(No Model.)

E. HILL.

METHOD OF GOVERNING THE MOVEMENTS OF PISTONS IN STEAM ENGINES.

No. 446,183. Patented Feb. 10, 1891.

Fig. 1

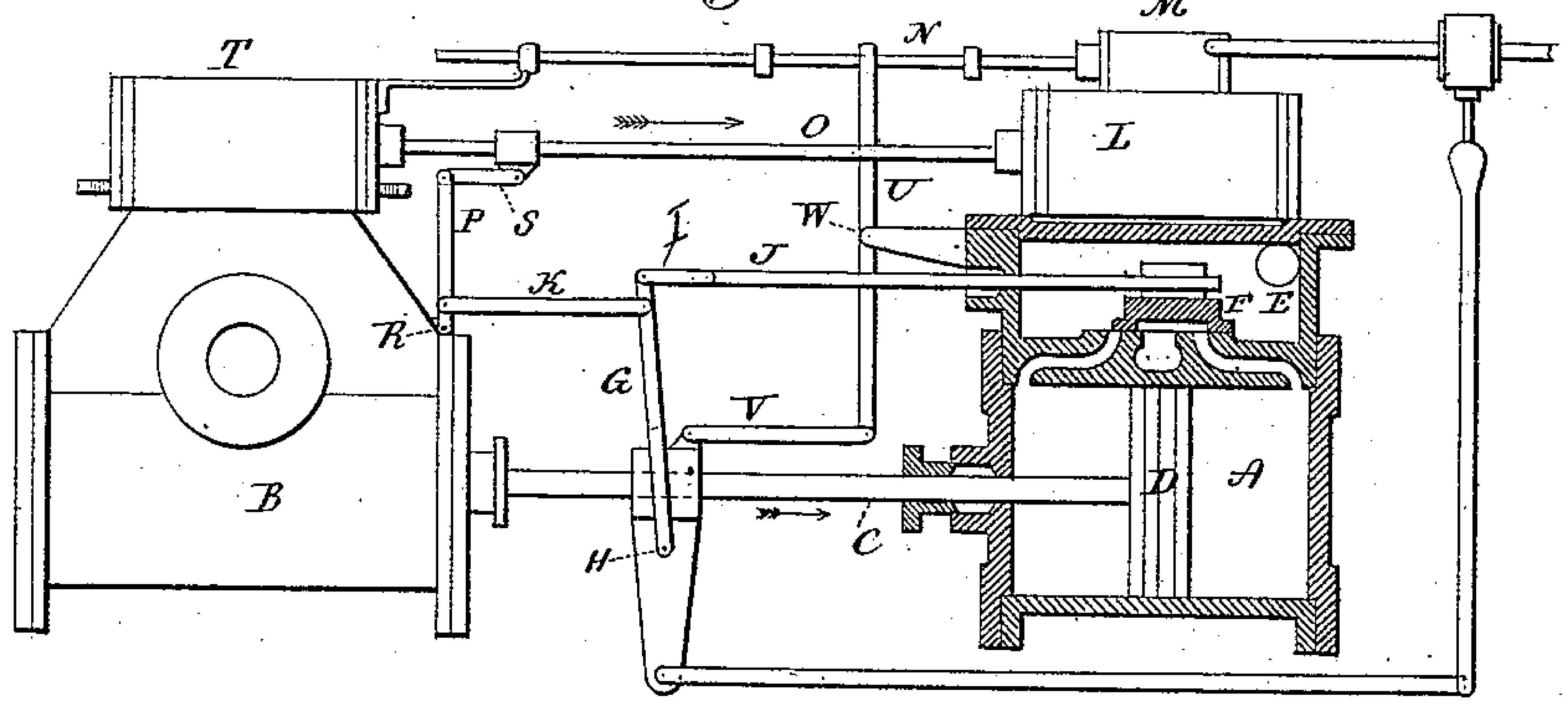


Fig. 2

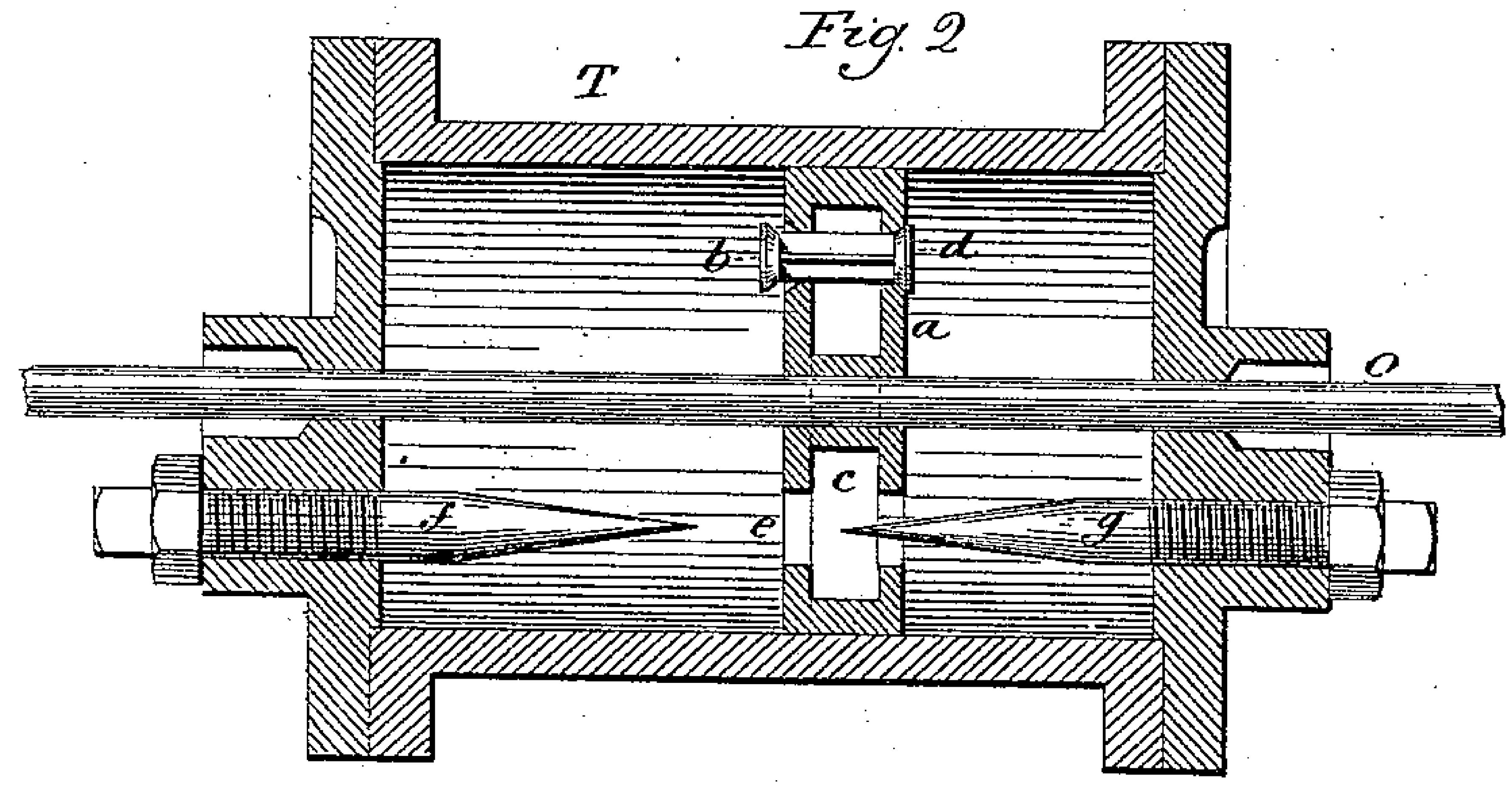


Fig. 3

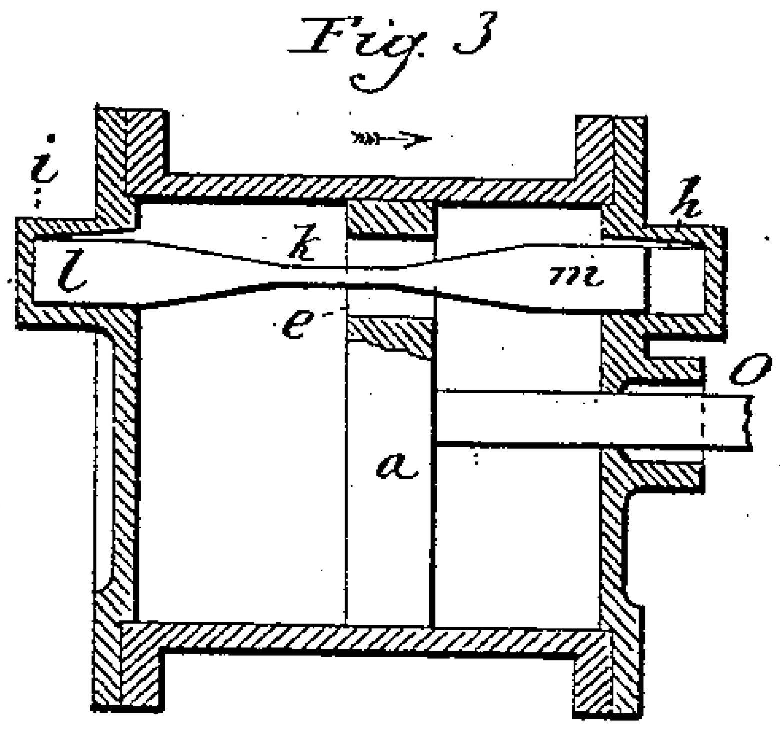
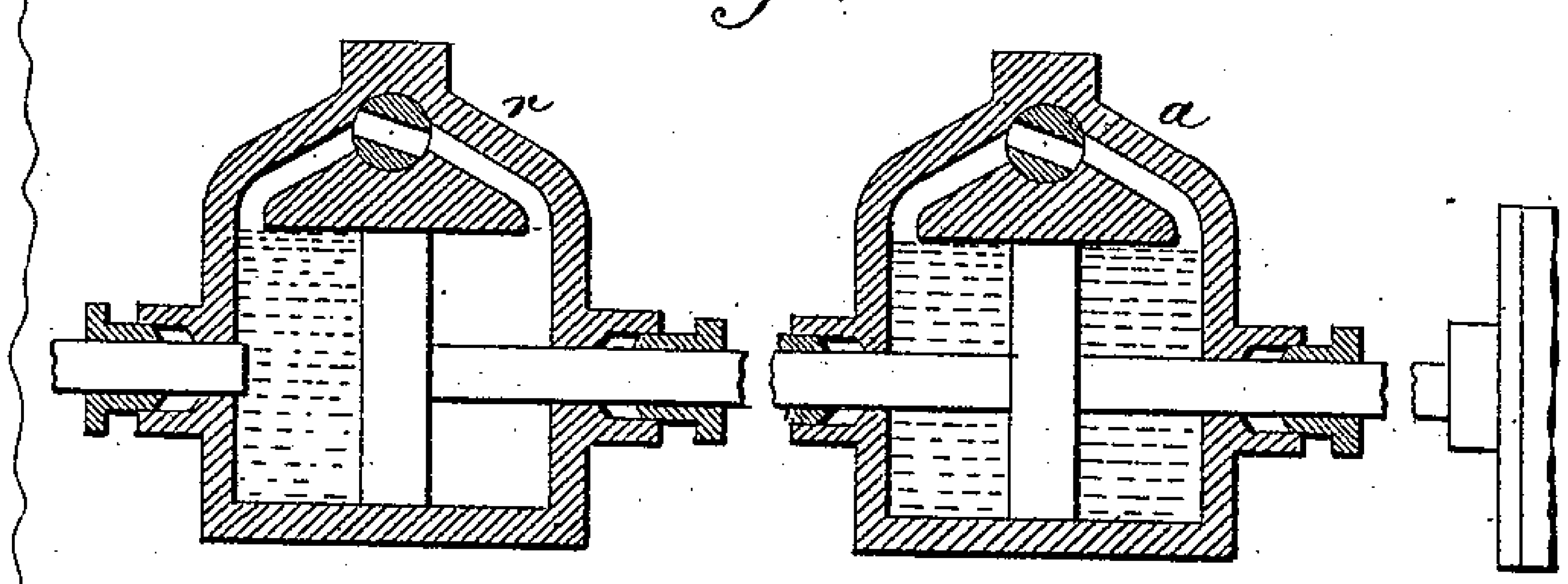


Fig. 4



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METHOD OF GOVERNING THE MOVEMENTS OF PISTONS IN STEAM-ENGINES.

SPECIFICATION forming part of Letters Patent No. 446,183, dated February 10, 1891.

Application filed October 31, 1887. Serial No. 253,806. (No model.)

To all whom it may concern:

Be it known that I, EBENEZER HILL, of South Norwalk, in the county of Fairfield and State of Connecticut, have invented a new Improvement in the Method of Governing the Movements of Pistons in Steam-Engines; and I do hereby declare the following, when taken in connection with accompanying drawings and the letters of reference marked thereon, to be a full, clear, and exact description of the same, and which said drawings constitute part of this specification, and represent, in—

Figure 1, a sectional side view of a steam-pump embodying the invention; Fig. 2, a detached longitudinal section of the cataract-cylinder enlarged; Figs. 3 and 4, modifications in the cataract-cylinder.

This invention relates to an improvement in governing the movement of pistons in steam-engines, more particularly appplicable to direct-acting engines, such as employed in connection with steam-pumps, but applicable to other engines.

In illustrating my invention I show it as applied to a steam-pump. If in such a pump the piston begins its stroke under a full head of steam, all the moving parts will start at a speed greatly above the average speed, then if during the stroke the steam be cut off the expanding steam will exercise its power to complete the stroke, but in so doing will be aided by the inertia of the said moving parts. The value of inertia in thus aiding in the movement of the piston has heretofore been recognized; but in all governing devices the aim has been to maintain uniform speed, and the inertia has been acquired by great weight of parts.

Inertia depends on two factors: first, the weight of the moving parts, and, second, the velocity of the said moving parts. It is evident, therefore, that the higher the velocity the greater the inertia.

The object of my invention is to utilize the force of inertia to a greater extent than can be done under the usual method of governing the movement of a steam-piston wherein a uniform speed of the moving parts is aimed at; and the invention consists, principally, in automatically governing throughout the whole stroke the admission of steam to the piston and so as to impart to the moving parts a velocity during the first part of the stroke greater than the average of the entire stroke, and then reduce the velocity of the said parts below that average during the last part of the stroke.

The means which I prefer to use for the government of the stroke is what is commonly called a "cataract-cylinder," and it is in direct connection with the piston, through which the valve for the admission and exhaust of steam from the steam-cylinder is controlled; but before particularly describing the cataract-cylinder I will generally describe a pump embodying the invention, as illustrated in Fig. 1.

A represents the steam-cylinder, and B the pump-cylinder, both of common construction, arranged in the same axial line, with a single piston-rod C, which acquires its movement through the piston D in the cylinder A.

E is the steam-chest of the cylinder A, in which is represented a common slide-valve F.

G represents a lever, which is hung by one end indirectly to the piston-rod, as at H, but so that that point of connection will move with the piston-rod C. The other end of the lever G is hung by a link I to the valve-rod J of the valve F, the fulcrum of the lever G being between its two ends, and as here represented, produced by a link K. Under this arrangement it will be observed that as the piston moves in one direction—say from left to right—the movement of the valve F will be in the opposite direction, and so that as the piston advances the inlet-port will be closed and the valve continue its movement in the opposite direction until the piston reaches the opposite end of the cylinder, when the port on that side of the cylinder will be opened and admit steam to move the piston in the opposite direction, so that so far as the action of the lever G and the valve-rod J are concerned the movement of the valve would be continuous throughout the stroke of the piston, but in opposite directions.

L represents a smaller steam-cylinder, which is parallel with the cylinder A, and as here represented is upon the steam-chest E. This cylinder L is provided with the usual steam-chest M and common slide-valve, as represented, N indicating the steam-valve rod of the cylinder L.

O represents the piston-rod of the cylinder L, and P represents a lever, one end of which is hung at a stationary point, say as at R, upon the pump-cylinder. The other end of the lever P is hung to the piston-rod O by a link S, and the link K connects the lever G with the lever P. It will be apparent that if the piston of the cylinder L travels also from left to right its action will be to open the valve C of the cylinder A—that is, will cause the valve F of the cylinder A to move in the direction of the piston of its own cylinder.

T represents a cataract-cylinder to govern the movement of the piston in the cylinder L. The valve-rod N of the cylinder is represented as actuated by a lever U, one end in connection with the valve-rod, the other end connected to the piston-rod C by a link V, the fulcrum W of the lever being between its two points of connection, and as shown.

A cataract-cylinder provided with a passage leading from one side of the piston to the opposite side, designed to produce a uniform speed of piston, with a throttling-valve between, is a common and well-known expedient, and are what are commonly termed "isochronous" engines.

What I deem as the best construction of cataract-cylinder, whereby the object of my invention will be attained, I illustrate in Fig. 2. The piston *a* is arranged to travel back and forth in the cylinder in the usual manner for steam-pistons, and it is fixed to the piston-rod O of the cylinder L, so that the piston of the cataract-cylinder T and of the cylinder L are in positive connection. Through the piston a valve is arranged, consisting of two valves *b d* on opposite sides of the piston, but connected through the piston, and so that when one valve is upon its seat on one side of the piston the valve upon the opposite side will be opened, as represented, and vice versa. At another point in the piston an opening *e* is made through it parallel with the axis of the piston, of any desirable size within the cylinder, and from the respective heads plugs *f g* project parallel with the axis of the cylinder and directly in line with the opening *e*. The diameter of these plugs at the respective heads and for a short distance therefrom is slightly smaller than the opening *e* through the piston, and so that the piston as it approaches one end of the cylinder will pass onto one of said plugs, then as it returns will pass off from the said plug and approaching the opposite end will pass onto the plug at that end. These plugs are preferably cylindrical for a short distance from the head, and thence are gradually reduced in diameter—say to substantially a point—as represented in Fig. 2. It will be understood that the cylinder is filled with water or other suitable fluid of a like nature, and that the piston being at one end of the cylinder, with the fluid upon the opposite side, as the piston moves toward the other end of the cylinder the fluid on the advancing side of the piston must pass to the retreating side of the piston as the piston advances, and that the velocity with which the piston can thus travel through the cylinder depends upon the rapidity with which the fluid can escape from the advancing to the retreating side of the piston. The valve on the advancing side of the piston will be closed because of the pressure of the fluid against it; but as the piston reverses at the respective ends of the cylinder the action of the fluid upon the then advancing side of the piston is to move the valves in the opposite direction, open the valve upon the retreating side, and close the valve upon the then advancing side. The length of the two connected valves is such that the valve will come against its end of the cylinder, so that at the extreme position of the cylinder both valves will be open to allow a passage through the piston from one side to the other, and so that as the piston starts to advance fluid from the advancing side may readily pass through the valve to the opposite side until the piston shall have moved so far that the valve is free to automatically close under the action of the fluid.

The piston of the cataract-cylinder starts under the action of the steam-piston in connection therewith, and as it starts it meets the resistance of the fluid on the advancing side, which accordingly tends to retard the advancing movement of the steam-piston. The plug *f* permits at first but a slight escape of the fluid through the piston; but as the piston advances it passes onto the contracting surface of the plug, consequently increasing the area of the passage through the piston and permitting a greater or more rapid escape of the fluid from the advancing side of the piston through the piston to the retreating side, and this increase of flow of the fluid permits a more rapid movement of the piston through the cataract-cylinder, and consequently more rapid movement of the steam-piston, and this movement will increase until the maximum area of opening through the piston is reached. From that point a uniform velocity of piston will result, because of the necessarily uniform passage of fluid through the piston, and this equal velocity will continue until the advancing piston comes to the plug in the end of the cylinder toward which it is moving. As it passes onto that plug the area of the opening is reduced, and that reduction increases until the piston reaches its extreme movement toward that end of the cylinder. The increasing resistance produced by the reduction of the passage for the fluid through the piston correspondingly retards the movement of the piston in the cataract-cylinder, and consequently retards the movement of the piston in the steam-cylinder.

The plugs are preferably made adjustable with relation to the passage through the piston.

To facilitate the passage of the fluid through the piston on reversing its movement, the piston may be made hollow, so as to form a chamber c therein, as represented in Fig. 2, and so that the passage e through the piston opens into this chamber from both sides, and the chamber extends to the valve, so that the valve on each side opens into the same chamber. When the piston is at one extreme and is on the point of turning, the larger diameter of the plug will substantially close the opening on the side nearest the head; but the diminishing diameter of the plug leaves a space around the plug in the opening on the other side of the piston, through which fluid may pass into the chamber c as the piston commences its return movement, and the fluid thus passing into the chamber c through the passage e will escape through the valve opening onto the retreating side of the piston, so that after the valve shall have closed on the advancing side there will still be an open passage through the piston and through the valve opening onto the retreating side, and the fluid will flow in this direction until the passage through the piston at e has fully passed from the plug on the retreating side.

Under this construction it will be apparent that the piston of the cataract-cylinder will be permitted to move more rapidly during the first part of the movement of the steam-piston than the average velocity of the piston, and that the velocity of the piston will be reduced below the average during the last part of the stroke, and that the admission of steam to the cylinder A is consequently governed throughout the whole stroke, the result of which is that a velocity is imparted to the moving parts during the first part of the stroke greater than the average of the entire stroke, and that the velocity of the parts is reduced below the average during the last part of the stroke.

In the arrangement of parts as illustrated in Fig. 1 it will be observed that the steam-valve lever G is hung upon a fulcrum which is movable in the direction of movement of the valve under the action of the cataract-piston, and that the opening movement of the steam-valve is in the same direction as the movement of the piston in the steam-cylinder, but that the connection between the steam-valve and its piston is such that were the fulcrum on which the lever G turns stationary the movement of the steam-valve would be in the opposite direction to that of its piston. Hence the opening movement of the valve is produced and controlled substantially by the cataract-cylinder, and as the piston in the cataract-cylinder is governed in its movement so that on starting from one end of its cylinder its movement increases in velocity the opening movement of the steam-valve is correspondingly accelerated, and such accelerated opening of the steam-valve admits steam to the piston of the steam-cylinder, thereby producing a corresponding rapid or accelerated movement of the steam-piston during the first part of its stroke, but as the piston of the cataract-cylinder approaches the other end of its cylinder its velocity decreases, bringing the fulcrum of the lever G to a stationary position, and so that the lever G may turn upon its fulcrum under the movement of the steam-piston D, and so that the retarding of the cataract-piston will permit the steam-piston D to operate the steam-valve F and more rapidly draw the valve to its closed position to reduce the supply of steam to the piston, thereby diminishing the velocity of the steam-piston during the last part of its stroke, the velocity of movement of the steam-piston during the first part of the stroke being greater than the average of the entire stroke, while the velocity of the last part of the stroke will be less than the said average. From this it follows that there will be a corresponding increase in the force of inertia gained during the first part of the stroke, to be utilized during the last part of the stroke over what can be acquired under a uniform velocity of the moving parts, or where the velocity of the first part of the stroke is less than the average. The method which I have thus disclosed may be embodied in other forms of mechanism, as will appear by the following.

In Fig. 1 I show a construction of the cataract-cylinder somewhat different from Fig. 2. In this case the piston is constructed with the same opening e, and through this opening the two plugs are united to form a longitudinal bar supported in the heads of the respective ends of the cylinder but adapted for a certain amount of free longitudinal movement. Under this arrangement one cylinder-head is constructed with a chamber h and the other cylinder-head with a like chamber i, both in axial line with the opening e through the piston. The bar is of a length a little greater than the length of the interior of the cylinder between the heads plus the depth of one of the chambers, but so as to be supported in the two chambers longitudinally through the piston. Midway of its length the bar is reduced in diameter, as at k, but gradually increases toward each end to the maximum diameter at the end portions l m, which end portions correspond substantially in diameter to the chambers i h in the respective ends of the cylinder. The piston moves freely over the bar as it travels from end to end of the cylinder. As the piston commences its advance from one end of the cylinder, the pressure of the fluid is brought against the end of the bar in the chamber at the end of the cylinder toward which the piston advances and causes the bar to instantly move longitudinally through the piston to a bearing at the other end of the cylinder. This movement of the bar, because of the reducing diameter of the bar, causes the area of the opening e through the piston to be instantly increased, and so as to permit the fluid to pass rapidly through the piston from the advancing to the retreating side. Then during the last part of the stroke the piston passes onto the enlarged end of the bar on its advancing side, thereby reducing the area of the opening through the piston, and consequently retarding the movement of the piston. The same result is accomplished in this case as in the cataract-cylinder first mentioned. Under this arrangement the movement of the bar or attached plugs produces substantially the same result on the reversal of the piston that the valve performs in the first illustration. Again, two cataract-cylinders may be used, as seen in Fig. 4, one cataract—say *a*—filled with fluid and set to regulate the highest speed, and the other cataract *r*, say, only partially filled with fluid. Under this arrangement the second cataract will have no effect upon the stroke until its piston has moved so far that the fluid in advance of it has filled the space. Then this second cataract *r* will act and regulate the slowest speed desired. These modifications will be sufficient to enable those skilled in the art to which this invention pertains to understand that this invention is not limited to any particular construction of the cataract, the essential feature of the invention being the automatic government of the admission of steam throughout the whole stroke, and so as to impart to the moving parts a velocity in the first part of the stroke greater than the average of the entire stroke, and to reduce the velocity of the parts below that average during the last part of the stroke.

I claim—

The method of utilizing the force of inertia in a steam-engine, which consists in automatically imparting to the moving parts a velocity during the first part of the stroke greater than the average of the entire stroke and automatically reducing the velocity of the parts below that average during the last part of the stroke, substantially as described.

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