(No Model.)

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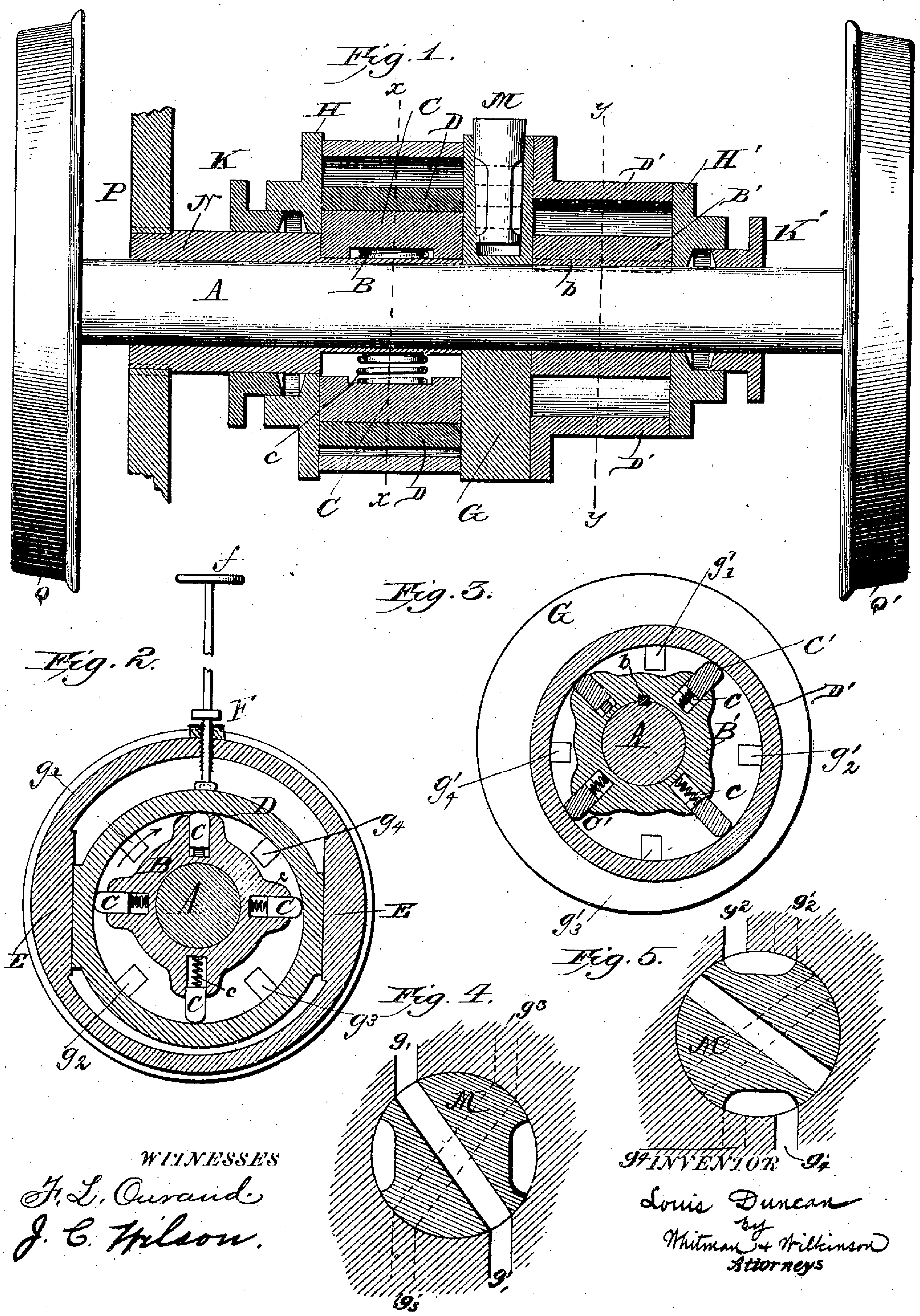
# L. DUNCAN.

## HYDRAULIC VARIABLE SPEED GEAR.

No. 466,660. Patented Jan. 5, 1892.

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(No Model.)

3 Sheets—Sheet 2.

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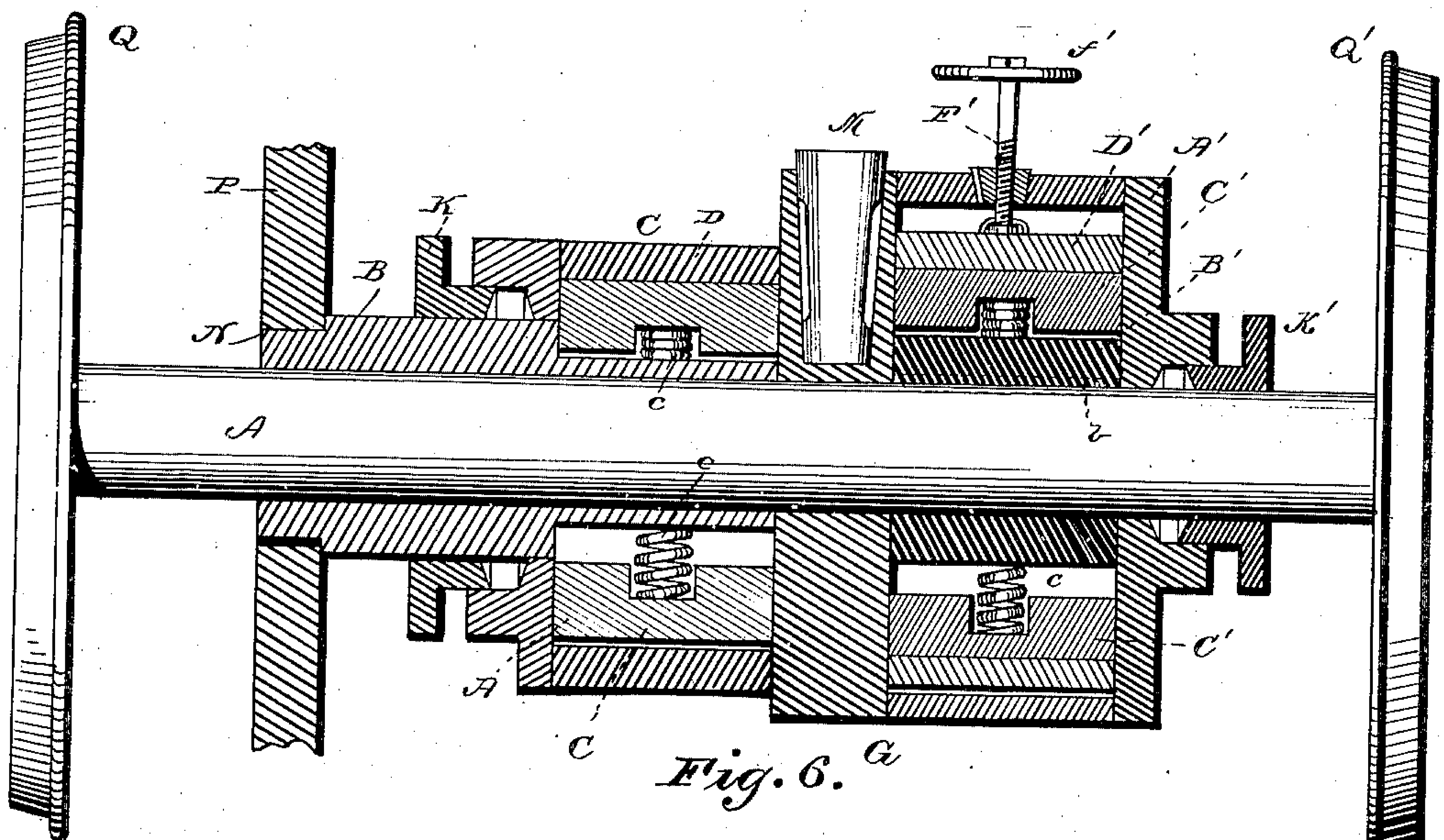

Fig. 6.

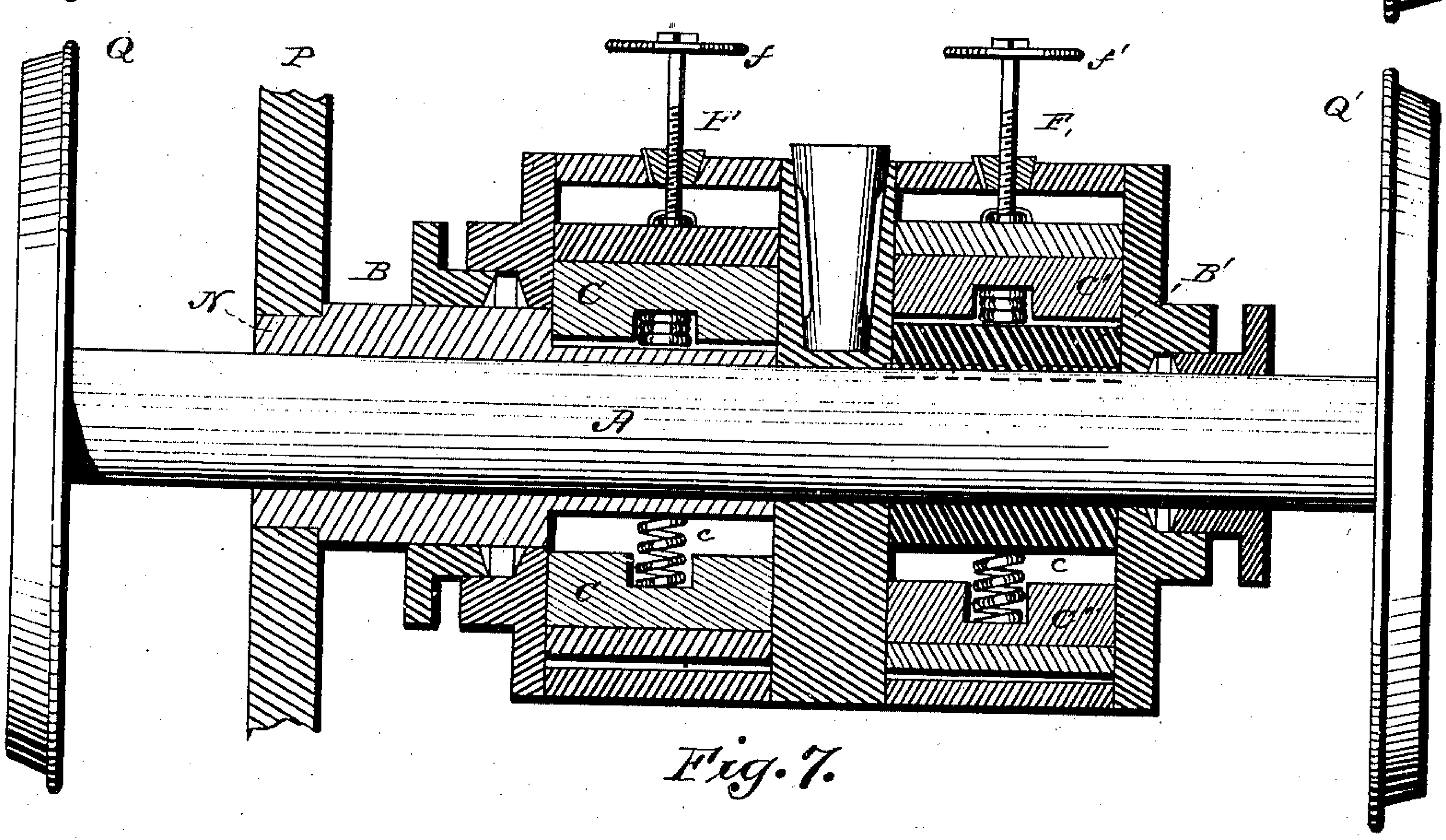

Fig. 7.

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# L. DUNCAN.

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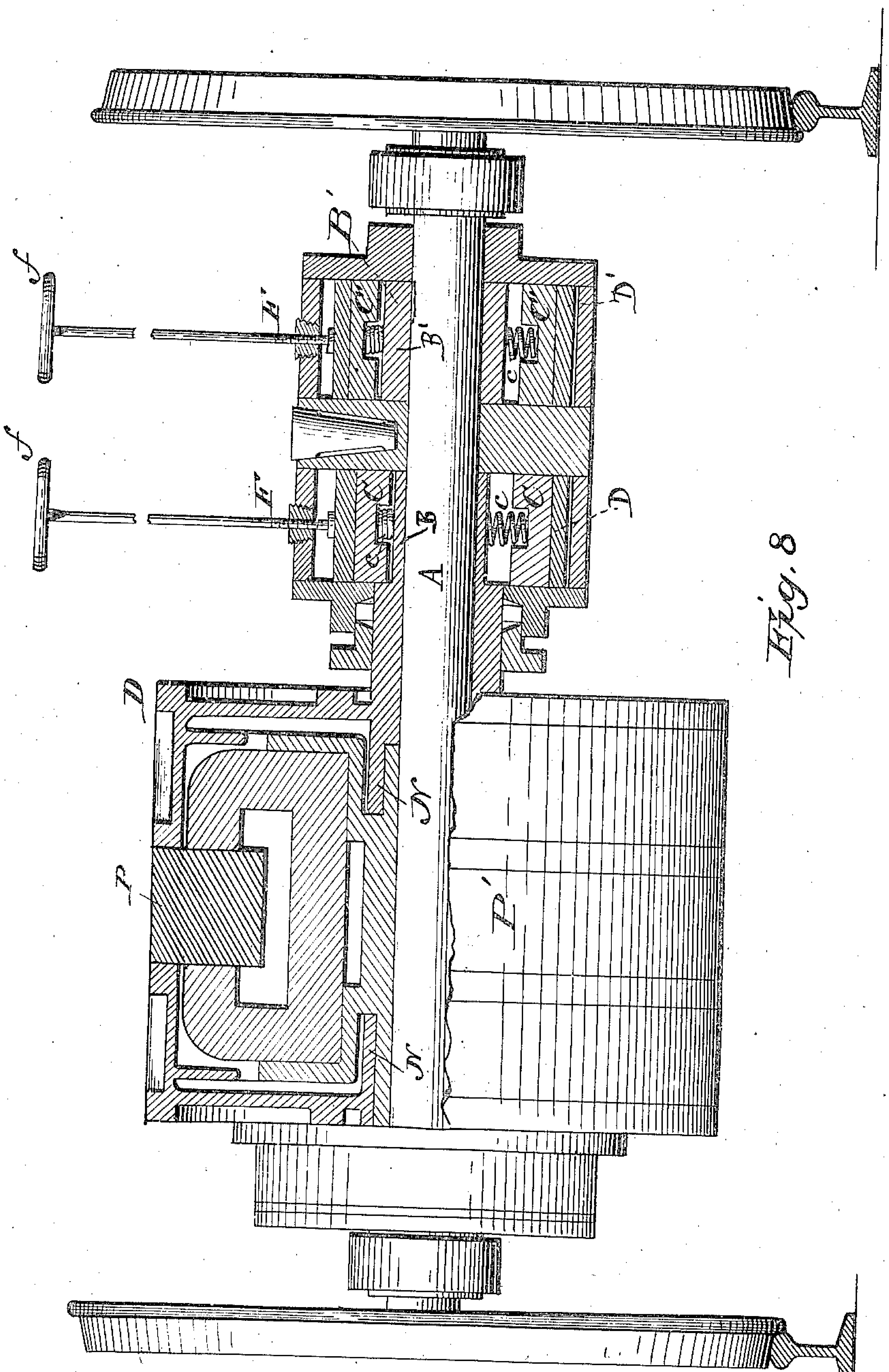


Fig. 8

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# UNITED STATES PATENT OFFICE.

LOUIS DUNCAN, OF BALTIMORE MARYLAND.

## HYDRAULIC VARIABLE-SPEED GEAR.

SPECIFICATION forming part of Letters Patent No. 466,660, dated January 5, 1892.

Application filed December 10, 1890. Serial No. 374,140. (No model.)

*To all whom it may concern:*

Be it known that I, LOUIS DUNCAN, a citizen of the United States, residing at Baltimore, in the State of Maryland, have invented certain new and useful Improvements in Hydraulic Variable-Speed Gears; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to hydraulic motors and speed-regulators; and its object is the providing of an apparatus which will furnish a gearing whose ratio may be kept fixed or varied at will, and at the same time the great losses due to friction and angularity common in multiple gearing may be largely diminished. To accomplish these results I couple together a hydraulic pump run by any convenient source of power and a hydraulic motor driven by the pump. Either the pump or the motor, or both, I have so adjusted that, although the quantity of the fluid flowing through both will be the same, by altering either or both of their eccentricities the velocity of flow of the liquid through the one or the other, or through both, may be altered at will, and thus their relative speeds may be changed.

While my invention is applicable to most of the forms of gearing, where, with a given motive power, a lower, a higher, or a variable rate of speed is desired, I will illustrate its use as applied to the gearing on the axles of electric cars, where it is desired to keep up a high rate of speed in the electric motor and regulate the speed of the car-wheels at will.

Reference is had to the accompanying drawings, wherein Figure 1 represents a vertical section through the axle and driving-gear of the car. Fig. 2 represents a vertical section through the pump along the line *x x* of Fig. 1. Fig. 3 represents a vertical section through the hydraulic motor along the line *y y* of Fig. 1. Figs. 4 and 5 represent cross-sections of two positions of a two-way valve connecting the pump and the hydraulic motor. Fig. 6 represents a vertical longitudinal section showing a modification of my device wherein I use a fixed pump and adjustable motor. Fig. 7 represents a vertical longitudinal section showing a modification of my device wherein I use an adjustable pump and adjustable motor. Fig. 8 represents a sectional elevation of an electrical motor having its revolving armature connected to the pump of variable eccentricity, which latter is mounted on the same shaft with and connected to a motor also of variable eccentricity.

A represents the car-axle.

B and B′ represents sleeves having sliding paddles C and C′, forced out by springs *c* against the interior surface of the cylinders D and D′, respectively. The sleeve B slips over the shaft A, either of which is free to revolve independently of the other, while the sleeve B′ is keyed to the shaft A, as at *b*. The cylinder D, surrounding the paddles C C, slides vertically (or horizontally or in any other direction, if preferable) in guides E E, Fig. 2, and is controlled by the screw F and hand-wheel *f*. The lower end of this screw is revolubly attached to the said ring D, while the hand-wheel *f* comes inside the car.

Since the shaft A is fixed relative to the vertical motion of the cylinder D, by moving this cylinder up or down the eccentricity of the pump is varied, and hence its output is varied. By causing the axis of the axle A and that of the cylinder D to coincide the paddles will simply churn the liquid around in the pump and its output will be *nil*.

The eccentricity of the hydraulic motor I have made constant and the cylinder D′ fixed; but this cylinder may also be adjusted like D, and the eccentricity of the motor, and hence the turning effect of the liquid, may be altered as with the pump, if desired. This is shown in Figs. 5 and 6, wherein the hand-wheel *f′*, attached to the screw F′, moves the ring D′ in the motor in a direction at right angles to the axle A.

H and H′ are the cylinder-heads for the outer ends of the pump and hydraulic motor, respectively, and K and K′ are the stuffing-boxes for the same.

Between the pump and the hydraulic motor I have shown a disk G, containing the passages for the fluid and the reversing-valve M. The fluid is forced by the pump through the motor and returning by regurgitating-passages to the pump, thus forming a closed fluid-circuit. These passages are not shown in Fig. 1, but are illustrated by the full and dotted lines in Figs. 4 and 5, while in Figs. 2 and 3 the orifices $g_1$ and $g_1'$, $g_2$ and $g_2'$, $g_3$ and $g_3'$, and $g_4$ and $g_4'$ are at the ends of the same channels, respectively. Thus the liquid leaves the pump by $g_1$ and entering the motor by $g_1'$ pushes the paddles C′ around until it escapes at $g_3'$. Hence it returns through the regurgitating-passage and the orifice $g_3$ to the pump. Should it be desired to run the motor backward, the reversing-valve is turned, so that the fluid from the pump passes through $g_2$ and $g_2'$ and returns from the motor through $g_4'$ and $g_4$.

The reversing-valve M is an ordinary two-way valve and may be constructed by any skilled mechanic. I do not claim it as a part of my invention.

Air-chambers may be supplied to any parts of my liquid-circuit in order to form a cushion and insure uniformity of action.

The pump is run by means of an electro-dynamic motor B′ E′. Any form of motor may be adopted, with revolving armature P, sleeve N, and sleeve B rigidly attached the one to the other. The electric connections and other features of the electric motor, for the sake of clearness in the drawings, are omitted.

Q and Q′ are the car-wheels.

The operation of my device is briefly this: The electro-dynamic motor drives the pump. The fluid from the pump runs the motor, and so turns the car-axle with the wheels Q and Q′. It will be readily seen that it is not necessary to have either the original motive power, the pump, or the hydraulic motor in juxtaposition; but in this present application of my invention they were so arranged in order to obtain the compactness necessary in the cramped space beneath the car.

My device may evidently be applied to one or more axles of the car.

It will be seen that by shifting the cylinder D slowly from its position concentric with A sudden jars in starting will be avoided, the strain coming gradually upon the hydraulic motor.

The number of revolutions of the hydraulic motor will depend upon the eccentricity of the motor and the quantity of liquid passing through it. The ratio between this number of revolutions and the quantity of fluid I will call the "speed ratio." Since if the eccentricity be constant the speed of the hydraulic motor will vary with the quantity of liquid flowing through it in a given time, it will be readily seen that if the "throwing" capacity of the pump be increased the speed of the motor will increase. If the said capacity of the pump be decreased, the speed of the motor will be decreased, and when the pump throws no liquid the effect on the hydraulic motor will be *nil*. Moreover, it will be also clear that if the flow of liquid be reversed in the motor the said motor will be impelled in the opposite direction, and hence if it be attached to a car-axle revolving in one direction the reversal of the flow of liquid will be equivalent to putting on brakes until the car is brought to a standstill, when it will begin to move backward; but for use as a brake it will be necessary to have air-chambers over the passages between the pump and the hydraulic motor, for otherwise the incompressibility of the liquid would cause the rapidly-moving motor to work the pump, and so suddenly reverse the electric motor with possibly disastrous results.

Another method of using my gear as a brake when used on car-axles is as follows: When the car is in motion, suppose the eccentricity of the pump is decreased. The momentum of the car will tend to make the hydraulic motor continue at the same speed, and for a while the condition of things is reversed and the motor will tend to drive the pump. As the speed ratio of the motor remains the same while that of the pump is increased, the speed of the pump will tend to increase, and therefore the speed of the electric-motor armature. The field of the electromotor being of constant strength and the speed increasing, the counter electro-motive force of the motor will become greater than that of the line and the motor becomes a dynamo, returning energy to the line and braking the car at the same time. When the eccentricity of the pump is zero, the hydraulic motor cannot possibly revolve. It is locked. When going down a grade, the motor may be used as a dynamo again, and the eccentricity of the hydraulic pump may be shifted to allow the car to descend at any desired rate, the system acting as a brake and returning the surplus energy to the line or the storage-batteries. This, it will be noted, does away with the necessity for air-chambers.

While I have shown the aperture for the flow of liquids in the hydraulic motor as constant and that in the pump as variable, it will be readily seen that similar variations in speed would be produced by varying the eccentricity of the motor, and that should the eccentricity of both pump and motor be variable these variations may be made to augment or to neutralize each other, as may be desired.

While I have shown my device as applied to the axles of electric cars, it may be readily seen that it is suitable for many other forms of gearing, notably in lathes, saw-mill feed mechanism, and in other machines where a variable speed is required.

It will be apparent that the pump and hydraulic motor may be any distance (even miles) apart if connected by suitable pipe and valve, and that the pump may be driven by a running stream or any other motive power and the water from the hydraulic motor go to waste, if desired. These and many other modifications of my invention would readily suggest themselves to any practical mind, and I do not therefore desire to limit myself to the construction described and shown; but

What I do claim, and desire to secure by Letters Patent of the United States, is—

1. In a variable-speed gear, the combination, with a rotary eccentric piston-pump and means for altering the eccentricity of said pump at will, of a hydraulic motor and a closed liquid-circuit connecting said pump and said motor, substantially as described.

2. In a variable-speed gear, the combination, with a shaft, of a rotary eccentric piston-pump and hydraulic motor, both mounted thereon, the cylinder inclosing said pump being movable at right angles to its axis, a device for moving said cylinder in said direction and so altering the eccentricity of the said pump, and a closed liquid-circuit connecting said pump and said motor, substantially as described.

3. In a variable-speed gear, the combination of a rotary pump having extensory paddles rotating within a cylinder, said cylinder being capable of adjustment in a plane at right angles to the plane of the said paddles, with a hydraulic motor receiving its fluid from the said pump, and a closed liquid-circuit between said pump and motor, substantially as described.

4. In a rotary pump, the combination of a shaft revolving in fixed journals, extensory paddles mounted on the said shaft, a cylinder inclosing said paddles, lugs on the said cylinder parallel to a diameter thereof, fixed guides inclosing the said lugs, and means for moving the said cylinder along the said guides, substantially as described.

5. In a rotary pump, the combination of a shaft revolving in fixed journals, extensory paddles mounted in a sleeve on the said shaft, a cylinder inclosing said paddles, lugs on the said cylinder parallel to a diameter thereof, fixed guides inclosing the said lugs, and a screw revolubly attached to said cylinder between said guides and engaging a fixed nut, substantially as described.

6. In a variable-speed gear, the combination of a hydraulic motor attached to a driving-shaft and a rotary pump connected to said motor, said pump fitting loosely on said shaft and being driven by any source of power.

7. In a variable-speed gear, the combination of a hydraulic motor attached to a driving-shaft and a rotary eccentric piston-pump with eccentricity variable at will connected to said motor, said pump fitting loosely on said shaft and being driven by any source of power.

8. In a variable-speed gear, the combination of a hydraulic motor rigidly attached to a driving-shaft, a rotary pump fitting loosely on the said shaft, and an electric motor also on the said shaft and connected to the said pump, substantially as described.

9. In a variable-speed gear, the combination of a hydraulic motor rigidly attached to a driving-shaft, a rotary eccentric piston-pump with eccentricity variable at will fitting loosely on the said shaft, and an electric motor also on said shaft and connected to said pump, substantially as described.

10. In a variable-speed gear for electric cars, the combination of a hydraulic motor rigidly attached to one of the axles of a car, a hydraulic pump fitting loosely on the said axle, and an electric motor also on the said axle and connected to said pump, substantially as described.

11. In a variable-speed gear for electric cars, the combination of the shaft A, an electro-dynamic motor mounted thereon, sleeves N and B, fitting loosely thereon, sleeve B′, keyed thereon, paddles C and C′, cylinders D and D′, and passages between the pump and the motor for the fluid, substantially as described.

12. In a variable-speed gear for electric cars, the combination of the shaft A, an electro-dynamic motor mounted thereon, sleeves N and B, fitting loosely thereon, sleeve B′, keyed thereon, paddles C and C′, cylinders D and D′, guides E and E′, and a closed circuit between the pump and the motor for the fluid, substantially as described.

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

LOUIS DUNCAN.

Witnesses:
W. F. HASSON,
RANDOLPH WINSLOW.