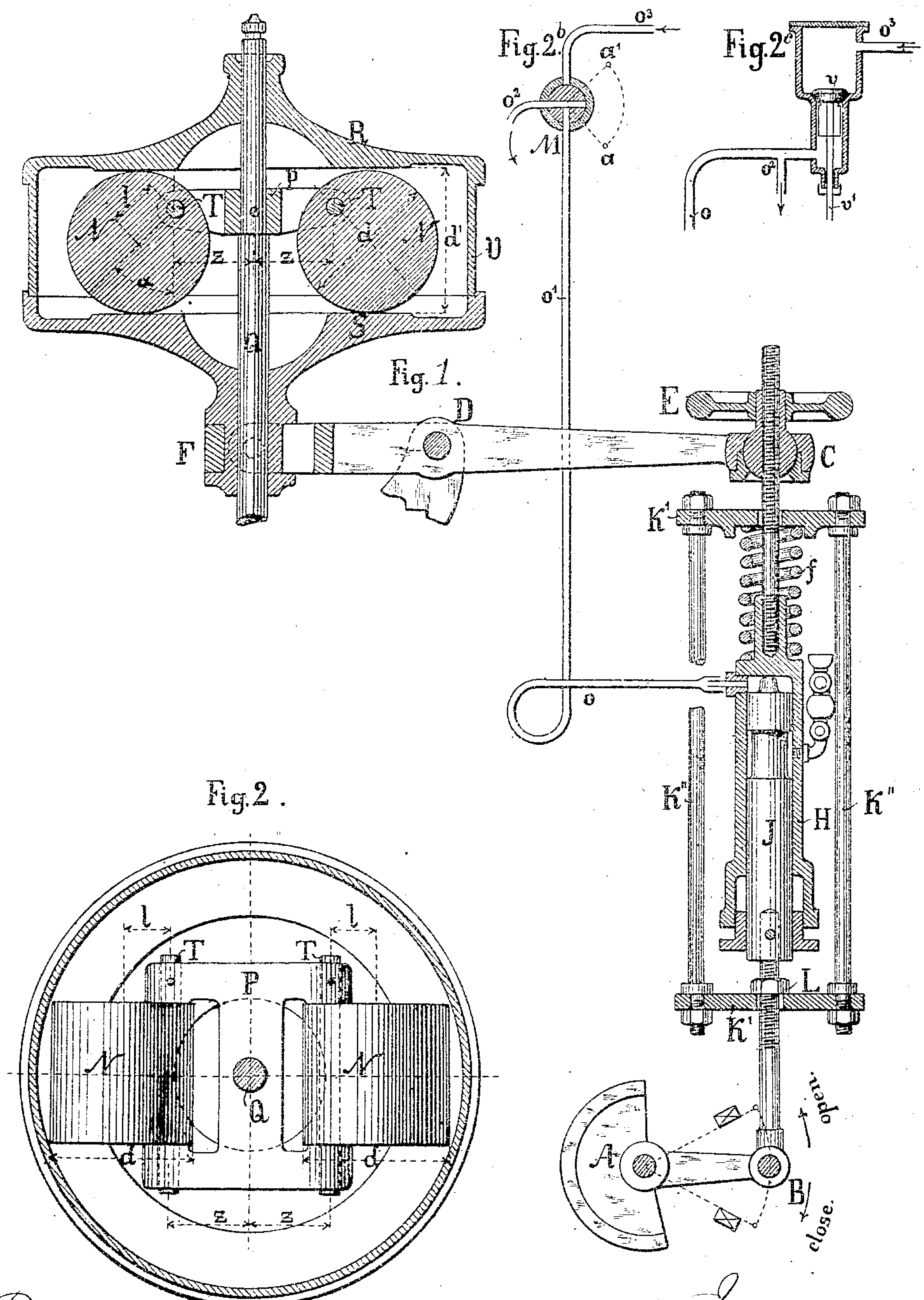
(No Model.) 3 Sheets—Sheet 1.

F. J. WEISS.
GOVERNOR.

No. 560,450. Patented May 19, 1896.



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(No Model.)

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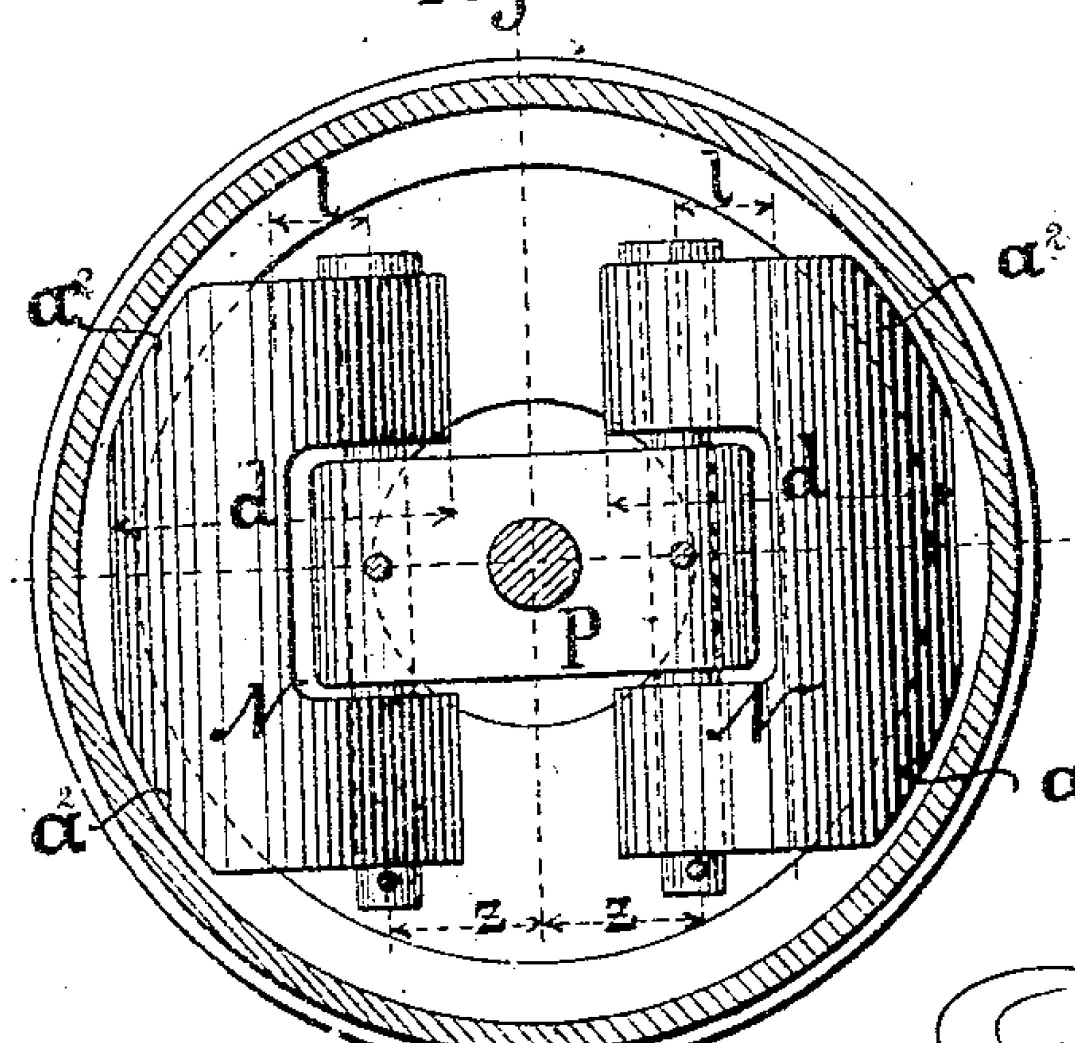
Fig. 2^a



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(No Model.)

3 Sheets—Sheet 3.

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Fig. 3.

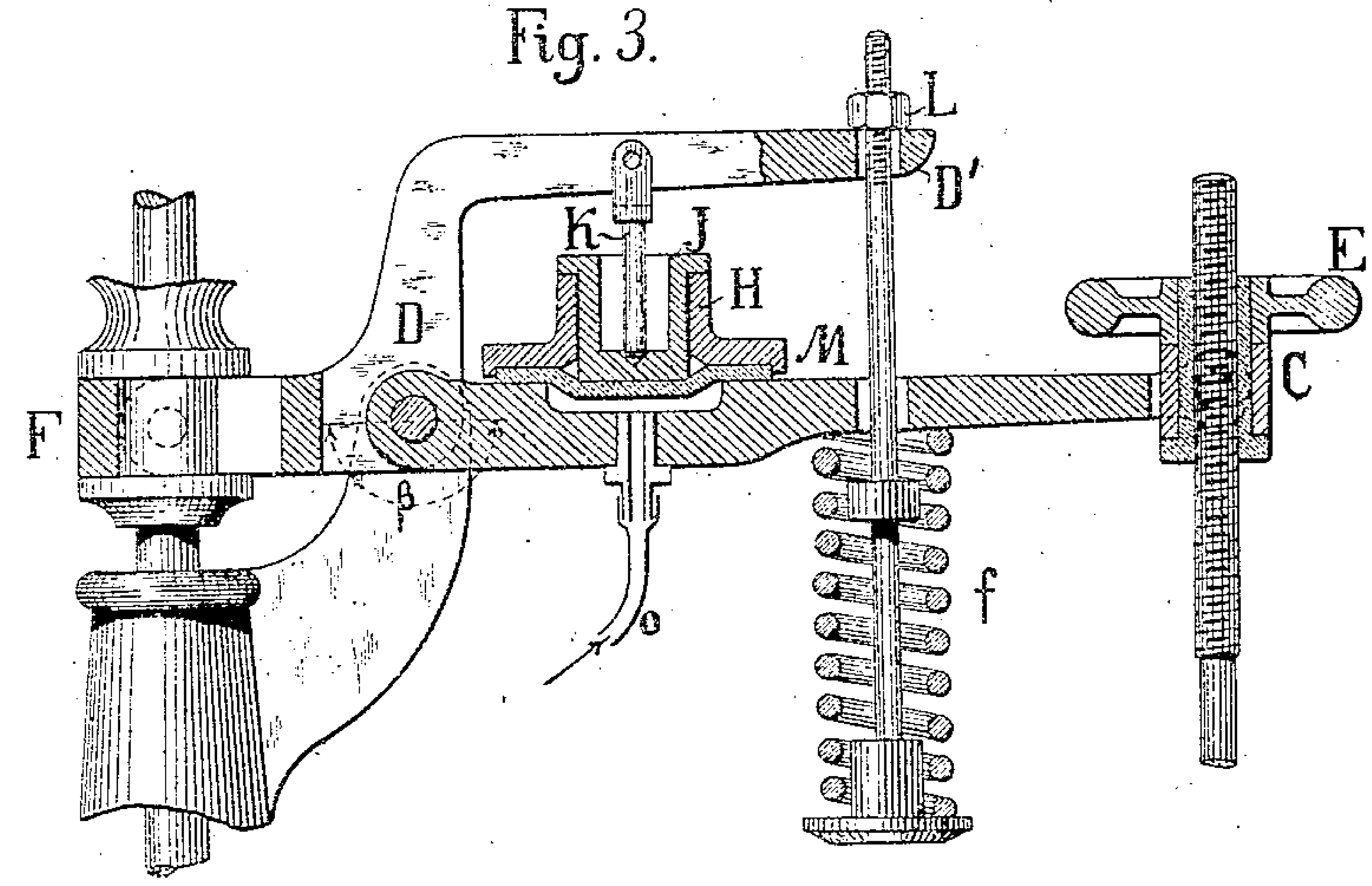
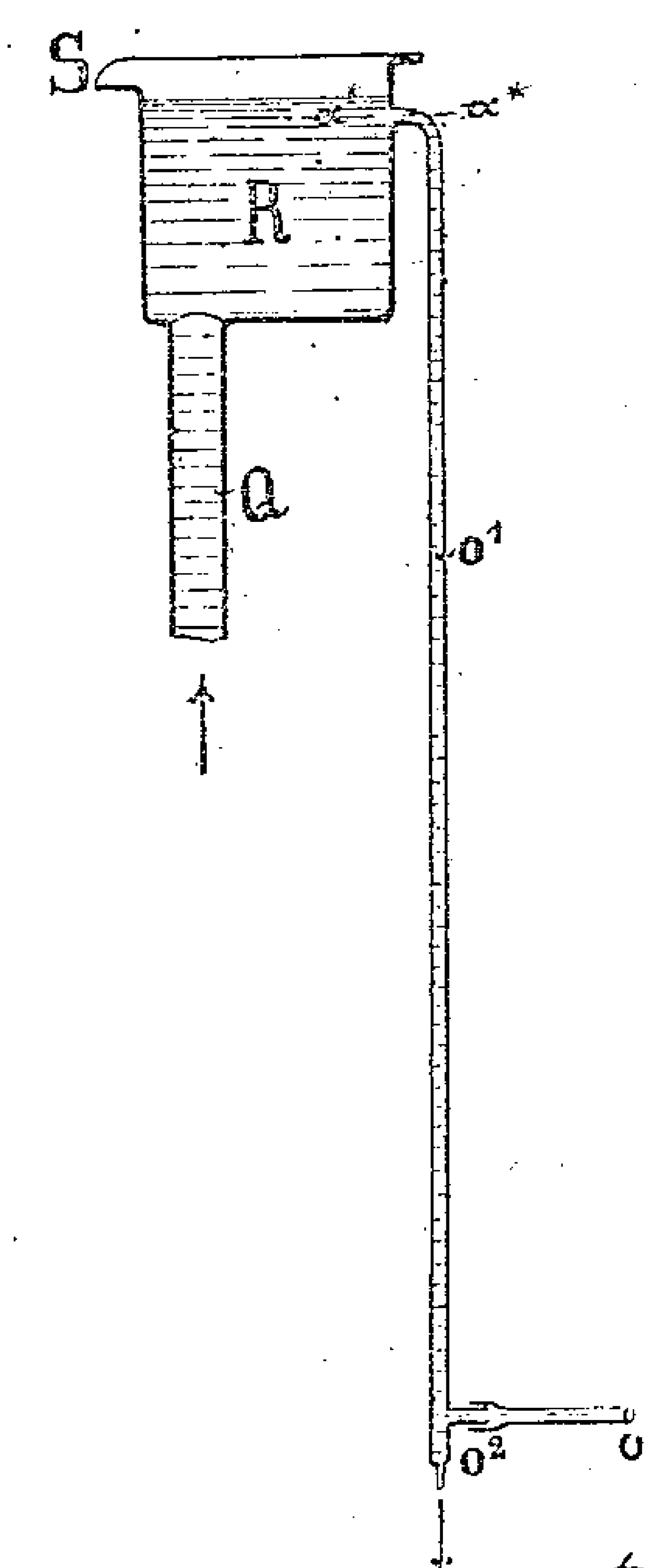


Fig. 4.



Witnesses:
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Inventor
Franz J. Weiss
By James L. Norris.
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UNITED STATES PATENT OFFICE.

FRANZ JOSEPH WEISS, OF BASLE, SWITZERLAND.

GOVERNOR.

SPECIFICATION forming part of Letters Patent No. 560,450, dated May 19, 1896.

Application filed April 22, 1891. Serial No. 389,989. (No model.) Patented in Switzerland September 21, 1889, No. 1,433, and March 14, 1891, No. 1,433/82; in Germany January 30, 1890, No. 54,922, October 30, 1890, No. 58,300, December 11, 1890, No. 58,304, and January 14, 1891, No. 58,518; in France April 5, 1890, October 29, 1890, December 10, 1890, and January 13, 1891, No. 204,822; in Belgium April 5, 1890, No. 90,096, October 29, 1890, No. 92,520, December 10, 1890, No. 93,047, and January 13, 1891, No. 93,415; in England April 15, 1890, No. 5,729, and in Austria-Hungary April 17, 1891, No. 77/11,904.

To all whom it may concern:

Be it known that I, FRANZ JOSEPH WEISS, of the city of Basle, in the canton of Basle and Republic of Switzerland, have invented a certain new and useful Improvement in Governors, (for which I have obtained Letters Patent as follows: in Switzerland, No. 1,433, dated September 21, 1889, and No. 1,433/82, dated March 14, 1891; in Germany, No. 54,922, dated January 30, 1890, No. 58,300, dated October 30, 1890, No. 58,304, dated December 11, 1890, and No. 58,518, dated January 14, 1891; in France, No. 204,822, dated April 5, 1890, October 29, 1890, December 10, 1890, and January 13, 1891; in Belgium, No. 90,096, dated April 5, 1890, No. 92,520, dated October 29, 1890, No. 93,047, dated December 10, 1890, and No. 93,415, dated January 13, 1891; in Great Britain, No. 5,729, dated April 15, 1890, and in Austria-Hungary, No. 77/11,904, dated April 17, 1891,) of which the following is a specification, reference being had to the accompanying drawings.

My invention relates to engine-governors, and more particularly to governors for use in pumping-engines.

In the governors heretofore generally employed the principal object has been to maintain as uniform a speed as possible for the engine under varying resistances. The object of my present invention is quite a different one, inasmuch as the object is not to maintain a uniform speed, but, on the contrary, to provide for varying and adjusting the speed of pumping-engines at will within the widest limits, so that the speed of the engine and connected water or air pump may be adapted to the amount of work required to be done at any time. This variation may be effected either automatically or by hand or in both ways combined while the engine is running, the above-mentioned object being attained exclusively by the action of the governor upon the expansion-valve gear of the engine, the feed-valves for the steam being kept quite open all the while and no recourse being had to throttling. In order to indicate in the name of the improved governor the fundamental difference between it and the class of governor heretofore generally employed, I may say that my improved device is an "effect governor," while those heretofore employed may be termed "speed-governors."

My invention consists in the combination, with what I call a "highly static governor," of a peculiar connecting mechanism to be more fully hereinafter described.

In the accompanying drawings, illustrating my invention, Figure 1 is a vertical sectional view of a governor and mechanism embodying my invention. Fig. 2 is a plan of the revolving chamber of the governor with the top cover removed therefrom, and Fig. 2ª a similar plan showing a modification. Figs. 2ᵇ and 2ᶜ are a diagram and a vertical section, respectively, of the pipe connections for admitting water into the mechanism connected with the governor for automatically regulating the same. Fig. 3 is a vertical section of another modified form of the mechanism. Fig. 4 is a sectional diagram showing the pipe connections for admitting water to the mechanism from a reservoir.

In order to render this specification better understood as regards the construction and operation of my invention, and also in order to avoid subsequent repetitions as much as possible without thereby impairing the clearness of the description, I will here state two facts having special reference to the question at issue:

First. The frictional work per revolution of a steam-engine and of a pumping-engine coupled therewith is uniform or constant for any number of revolutions of the steam-engine per minute, provided the load on the engine remains the same. It is often wrongly assumed that the said frictional work increases with an increase in the number of revolutions of the engine.

Secondly. If a pumping-engine requiring a given useful effect per revolution be coupled with an expansion-engine, and the sectional areas of the steam-conduit from the boiler, as well as the exhaust-passages of the engine and also the sectional area of the passages for the liquid in the pumping-engine, be sufficiently large, so that within the widest limits of speed admissible for the engine a throttling of the steam and of the working liquid does not take place, or, at least, not beyond a very limited extent, then the said steam-engine, all other things remaining equal, will always require the same cut-off, no matter whether the engine within the admissible limits of speed is running fast or slow.

Supposing, for instance, that an air-compressor is driven by an expansion-engine, then the area of the indicator-diagram of the steam-cylinder must be equal to the total area of the indicator-diagram of the air-cylinder plus the area of a surface representing the frictional effect of the entire engine per single stroke of the same. When the air-pressure remains uniform, the area of the indicator-diagram of the air-cylinder will also remain uniform, no matter whether the engine is running fast or slowly. According to what has been said in the above first statement the frictional work per revolution is likewise uniform, irrespective of the speed. Hence the total of both must also remain uniform, and the area of the steam-cylinder diagram must therefore remain uniform likewise.

It follows from the above that with a uniform steam-pressure the cut-off must remain uniform throughout, no matter whether the engine runs slow or fast. This cut-off I will hereinafter call the "necessary" cut-off. Contrary to the popular idea it is not possible to change the number of revolutions of such an engine by varying the expansion unless at the same time the steam is throttled, be it intentionally or unintentionally. If the steam-cylinder is given a greater than the necessary cut-off, then the engine will run away. If, on the other hand, the cut-off is less, then the engine will stop.

I will now explain the construction and peculiar operation of my improved device with reference to the accompanying drawings.

The device shown in one form in Fig. 1 consists of the two following principal parts, which must operate together—that is to say, of a highly static centrifugal governor and of an intermediate adjusting mechanism between the said governor and the valve-gear of the engine. Each of these two connected parts must conform to certain specific conditions, to be hereinafter pointed out, as follows—that is to say, the governor, as already named, must be a highly static one, or, in other words, to each variation in the angular position of its balls must correspond a different rotary speed of the governor-shaft. At the same time the governor employed must be of great "regulating capacity." By this term, as applied to a governor, I mean the quotient obtained by dividing the greatest number of revolutions of the governor at the most outward position of its balls by the smallest number of revolutions thereof at the least outward position of its balls. I will hereinafter explain how a governor should be constructed in order to insure this quality in the highest degree, and I will at the same time show a very suitable construction of such a governor. As regards the other element of the combination, the intermediate adjusting mechanism between the governor proper and the valve-gear of the engine, this mechanism must be so arranged that one or more parts of the mechanism, no matter which part or parts, may or will be adjusted in such a manner relatively to the other parts of the said mechanism, while the pumping-engine is in motion, as to alter the relative positions of that part of the expansion-valve gear which regulates the cut-off, with regard to the balls of the centrifugal governor, and that without at the same time materially changing the total proportion of transmission between the movements of the nut of the governor and the stroke or movement of that part of the expansion-valve gear which regulates the cut-off. Thus the connecting-rod C B may be made longer or shorter by a screw and a hand-wheel E, or the same effect as that attained by thus lengthening or shortening the connecting-rod C B may also be attained in different other ways—for instance, by providing for turning the lever D C relatively to the lever D F or for turning the lever B A. Inasmuch as every adjusting mechanism constitutes a connected system of rods for traction or pressure and levers, the above conditions for the relative adjustment of parts are fulfilled by either lengthening or shortening the rods or turning the levers into different positions. The said adjusting mechanism acts directly upon the expansion-valve gear, the latter in the present case, as shown in the drawings, being supposed to be a Rider expansion-valve gear.

Supposing the device here shown to be connected with a steam-engine for driving a pump required to lift water into a reservoir to a certain height, and supposing that the steam-cylinder, the steam-pressure remaining uniform and the ports being quite open, require a certain cut-off—say of 0.30—this being, as we will suppose, the "necessary" cut-off, according to the definition of this term as hereinbefore given, then the balls of the governor will, by reason of the corresponding position of the Rider gear, assume a certain position or angle of throw. We will suppose this angle to correspond with, say, sixty revolutions per minute of the engine, and that the pump will then be lifting, say, four cubic meters of water per minute. As long as no change whatever takes place or is effected, the governor will in the usual manner maintain the number of revolutions at sixty per minute and the amount of water supplied per minute at four cubic meters. Supposing, however, that the quantity of water required becomes less—say one cubic meter per minute—and that it be desired, therefore, to correspondingly reduce the number of revolutions of the engine from sixty to fifteen, the steam-inlet valve being kept fully open all the while, or, in other words, no recourse being had to throttling of the steam, the attendant will then merely have to turn the hand-wheel E, Fig. 1, in such a direction as to thereby increase the length of the connecting-rod C B. As the balls of the centrifugal governor, by reason of inertia, will resist a change in their position and thus retain the lever F D C in its position, the adjusting-lever B A will thus at first be pressed downward and the cut-off correspondingly reduced. The cut-off for the steam-cylinder having thus become reduced below the standard or necessary degree will no longer be sufficient to overcome the pressure of the water plus the friction of the entire engine, and the latter will therefore have a tendency to stop. This, however, will be automatically prevented in my improved device in the manner which I will now explain. Before actually coming to a stop the engine will first begin to slow down. The balls of the static governor will, in consequence, assume a lower position of equilibrium corresponding to the reduced speed of the engine, thereby causing the adjusting-lever B A to be lifted to such a position as again to produce a larger cut-off or the necessary cut-off. This cut-off will not, or at least not materially, differ from the cut-off as previously, but the engine will, as intended, be running slower now in accordance with the lower position of governor-balls. After all these movements will have taken place the adjusting-lever B A will automatically have assumed its previous position, and only the "configuration" of the other parts of the governor and connected adjusting mechanism will have become changed with the different rotary speed of the governor.

Supposing, on the other hand, that it be desired to increase the work effect of the pump, or, in other words, to increase the number of its strokes, then the hand-wheel E will have to be turned in the opposite direction, so as to shorten the connecting-rod B C, Fig. 1. The cut-off in the valve will thus be made larger than the necessary cut-off, and the engine will have a tendency to "run away." In consequence of the higher speed of the engine, however, the governor-balls will assume a higher position, thereby in turn causing the lever of the valve to be pressed down again into its original position, when it will again produce approximately the same cut-off as previously, or, in other words, giving the necessary cut-off, the engine now, however, running faster in accordance with the higher position of the balls of the static governor. In a static or approximately static governor which will "play" only at one and the same number of revolutions and in which the balls will then be either in an elevated or in a lowered position, the action as above described with reference to a static governor would not take place, and it is for this very reason that I require for the particular object pointed out in the introductory part of this specification a highly static governor with a very high degree of dissimilarity, while this quality for any other purpose would be of no use whatever.

For the sake of stating a concrete example and thereby rendering the peculiar action of my apparatus more intelligible I have in the drawings and specification assumed the governors hereinbefore described as being connected with and acting upon a Rider expansion-valve gear. It is obvious, however, that these governors may also be applied to any kind of expansion-valve gear, such as the Corliss-Sulzer, Colmann, or any other kind, just as governors of various kinds, such as Watt's, Porter's, Proll's, Buss's, or others, may be applied to all kinds of expansion-valve gears. I may even go so far as to say that the valve-gears above named, so effective in connection with engines for running a system of gearing, are rendered still more capable of developing their peculiar advantages, more particularly for pumping-engines, when applied in connection with a governor of the kind hereinbefore described.

The limits within which the number of revolutions of engines may be regulated by means of these governors will be greater the more static the governors proper used in connection therewith will be, or, to use a more concise expression already previously employed, "the greater their regulating power will be." It will be well to leave the peculiar dynamometric apparatus, shown in the drawings as connected with the rod C B of the adjusting mechanism, out of consideration altogether for the present, as the same will be specially referred to later on.

Figs. 1, 2, and 2ª show a form of governor wherein the proportion between the distance of the fulcrum of the pendulum from the axis of the governor, on the one hand, and the length of the said pendulum, on the other hand, may be made relatively great in a very small space, thus rendering this construction particularly well adapted for governors of the kind hereinbefore referred to.

A revolving chamber R V S, Fig. 1, provided with a recessed groove below for receiving the nut F, is so mounted on the vertical shaft Q of the governor as to admit of freely moving up or down on the same. If desired, it may also be so arranged on the shaft as to be capable of freely rotating on the same. This, however, is immaterial. The inner surfaces of the top cover R and the bottom S of the revolving chamber are turned smooth, forming right angles with the governor-shaft Q, their distance d' from each other being equal to or a fraction of a millimeter larger than the diameter d of the two cylindrical weights N. By reason of the varying centrifugal force of the weights N the latter will from time to time assume a higher and a lower position, as the case may be, and the angle will become larger and smaller. The cylindrical weights in performing these movements will carry the revolving chamber R V S, with the grooved recess formed thereon for the nut F, up and down with them, the said revolving chamber, as already stated, being arranged to slide freely on the governor-shaft Q. These movements are in turn transferred to the expansion-valve gear of the engine by means of the intermediate devices F D C B in the same manner as previously explained. The weight of the chamber R V S serves to increase the "energy" of the governor, Fig. 1, and in spite of this weight there is still an ample regulating capacity.

It has been found that the number of revolutions of an engine may by means of this governor, in connection with the intermediate mechanism hereinbefore described, be regulated within such wide limits that the maximum number of revolutions will be 4.80 times as great as the minimum number of revolutions, or, in other words, the capacity of the engine may be increased to 4.80 times from the single. It may also be adjusted for any intermediate value. It will thus be seen that such a variation in the number of revolutions may be secured as could not even approximately be obtained heretofore by any other means and without having recourse to a throttling of the steam.

When the revolving chamber R V S is made sufficiently heavy so that its weight alone will be sufficient to overcome the resistance of the intermediate mechanism between the governor proper and the expansion-valve gear of the engine, then the construction of the governor proper, as shown in Figs. 1, 2, and 2ª, may be simplified, inasmuch as in that case it will be sufficient to let only the upper surface R of the chamber touch or engage with the cylindrical weights N, or, in other words, to let the entire chamber R V S rest upon the said cylindrical weights N with its top cover having a smoothly-finished lower surface. The bottom S of the chamber need not in this case touch the cylindrical weights and will not therefore require to have a finished surface. In this arrangement the energy of the governor will become less when the governor drops into a lower position. It is obvious that, so far as the character of the governor proper hereinbefore described is concerned, it is immaterial whether the cross-piece P be made to surround the cylindrical weights N, as shown in the plan, Fig. 2, or whether the cylindrical weights N be made to surround the cross-piece P, as shown in the plan, Fig. 2ª. I may also, with a view to obtain as rounded and solid a shape as possible, round off the corners of the cylindrical weights N at A, as indicated in the same view, Fig. 2ª.

When employing my improved device in connection with pumping-engines for water or air, it is desirable to provide means for regulating the work or effect of the pumps not only by hand, as hereinbefore described, but also automatically and in such a manner as to cause the working speed of the engine to become automatically reduced when the water or air pressure will have reached a predetermined point. Constructional arrangements of this kind are shown in Figs. 1 and 3.

The most frequent use for governors of this kind will be for engines intended for driving water or air pumps. In such cases it is desirable to provide means for regulating the said pumps not only by hand, as heretofore described, but also automatically and in such a manner as to cause the working speed of the engine to be automatically reduced when the water or air pressure shall have reached a predetermined point. Constructional arrangements of this kind are shown in Figs. 1 and 3, and I will proceed to describe the same in the first place with reference to Fig. 1. The movements of the nut F of the governor proper, Fig. 1, are, by means of the intermediate mechanism—that is to say, the lever F D C and connecting-rod C B—transmitted to the device for regulating the cut-off, the latter in this case also being the expansion-valve of a Rider gear. The connecting-rod C B is here shown as formed in two portions—that is to say, an upper portion rigidly connected at its lower end with the barrel H and a lower portion connected at its upper end with a plunger J, tightly fitting in the barrel H and capable of moving within the latter. When the screw L is screwed down, the plunger J is, by reason of the arrangement of cross-pieces K′, connecting-bars K″, and spiral spring *f*, pressed against the bottom of the barrel H with a certain force, which may be regulated. As long as the parts remain in this position the entire dynamometric apparatus thus formed between the joints C and B acts as if it did not exist at all—that is to say, as if C and B were connected by one rigid connecting-rod.

o is a flexible tube of gutta-percha or other suitable material, so as not to interfere with the movement of the other mechanism. It communicates on the one hand with a space between the bottom of the barrel H and the plunger J, and on the other hand with the pressure-conduit of the pump, the work of which is to be regulated.

For the purpose of explaining the device in connection with a concrete example, we will assume the same to be applied to a steam-engine for driving an air-compressor, the said air-compressor being intended for working, say, twelve rock-drills. In this case the flexible tube is arranged so as to communicate direct with the pressure-conduit of the compressor in such a manner that the pressure of compressed air within the barrel H is exerted below or, as here shown, above the plunger J.

Supposing it is required that the air-pressure shall not exceed a certain limit—say seven atmospheres, for instance. The pressure of the spiral spring *f* will by means of the screw L be first adjusted in such a manner as not to permit the plunger J to be lifted from the bottom of the barrel until the tension of the air above the said plunger shall have become equal to seven atmospheres. We will suppose that the quantity of air required for working the twelve rock-drills were such as the compressor will furnish at, say, one hundred revolutions per minute. The engineer will then, by turning the hand-wheel E in the manner as hereinbefore described, give the engine such a number of revolutions per minute as will either be equal to the required maximum number of one hundred per minute or a little above. This done, the engine is allowed to work on by itself. The apparatus will then act as follows—that is to say: As long as the air-pressure does not attain the predetermined limit of seven atmospheres the plunger J will remain at the bottom of the barrel H and the dynamometric apparatus between C and B will not come into action, but will simply act the same as a rigid bar or connection between C and B, the entire regulating apparatus maintaining the speed of one hundred or a little more, as originally secured by the adjustment of the hand-wheel E.

Supposing now that six of the twelve rock-drills were stopped, as the compressor will for a while still maintain the previous speed the air-pressure will now rapidly increase, because less air is being consumed than is being supplied by the compressor. As soon as the air-pressure exceeds the predetermined limit of seven atmospheres, however, the pressure of air exerted upon the plunger J will overcome the resistance of the spring f and the plunger will be pressed down within the barrel H, thereby in turn pressing down the adjusting-lever B A of the regulating-valve gear, and thus causing a shorter cut-off in the steam-cylinder. As previously explained, the result would be that the engine would now come to a standstill, since the cylinder is no longer receiving the "requisite" cut-off. This, however, is again automatically prevented on the part of the apparatus, as the engine, and with it also the static governor, will before coming to a stop first begin to run slower, thus causing the governor-balls to drop into a lower position of equilibrium, the adjusting-lever B A thereby being lifted into its previous position again through the intermediate devices F D C B and again securing the requisite amount of cut-off in the steam-cylinder. At the same time the governor-shaft and also the engine will in accordance with the lower position of the governor-balls make a smaller number of revolutions per minute.

It will be understood from the character of the apparatus as described that the movements of the plunger J will be such as to cause the balls of the governor to drop so far and the rotary speed of the engine to be in consequence reduced to such an extent as to cause the compressor at all times to supply just the amount of air that is required under the varying circumstances, for if the compressor supplies a greater amount of air then the pressure will increase still more and the plunger will be lifted still further, which will cause the speed of the engine to be still further reduced through the regulating device above described.

Supposing a contrary case—that is to say, a case in which a greater amount of air is required, which may be caused, for instance, by four of the six rock-drills previously stopped being set to work again. In this case the compressor, by reason of the slow speed which it is as yet retaining, will be supplying less air than is required. The air-pressure will therefore become reduced. This will at the same time cause the air-pressure exerted upon the plunger J to become reduced to such an extent as to make it less than the pressure of the spring f. The plunger J will therefore be drawn back into its barrel, which will in turn cause the end B of the adjusting-lever B A to be lifted, thus giving the steam-cylinder a larger cut-off. The previous cut-off having been the requisite amount of cut-off now becomes too great and the engine will have a tendency to run away. This, however, is again automatically prevented by the apparatus, the increased speed lifting the governor-balls into a more elevated position of equilibrium and the adjusting-lever B A being again lowered through the intermediate devices F D C B to such an extent as to again give the requisite amount of cut-off for the steam-cylinder.

Unless provision is made for limiting the extent of movement of the plunger J as it is being pressed out of its barrel, it may occur that the engine will be automatically brought to a standstill through the apparatus shown in Fig. 1 when no compressed air is further required, as in such case, even if the number of revolutions be ever so small, the air-pressure will still always be increasing and the plunger J be still further pressed out of the barrel until finally the cut-off is brought below the requisite amount.

In practice it is by no means desirable to have the engine thus automatically brought to a standstill. It is therefore advisable to limit the extent of the outward movement of the plunger in its barrel. This may be effected by arranging the upper cross-piece K' in such a manner as to strike against the upper end or continuation of the barrel H, thereby preventing the plunger J from being pressed out of the barrel any farther than would be sufficient to secure the requisite amount of cut-off for the steam-cylinder during the lowest position of the governor-balls, and hence also during the smallest possible speed of the governor and engine. It is also advisable to provide means for allowing the extent of movement of the plunger to be adjusted. By this arrangement the engine is secured from being brought to a standstill by the apparatus, but it will remain in motion with a minimum number of revolutions.

The small quantity of compressed air (or water, as the case may be) supplied by the machine at such a minimum speed of the engine may be removed or blown off through a properly-constructed safety-valve.

Fig. 3 shows a modification of the apparatus represented in Fig. 1, and consists in rendering the adjustment of lever F D D' with regard to lever D C automatic. A dynamometric apparatus M H J K, Fig. 3, is here provided between the said two levers, the said apparatus being actuated by the pressure of a liquid. The flexible pipe *o*, connected with the pump to be regulated, and receiving from the same liquid, communicates at its other end with an air-tight chamber below an elastic membrane M, arranged within a casing H, provided on or connected with lever D C. The movements of the membrane are transmitted to the lever F D D' by means of a piston J and rod K. The rear portion of lever F D D' is drawn toward lever D C by a spring *f*, the tension of which may be regulated at will by means of the screw-nut L. The said screw-nut L is tightened to such an extent as not to allow the piston J on the membrane to be lifted until the pressure of the working liquid exceeds a predetermined point, say eight atmospheres. By subsequently turning the hand-wheel E the speed of the governor is so adjusted as to make the pump to be regulated thereby supply the maximum quantity per minute that may be desired for the present, or rather a trifle more.

As long as the tension of the liquid does not exceed the above predetermined pressure of eight atmospheres the piston above the membrane will remain in its lowest position and the parts F D D' C will act the same as one rigid lever F D C. As soon, however, as the pressure of eight atmospheres is reached and about to be exceeded the membrane M and piston J will be lifted from their lowest position of rest and the levers D D' and D C will be pressed away from each other, or, in other words, the angle B will become reduced. As the lever F D D', by reason of the inertia on the part of the static governor connected with the nut F, will in the first moment still remain in its position, the lever D C will be pressed down, and the speed of the governor, and hence also that of the engine connected with the same, will in consequence be automatically and correspondingly reduced in exactly the same manner as already explained with reference to the construction shown in Fig. 1.

Supposing that the pressure of the working liquid now becomes reduced again—say in consequence of an increase in the consumption of the same—the piston on the membrane, by reason of spring *f*, will again be lowered, lever D C will be raised, and the speed of the engine will thereby be automatically increased. What has been previously said about the advisability of limiting the extent of movement of the plunger J, Fig. 1, applies also in case of the piston J, Fig. 3.

It is obvious that the construction of my apparatus as described with reference to Fig. 1 may be applied in all cases where a pump driven by an expansion steam-engine is to be regulated in such a manner as to be first given such a number of revolutions by hand as to secure the maximum supply of liquid or gaseous fluid as may for a time be required and to enable the speed of the engine to be automatically reduced to any desired extent when the pressure of the working liquid or fluid exceeds a predetermined limit.

The particular construction of the apparatus as above described is not suitable, however, for regulating the following classes of pumps—that is to say, first, force-pumps for hydraulic accumulators driven by water or air, and, secondly, water-pumps for discharging their water into a reservoir situated at a certain height.

In the pumps above mentioned the pressure of the working liquid always remains uniform, and in pumps of the first kind depends on the pressure exerted upon the piston of the accumulator, and in pumps of the second kind on the height at which the reservoir is situated above the pump. It is not possible to regulate such pumps by the varying pressure in the manner above described, for this reason, that varying pressures are, in these cases, not intended or do not occur. Another kind of regulation, however, is desirable for cases of this kind—that is to say, in pumps of the first kind above referred to it is desirable to slacken the speed of the pump as the piston of the accumulator approaches its highest position, and in pumps of the second kind to slacken the speed of the pump as soon as the water in the reservoir reaches a certain level. These objects may in the case of pumps for accumulators be attained by means of the auxiliary devices shown in Figs. 2^b and 2^c in connection with the governors forming the subject of this specification, and in the case of reservoir-pumps by means of the arrangement of pipes shown in Fig. 4.

Instead of arranging the flexible pipe *o*, Fig. 1, so as to communicate with the water of the accumulator direct it is first connected with a three-way cock M, Fig. 2^b, by means of the pipe o'. Another pipe o^3 likewise entering the three-way cock M communicates with the water in the accumulator, and a third pipe o^2 is provided for discharging the liquid into the open air. In the position of the cock as shown in the drawings—that is to say, when the handle *a* of the plug is lowered—the water is not in communication with the regulating apparatus, and the plunger J, Fig. 1, is not under pressure, since the space above it within the barrel H is in communication with the open air through the pipe *o* and its continuation o', as well as cock M and discharge-pipe o^2. As already stated, the regulating device, Fig. 1, will now act in the same manner as if the dynamometric apparatus between C and B were entirely dispensed with and as if the lever C were simply connected with the end B of the adjusting-lever B A by a rigid bar C B. The static governor will, therefore, give the engine the number of revolutions for which it has been adjusted through the hand-wheel E.

We will now suppose that the amount of water consumed becomes less. The piston of the accumulator will then rise and it will be desirable to automatically reduce the speed of the pump in accordance with the reduced consumption of water. This will be effected through the governor forming the subject of my invention and shown in Figs. 1 and 2^b in the following manner—that is to say: As soon as the piston of the accumulator has risen to a certain height an arm connected therewith, but not shown in the drawings, will strike the handle a of the three-way cock M from below, and as the piston continues to rise will lift it up still farther until it ultimately reaches the position a'. In this position the water in pipe o^3 will, by means of the said three-way cock M and the pipes o' and o, be brought into communication with the space above the plunger J, the latter will be pressed out of its barrel, thereby pressing down the adjusting-lever B A and causing the number of revolutions of the engine to become reduced by reason of the lower position of the governor-balls resulting therefrom, and the adjusting-lever will be subsequently drawn back into its previous position, thus again securing the requisite cut-off for the steam-cylinder, all as hereinbefore described. If the consumption of water subsequently increases and the piston of the accumulator be correspondingly lowered, then the second arm connected therewith, but not shown in the drawings, will press down the handle of the three-way cock M into the position a, thus again causing the same position of the cock and its connections as shown in the drawings. The water within the pipe o^3 will be again cut off and the space above the plunger J will be brought into communication with the open air again through the cock M and discharge-pipe o^2. The water collected above the plunger J being thus allowed to discharge into the open air, the said plunger will be drawn into the barrel again through the spring f. As previously shown, this will again cause the number of revolutions of the governor and hence also of the engine to be increased, and at the same time the regulating mechanism will be brought back into its original position.

Fig. 2^c shows a modification of the arrangement of the auxiliary apparatus in Fig. 2^b. In this arrangement the pipe o^3 is likewise in communication with the water, the pipe o^2 discharges into the open air, and the pipe o' is connected with pipe o and hence also with the barrel H, Fig. 1. When the piston of the accumulator rises, an arm connected therewith, but not shown in the drawings, will strike against an elongation v' of a valve v from below and thereby lift the said valve v, thus causing the water to be admitted from the pipe o^3 into o' and o and to enter the barrel H above the plunger J, pressing the same out of its barrel and thereby tending to reduce the speed of the engine. Of course some of the water will at the same time escape into the open air through the open discharge-pipe o^2. However, the discharge-opening of the said pipe o^2 being made of much smaller sectional area than those of the pipes o^3, o', and o a certain pressure, although of reduced volume, will still prevail within the said pipes and connections, this pressure being still sufficient in its action upon the plunger J to overcome the pressure of the spring f. When the piston of the accumulator is subsequently lowered again, the arm above referred to as being connected with it will likewise be lowered with it, causing the valve v and its elongation v' to drop and to again cut off the water within the pipe o^3 from the regulating apparatus, whereupon the spring f will again draw the plunger J back into its barrel, the water collected above the plunger being forced out of the discharge-pipe o^2 into the open air and the engine will begin to run faster.

The discharge o^2, Fig. 2^c, may also be entirely dispensed with by arranging the elongation v' of the valve so as not to fit quite closely with the valve-chamber—say by dispensing with a stuffing-box and simply allowing it to enter the valve-chamber through an aperture with a certain amount of play. The space thus formed will then take the place of the special discharge-pipe o^2.

The auxiliary apparatuses shown in Figs. 2^b and 2^c may be applied in exactly the same manner in connection with the construction represented in Fig. 3, as well as with that in Fig. 1. It is also obvious that in applying the auxiliary apparatus of Figs. 2^b and 2^c it is not necessary, either as regards Fig. 1 or Fig. 3, to give the spring f any special tension to depend just exactly from the pressure of the working liquid within the accumulator. All that is required in this respect is that on the one hand this tension shall be less than the full pressure exerted upon the plunger J, Figs. 1 and 3, on the part of the working liquid in case of the device in Fig. 2^b and less than the reduced pressure in the case of the device in Fig. 2^c, and on the other hand that the tension shall be at least sufficient to draw the plunger J back into its position of rest when the pressure of the working liquid has ceased to act upon the plunger and at the same time to overcome the resistance of the intermediate parts for transmitting the movements between the governor and expansion-valve gear. These two opposite limits for the tension of the springs f are so far removed from each other as to render it very easy to secure some intermediate degree of tension by properly adjusting the screws L, Figs. 1 and 3.

What has been previously stated with regard to automatically bringing the engine to a standstill and automatically producing a minimum number of revolutions of the same without causing a dead stop through the mechanism in Figs. 1 and 3 is of special importance in the case of such pumps for accumulators as those in which the pistons are nearly always working in their highest position, which they must not be allowed to exceed. Now supposing that by certain means, the particulars of which do not here concern us, provision had been made for automatically bringing the engines for the forcing-pumps to a standstill each time the piston of the accumulator had attained its highest position, (this very often occurring several times in the course of one minute,) in such case it may very easily occur that when the piston of the accumulator is lowered the engine will not at once move again by itself, which may prove of very serious consequences for the machinery and the people employed on the same—as, for instance, in steel-works, foundries, and the like. It is therefore preferable not to bring the forcing-pumps to a standstill at a high position of the accumulator-piston, but merely to automatically give them a minimum number of revolutions. The small quantity of water that is still being lifted by the pumps at such a small number of revolutions may be allowed to escape through safety-valves or discharged through a suitable valve arranged so as to be opened by the accumulator-piston when reaching its highest position, unless some other use may be found for the water.

In the arrangements shown in Figs. 1 and 3 the engine instead of being brought to a standstill is simply given a minimum number of revolutions, as already stated. This is attained by limiting the extent of outward movement of the plunger J, Figs. 1 and 3, preferably by means of an adjustable collar or similar device in such a manner as to allow the said plungers to move out of their barrels only so far at the lowest position of the governor-balls as to barely secure the requisite cut-off through the adjusting-lever B A, Fig. 1.

Fig. 4 shows an arrangement of pipes serving as an auxiliary apparatus by means of which the automatic governor as represented in Figs. 1 and 3 may also be applied in the case of pumps for reservoirs. The water is by means of pipe Q conveyed to a reservoir R having an overflow S, Fig. 4. At its lower end the said pipe o' communicates with the reservoir R at a^* a^* a little below the level of the overflow S. At its lower end the said pipe o' is provided with a discharge o^2 of smaller section than the pipe o' for automatically removing the liquid from pipe o' and discharging it into the open air. The pipe o connected with the pipe o' laterally is the same flexible pipe already referred to as communicating with the apparatus for regulating the steam-engine of the reservoir-pump. So long as the water within the reservoir R remains below the level a^* a^* the automatic regulating device, Fig. 1 or 3, will remain inactive and the engine will be making that number of revolutions to which it has been adjusted by means of the hand-wheel E, Fig. 1 or 3. Supposing, however, that the water within the said reservoir, Fig. 4, begins to rise above the level a^* a^* then the pipe o' will be filled with water, although part of the water will escape through the discharge o^2, the latter being of much smaller section. The pressure of the water will pass through the flexible pipe o into the dynamometric apparatus, Fig. 1 or 3, and will bring the same into action, as already described, in such a manner as to reduce the speed of the engine, thus causing the pump to lift a correspondingly small amount of water. If the consumption of water from the said reservoir R increase again, then the water-level will sink, the water within the pipe o' will be discharged through o^2, and the pressure within pipe o, and hence also within the dynamometric apparatus, will cease, the said apparatus resuming its previous position and thereby causing the engine to regain its former speed, as already described.

Having thus fully described my invention, what I desire to claim and secure by Letters Patent is—

1. In a pumping-engine with variable expansion the combination with a strongly static centrifugal governor of high regulating capacity, of an adjusting mechanism F D C B, and of means capable of being operated substantially as described by the liquid pumped, for lengthening and shortening the rod C B of the said mechanism while the engine is running, so as to thereby alter the relative positions of the member which regulates the cut-off in the expansion-valve gear and of the balls of the centrifugal governor, without at the same time altering the total proportion of transmission between the stroke or movement of the said member of the valve-gear and the throw of the governor-balls, substantially as and for the purpose set forth.

2. In combination with the adjusting device F D C B intermediate the centrifugal governor and the expansion-valve gear of a pumping-engine as described, a governor having eccentrically-suspended cylindrical weights N, a nut F adapted to have the vertical movements of the said weights transmitted to it, and a chamber R V S carrying the said nut and surrounding the governor-shaft, but otherwise freely movable, the said chamber surrounding the said weights by means of interior horizontal top and bottom surfaces, substantially as and for the purpose set forth.

3. In combination with the adjusting device F D C B intermediate the centrifugal governor and the expansion-valve gear of a pumping-engine as described, a governor having ec-

centrically-suspended cylindrical weights N, a nut F, adapted to have the vertical movements of the said weights transmitted to it, and a chamber R V S carrying the said nut and surrounding the governor-shaft, but otherwise freely movable, the said chamber resting on the said weights with an interior horizontal top surface, substantially as and for the purpose set forth.

4. In combination, with a governor, eccentrically-suspended weights, a chamber arranged on the governor-shaft so as to move freely thereon and surrounding the said weights and a nut connected with the said chamber and with the regulating-gear of the steam-engine, substantially as and for the purpose set forth.

5. In combination with a governor, eccentrically-suspended weights, a chamber arranged so as to move freely on the governor-shaft and surrounding the said cylindrical weights by means of interior horizontal top and bottom surfaces and a nut connected with the said chamber and with the regulating-valve gear of the steam-engine, substantially as and for the purpose set forth.

6. In combination with a governor, eccentrically-suspended weights, a chamber arranged so as to move freely on the governor-shaft and resting upon the said weights with its interior horizontal top surface and a nut connected with the said chamber and with the regulating-valve gear of the steam-engine, substantially as and for the purpose set forth.

7. In combination with a steam-engine, a governor having eccentrically-suspended cylindrical weights the upward and downward movements of which are transmitted to a nut arranged on a chamber surrounding the governor-shaft but otherwise freely movable, the said chamber either surrounding the cylindrical swinging weights by means of interior horizontal top and bottom surfaces or simply resting on the said weights with an interior horizontal top surface, substantially as and for the purpose set forth.

8. In a steam-engine the combination, with the governor-shaft Q of the swinging weights N, the chamber R V S, the nut F and the devices F D C B for transmitting movements to the regulating-valve gear, substantially as and for the purpose set forth.

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

FRANZ JOSEPH WEISS

Witnesses:

GEORGE GIFFORD,

CHAS. A. RICHTER.