^a, also centered on the axle M and driven by the member C of the differential gear. On the other axle, M′, of the car is supported a water-motor 25^a, connected to and adapted to drive this axle through the gears 30 and 31. The pump 7^a is connected to the motor 25^a by the pipe 33, through which the water is forced under pressure to drive 25^a. 34 is a discharge-pipe returning the water to the pump 7^a. 35 is a by-pass controlled by the valve 36. In this system the car is maintained in a state of rest by opening the by-pass valve 36 to its full extent, allowing the water to circulate idly. To start the car, the valve 36 is closed gradually, forcing more or less of the water to circulate through the motor 25^a. In this system the pump 7^a and the motor 25^a constitute a controllable balancing-load, the energy of which is applied to the axle M′ to assist the member C in propelling the car. In order to reverse the direction of the car, the motor 4 is reversed and the water from the pump 7^a is directed by the three-way valve 37 through the pipe 38 into another water-motor 25^b, which through the gears 32 and 31 will rotate the axle M′ in the opposite direction.

In Fig. 8 is shown a steam-engine or a reversible gas-engine 4^a, substituted for the alternating-current motor of Figs. 6 and 7. This engine is connected to the first member D by the gears 39 and 39^a, the latter loosely surrounding the axle M. The regulation of the speed and direction of movement of the car may be controlled through the same system as that shown in Fig. 6.

From what I have already disclosed it is clear that a pump or dynamo may be used to form a definite restraint to one member of a differential train, so that a constant reaction is obtained in another member connected with a reel, resulting in a steady and limited torque therein; but there is one particular type of winding-machines used for the purpose of maintaining a steady pull rather than for reeling in or paying out whatever is wound thereon. Chief of these are the towing-machines employed for securing one end of a tow-line between vessels of a tow. In offshore work these tow-lines are subjected to sudden jerks that tend to part them, and it is desirable that these unequal strains be precluded by carrying the end to a reel which shall automatically pay out the line under pulls heavier than normal and reel it in when a following sea reduces the strain to less than normal.

In Fig. 9 is shown my invention employed in this duty. 4^b is a two-cylinder double-acting engine driving the pinion 40, which is connected to the member D through the gears 41 and 42. The rim R is fitted with gear-teeth meshing with the gear 43, which is concentric with and rigidly attached to the reel 44. The member C is keyed to the shaft 45, which is fitted with cranks 46 46 46, actuating the pistons 47 47 47 in the cylinders 48 48 48. The suction-pipe 49 common to all these cylinders draws water from overboard. The discharge of all the cylinders is through a common discharge-pipe 50, which includes a valve 51. If the valve 51 be opened wide, the pistons offer little resistance to C, and consequently little pressure is produced on the spindles or spokes of the rim R; but as this valve is gradually closed the free action of the pistons is restrained, producing a definite resistance in the member C and a pressure on the spindles equal to twice that exerted by the teeth of C. Suppose, therefore, it be desired to keep a steady strain of eight tons on the tow-line 52 and that this is equivalent to a pressure of six tons on the spindles or three tons on the teeth of C, the valve is closed to the proper extent to so restrain C. If now the strain on the tow-line 52 momentarily falls below eight tons, the pressure on the spindles is sufficient to cause the rim R and the reel 44 to revolve with a pull, tending to keep the line under a strain of eight tons. If, on the other hand, the tow-line be subjected to a pull greater than eight tons, the spindles can only oppose a strain equivalent thereto, and the reel pays out under the set restraint. It will further be seen that if the valve 51 be closed too much for the resistance of the tow the effect would be to reel in more line than is paid out during abnormal strains, or, vice versa, if it should be insufficiently closed to balance the average strain the reel would pay out more than it would take up. This can be prevented by causing the reel after unwinding a definite number of turns from its normal position to close the valve 51 slightly more, or after winding up a definite number of turns beyond its normal position to open the valve slightly. When it is desired to reel in the tow-line, the valve 51 may be nearly or entirely closed, and in towing in smooth water, where it is unnecessary to keep steam on the engine, the friction-band 53 may be applied to the friction-wheel 54.

I am aware that others have made use of the differential gear in the solution of certain specific problems; but, so far as I know, the result in each case fails to disclose an appreciation of the full functions of such gear and their disclosures fail to make known the general characteristics of the internal reactions in a manner which exhibits its adaptability to the many broad uses that would logically follow. In some cases efforts have been made to minimize the loss through heat in the old friction-band by driving the third member by a worm actuated by the expenditure of a small amount of power taken from the face of the first member. In this case, however, it is impossible to conceive that the third member is reacting to return power to the first member through the worm. Furthermore, in this case the worm actually locks the third member if the friction-wheel used to drive the worm from the face of the first member be removed therefrom. In another case the electric reactions between two electric machines are employed, and it is essential that they alternately become dynamos and motors, thereby prohibiting that one of them be an induction-motor or a prime motor, such as a steam or an explosive-vapor engine.

It is obvious that changes may be made in the construction and arrangement of the parts as herein shown without departing from the scope or spirit of my invention. I therefore do not desire to be limited to the exact construction and form here shown.

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

1. In an apparatus for transmitting power derived from a given source, means for dividing the power into two always equal parts, means for conveying one of these parts to be used for any desired work, and a means for conveying the other part to operate a controllable load.

2. In an apparatus for transmitting power derived from a given source, means for dividing the power into two always equal parts, means for conveying one of these parts to be used for any desired work, and means for conveying the other part to operate a variable controllable load.

3. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for transmitting power to one member of the train and means for connecting another member to a load, means for imposing upon the remaining member a load of that quantity which, when divided by the resistance offered by the load attached to the second member gives therein the speed required.

4. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for transmitting power to the first member, means for restraining by substantially a frictionless load the speed of another member whereby a resultant speed is produced in the remaining member.

5. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for transmitting power to one member of the train and means for restraining by a substantially frictionless and controllable load another member thereby producing in the remaining member various resultant speeds.

6. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for transmitting power to one member of the train, means for imposing upon another member a substantially frictionless load producing in the remaining member a resultant torque.

7. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for transmitting power to one member of the train and means for imposing upon another member a substantially frictionless and controllable load and producing in the remaining member a variable torque.

8. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for continuously driving one member of the train, means for connecting the load with another member, means for connecting a substantially frictionless and controllable load with the remaining member, means for varying the amount of the controllable load to produce corresponding effects of speed in the member connected with the first-mentioned load.

9. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for continuously driving one member of the train, means for connecting a load with another member, means for connecting a substantially frictionless and controllable load with the remaining member, means for varying the amount of the controllable load to produce corresponding effects of torque in the member connected with the first-mentioned load.

10. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for conveying said power to and continuously driving one member of the train, means for connecting a load with another member, a dynamo forming a controllable load, means for connecting said dynamo with the remaining member so that various effects of speed may be produced at will in the member connected with the first-mentioned load.

11. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for transmitting power to and continuously driving one member of the train, means for connecting a load with another member, a dynamo connected with the remaining member in such manner that the energy expended through this member produces a current of electricity which may be stored to perform future work, a storage battery, means connecting the dynamo and storage battery and means for utilizing said energy.

12. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for transmitting power to and continuously driving one member of the train, means for connecting a load to another member, a converter of power connected with the remaining member and means for regulating the duty performed by the converter so that the effort produced in the member connected with the load may be governed by controlling the resistance offered by the converter.

13. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for transmitting and continuously driving one member of the train, means for connecting a load to another member, a dynamo connected with the remaining member and means for regulating the duty done by the dynamo so that the effort pro-

duced in the member connected with the load may be governed by controlling the resistance offered by the dynamo.

14. In an apparatus for transmitting power, derived from a given source, a train of differential gears, means for conveying power to one member of said train, means for connecting a load with another member, a converter of power connected with the remaining member, means for regulating the load formed by the converter, suitable receptacles for conserving the potential energy produced by the converter, leads connecting the converter with the receptacle, and means for utilizing said energy.

15. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for conveying power to one member of said train, means for connecting a load with another member, a dynamo connected with the remaining member, means for regulating the load formed by the dynamo, suitable receptacles for conserving the potential energy produced by the dynamo, leads connecting the dynamo with these receptacles, and means for utilizing said energy.

16. In an apparatus of the class described, a shaft, an alternating-current motor loosely journaled on the shaft, a direct-current generator connected to the same shaft, a differential gear between the motor and the generator, one member of the gear being connected to the motor, another to the generator, and the third to the shaft, wires connected to the brushes of the generator, a wire which surrounds and excites the field-magnet of the generator and through which a small portion of the current passes, and a wire returning the current to the other brush of the generator, as and for the purposes set forth.

17. In an apparatus of the class described, a shaft, an alternating-current motor loosely journaled on the shaft, a direct-current generator mounted on the same shaft, a differential gear between the motor and the generator, one member of the gear being connected to the motor, another to the generator, and the third to the shaft, wires connected to the brushes of the generator, a wire which surrounds and excites the field-magnet of the generator and through which a small portion of the current passes, a wire returning the current to the other brush, and a switch and resistance.

18. In an apparatus of the class described, a shaft, an alternating-current motor loosely journaled to the shaft, direct and return wires connected to the motor, a direct-current generator mounted on the shaft, a differential gear consisting of three members, one member being connected to the alternating-current motor, another to the generator, and the third to the shaft, wires connected to the brush of the generator, one of the wires surrounding the field-magnet of the generator and through which a small portion of the current passes, a pole-changing switch and resistance in said wire, another wire connected to the resistance and leading to the brush of the generator.

19. In an apparatus of the class described, an axle, an alternating-current motor loosely journaled on the axle of a vehicle, a direct-current generator mounted on the same axle, a differential gear between the motor and the generator, one member being connected to the motor, another to the generator, and the third to the axle, a series motor on another axle of the vehicle, wires connected to the brushes of the generator, these wires having two branches, one of which surrounds and excites the generator through which a small portion of the current passes, the other branch adapted to carry the main portion of the current and leading to the series motor, a return-wire from the series motor connected to the second-mentioned branch wire, another wire connected to the other brush and connected to the said return-wire and the first-mentioned branch wire, as and for the purposes set forth.

20. The combination of a car-axle, an electric motor, an electric generator, a train of differential gears connecting the axle, motor and generator, a motor on another axle of the car and means for conveying current from the generator to the second motor, whereby the current produced in the generator is utilized in the second motor to assist in propelling the car.

21. The combination of a car-axle, an electric motor, an electric generator, a train of differential gears connecting the axle, motor and generator, a motor on another axle of the car, means for conveying current from the generator to the second motor and means for controlling the current produced by the generator.

22. In an apparatus for transmitting power, means for dividing power derived from a given source into two always equal parts and means for conveying each of these two parts to perform independent work.

23. In an apparatus for transmitting power derived from a given source, means for dividing this power into two always equal parts, means for conveying the first equal part directly toward the performance of work, means for conveying the second part indirectly toward the performance of the same work and means for controlling the second part.

24. In an apparatus for transmitting power derived from a given source, means for dividing this power into two always equal parts, means for conveying one of these parts to perform desired work, means for converting the other part into potential energy, and means for utilizing said energy.

25. In an apparatus for transmitting power derived from a given source, means for dividing this power into two always equal parts, means for conveying one of these parts toward the performance of any desired work, means for conveying the other part for the performance of independent work and means

for governing a load substantially frictionless carried by the means for conveying the second part, whereby, the work done by the first part is controlled.

26. In an apparatus for transmitting power derived from a given source, means for dividing this power into two always equal parts, means for conveying one of these parts to be used for the performance of any desired work, means for conveying the other part independently of the first and means for governing the work performed by the second part whereby the work performed by the first part is controlled.

27. In an apparatus for transmitting power derived from a given source, a train of differential gears, means for transmitting power to one member of the train, means for imposing on another member a load substantially frictionless whereby a reaction is caused in the third member and means for transmitting from the third member the power developed therein.

28. In an apparatus of the class described, a train of differential gears, means for transmitting power to one member of the train, means for imposing on another member a controllable load substantially frictionless thereby causing in the remaining member a corresponding reaction and means for transmitting the power developed in the third member to perform the desired work.

29. In an apparatus of the class described, a train of differential gears, means for transmitting power to one member of the train, means for restraining by a substantially frictionless load a second member whereby the remaining member is caused to rotate at a speed equal to the measure of the reaction produced in the second member divided by the resistance which the remaining member encounters and means for transmitting the power developed in said remaining member.

30. In an apparatus of the class described, a train of differential gears, means for continuously driving one member of the train, means for connecting a load with the second member and means substantially frictionless for controlling the relative speed of rotation between the first and third members.

In testimony whereof I affix my signature in the presence of two witnesses.

JOHN HALL BARNARD.

Witnesses:
H. M. SEAMANS,
T. C. DELANEY.