No. 702,038. Patented June 10, 1902.

E. THOMSON.

REGULATION OF SPEED AND POWER ENGINES.

(Application filed Nov. 4, 1899.)

(No Model.) 2 Sheets—Sheet 1.

FIG. 1.

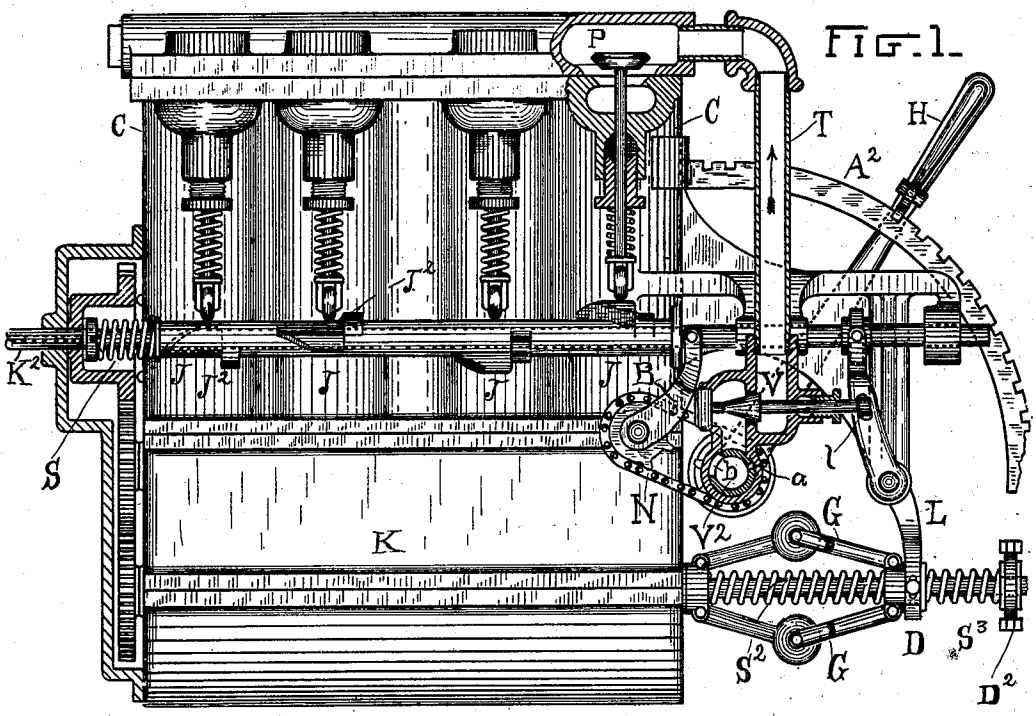
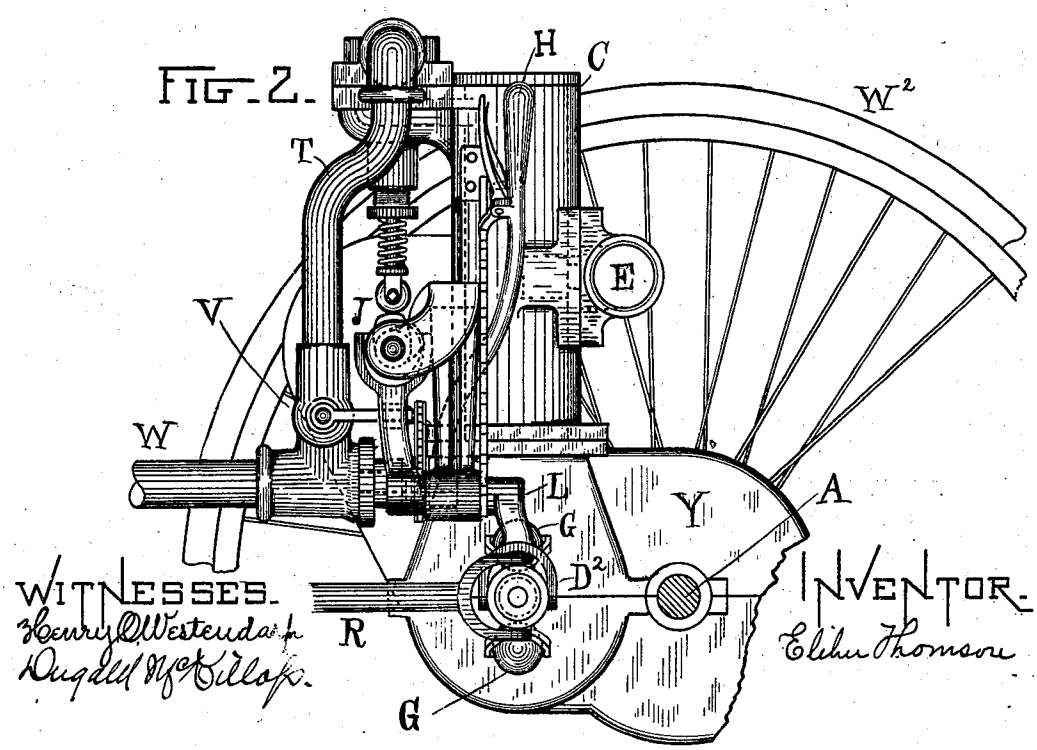


FIG. 2.



WITNESSES.
Henry D. Westendahl
Dugald McKillop.

INVENTOR.
Elihu Thomson

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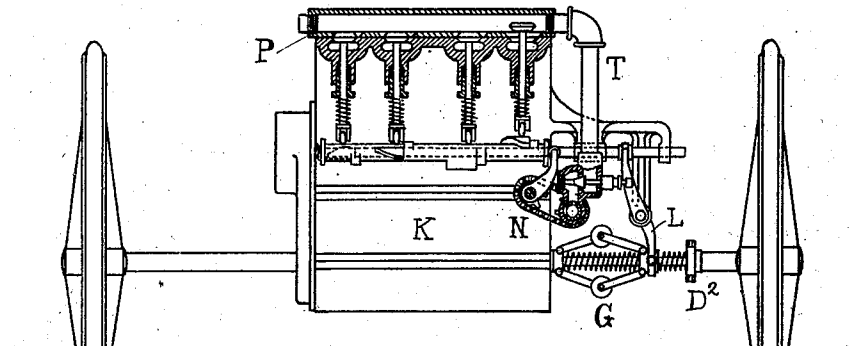

FIG. 3.

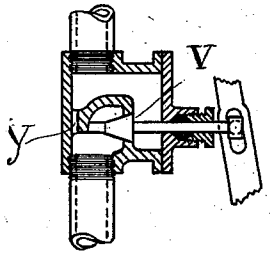

FIG. 6.

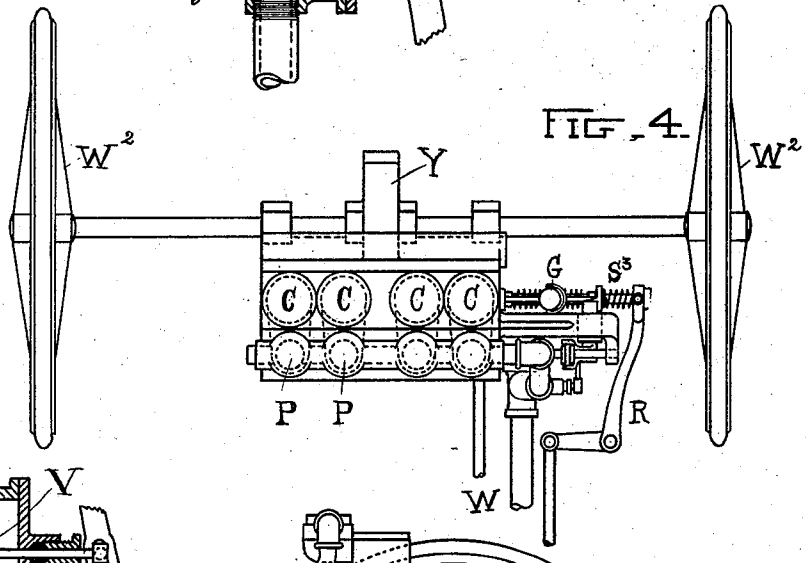

FIG. 4.

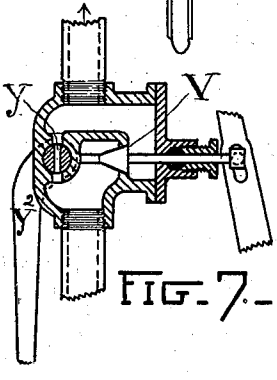

FIG. 7.

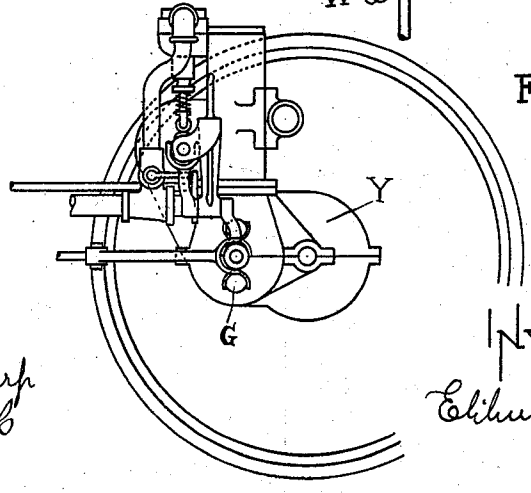

FIG. 5.

WITNESSES.

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UNITED STATES PATENT OFFICE.

ELIHU THOMSON, OF SWAMPSCOTT, MASSACHUSETTS.

REGULATION OF SPEED AND POWER ENGINES.

SPECIFICATION forming part of Letters Patent No. 702,038, dated June 10, 1902.

Application filed November 4, 1899. Serial No. 735,749. (No model.)

To all whom it may concern:

Be it known that I, ELIHU THOMSON, a citizen of the United States, residing in Swampscott, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in the Regulation of Speed and Power Engines, of which the following is a specification.

The present invention relates to the regulation of speed and power engines, such as may be used for the propulsion of automobiles and similar work.

My invention may be applied to the operation of various types of engines from which power is obtained, and it is particularly applicable to the form of engine forming the subject of my application for patent filed April 13, 1898, Serial No. 677,449. This engine is practically an engine designed for superheated steam, securing the highest economy of water consumption for a non-condensing plant, and is provided with puppet-valves for steam admission and a cam-shaft for operating the puppet-valves, which cam-shaft may be so moved or adjusted that the period of the taking of steam is varied by making the cut-off early or late. The exhaust of the engine passes out of steam-ports uncovered by the piston near the end of its stroke, although other exhaust means may of course be provided.

My present invention relates to the control of such engines and may be briefly described as embodying a centrifugal device operated by the engine, which centrifugal device as the speed rises automatically opens a throttle-valve, which when the engine is stopped is nearly closed. At the same time that the centrifugal device or other speed-responsive mechanism as it gradually opens its throttle-control valve on the rise of speed, also diminishes the period of the stroke of the engine during which steam is admitted to the cylinder or cylinders. In other words, the cut-off is made earlier as the speed rises. The longest admission is that at starting, while the throttle-valve is nearly closed or the steam wire-drawn, while the running condition is a throttle-valve wider open as the speed increases and a cut-off earlier as the speed increases. By this means in my invention I am enabled to secure a gradual starting and also to set a limit to the speed of running, depending upon the condition and use of power. For automobile-work the speed will not in my invention rise to its highest point except on a good level road demanding small power, and in such case the running will be more economical on account of the earlier cut-off. For hill-climbing the speed will automatically fall and the torque of the engine will increase, owing to the longer time of admission of steam during the working stroke. I thus relieve the operator of all necessity for personal control or attention during these changes, and I also secure the results by simply providing for the operator's use a throttle-valve in addition to the governing-throttle or in combination with the same, whereby he may at will open and close the steam-passage to the engine at some convenient point without seriously interfering with the functions of the other operating mechanism, as before outlined.

In my invention I also provide a means for governing at will the set or adjustment of the centrifugal or speed-response control device whereby its action may be changed in such a way that its functions may be completed or performed during changes of speed at different speeds relatively—that is to say, if the governing device be set to respond readily to a low speed in one condition the operator may have it within his control to render it less sensitive by bringing into action a counteracting spring whereby it only responds to much greater speed. This enables the operator to set his control apparatus within limits of speed without interfering with its functions for relative changes of speed.

It is to be understood that the principles outlined in my invention may be employed in various ways and in combination with various forms of engine without departing from my invention in any essential particular.

Figures 1 and 2 show diagonal views of the engine with my control apparatus attached. Figs. 3, 4, and 5 are views showing its arrangement as applied to the driving of automobiles. Figs. 6 and 7 are other details.

Referring now to Figs. 1 and 2, C C represent a range of cylinders—say four in num-

ber—the pistons of which operate cranks contained in the crank-case K. (Cranks not shown.) These cranks serve to revolve the shaft upon which the governor G G is mounted, and this shaft is geared or otherwise connected by transmitting mechanism to the axle A of the vehicle. The admission of steam to the cylinders is under control of the puppet-valves P, actuated by a suitable cam-shaft K^2, the cam projections from which, as indicated at J, are arranged in accordance with well-known principles, such that a motion endwise of the sleeve carrying the cam J J J J upon the cam-shaft will vary the time that the puppet-valves are open during the stroke, and in addition a further motion may cause reversal of the engine, though this latter is no feature of the present invention. Other arrangements of variable cams can of course be made. I have, however, shown the one mentioned for simplicity as typifying other arrangements having the same purpose in view. The sleeve carrying the cams J J J J may be made to tend in one direction by a spring, as at S, and be positively moved in the other by the governing device to be described. The governor G G may be a centrifugal arrangement, with weights carried on pivoted arms, and a spring S^2 may be provided, tending to keep the weights in toward the shaft. As the weights are removed by centrifugal force during the rotation, the spring S^2 is compressed in the usual way, and the grooved collar D is moved along the shaft. This collar in moving actuates a lever L, which draws the sleeve carrying the cams J J J J along the cam-shaft K^2, the cam-shaft itself being geared to the engine-shaft, as indicated to the left, and splined to the sleeve. The arrangement of the cams J J J J is such that as the speed rises and the collar D moves to the left the narrowing portion of the cams will be brought into action in opening the valves P of the engine for steam admission. On the other hand, when the engine is at rest the spring S (or other device for the same purpose) draws the cam-sleeve over, so as to give the cams their full effect of keeping the valves P open during a considerable portion of the stroke. A second spring S^3 may be provided to act upon the governor G G and may be manually adjusted by a moving collar given any definite position by any operating-lever, or the effect of speed upon the governor may be adjusted in other well-known ways. This collar is indicated simply at D^2 and may be used to compress or extend the spring S^3, as desired, thereby making the governor G G variably responsive to the various speeds or of varying sensitiveness to a given speed.

It must be understood that the governor G G has no function in maintaining a definite speed, as in the case of an ordinary steam-engine; neither has it any definite speed-limiting function, as that will depend upon the work to be done or the resistance to be overcome by the engine. Lever L has in addition an attachment at *l* for the valve-stem of the throttle-valve V, which valve when the parts are at rest is almost closed, thus almost completely throttling the steam passing through the pipe T to the engine through the valves P, &c., it being assumed that the steam comes from below upward in the direction of the arrow. A hand-lever H, which is provided with retaining-catches, so that it may be placed in any position on the arc A^2 by inserting the catch in the notches in said arm, moves a steam-admission valve V^2. When thrown downward to the right, the handle H opens full steam from the supply-pipe W to the pipe T. It is sometimes desirable that this action be made to take place in stages of opening of the valve. Therefore the notches in the arc A^2 to the right of the hand-lever H are provided, as shown, though these are not essential. It is also desirable sometimes that the lever H be used for reversal in reversing the engine. To this end a suitable gearing, as a chain N or other device, is provided for actuating an arm B, the purpose of which is to throw the cam-bearing sleeve upon which the cams J J J J are mounted over to the left far enough to bring into action the sections of the cams, as at J^2, which open the valves P for admitting the steam, so as to cause reverse rotation. This reverse action of the handle H might of course be omitted from my invention, if desired, without affecting its action otherwise. In this reversing action the handle H is thrown to the left. When it is thrown to the right to admit steam, a port *b* in the valve V^2 of quite large dimensions is opened for the steam—that is, the valve is given a wide opening and the arm B is carried sufficiently far to the right so as not to interfere with the movements of the cam-bearing sleeve on the cam-shaft K^2 in response to the speed acting on governor G G. When the handle H is thrown far to the left for reversal, a small port (indicated at *a*) may be opened for the steam, so that no rapid motion during the reversal can ever be obtained. The opening E in Fig. 2 shows the exhaust-passage of the engine. Also in Fig. 2 the rod R may communicate the means for operating the stem D^2 by changing the tension or compression of the spring S^3. W^2 may represent one of the wheels of a vehicle driven by the mechanism.

Fig. 3 represents the mounting of a power plant just described upon the vehicle, driving the vehicle-wheels W^2 W^2 through suitable gearing. In this case the puppet-valves are shown as four in number in section, and some of the similar parts are lettered similarly.

In the plan view, Fig. 4, similar parts are seen, and the gear-box Y appears, as in Fig. 2, as a case containing gear or transmitting mechanism from the engine-shaft to the wheel-shaft. Differential gearing may be

embodied in this mechanism; but as this is no part of the present invention there is no need of further describing it.

Fig. 5 shows an end view more in outline than Fig. 2.

The operation of the devices is briefly as follows: Assume the machine at rest and the handle H in the position shown in Fig. 1, with the steam-pressure on the supply-pipe W from any suitable boiler or generator. If valve V^2 be opened by throwing the handle H over to the right and down, steam is admitted to pipe T, which is the supply-pipe of the engine; but it is wire-drawn or throttled at V, so that it can escape but slowly to the engine. As the same time the cams J J J J are so set that the puppet-valves P will be kept open for admission of steam during, for example, two-thirds of the working stroke of the piston in the cylinders. Under these conditions the engine will take a moderate start without the care of the operator. There will be no too-rapid acceleration; neither will the drain upon the steam nor the strains upon the engine be at all abnormal or high. If now motion is acquired with continued acceleration, the governor G G begins the process of compressing the spring S^2 and moving the lever L so as to do two things—viz., diminish the time of admission of steam during the stroke by moving the cam-carrying sleeve to the right, and also at the same time that this progressive movement takes place as the speed rises the valve V is opened, so that it gives much less obstruction to the incoming steam. The valve V in this way continues opening until it reaches its maximum area, and the cam-carrying sleeve continues in motion as the speed rises until the minimum cut-off is at last reached. It is not essential that these two conditions be at all coincident, as the full opening of the valve V may be attained before the entire throw of the cam-carrying sleeve is accomplished. The action just described results practically in limiting the maximum speed which can be attained to accord with the conditions of service, for the torque of the engine falls at the end to a small amount on account of the slight opening of the admission-valves, at the same time the economy of the use of steam (owing to the engine working under high expansions) is maintained. If the sleeve D^2 be manually set in new positions, so as to compress or expand this spring S^3 differently, then the actions of the governor without being essentially changed are slightly modified as to the range of speed they cover. If the vehicle with the handle H thrown so as to open the valve V^2 is running along on a level and strikes a grade demanding a greater torque, the governor G G will partially collapse and move the cam so as to give a greater time of admission; but if this occurs to any considerable extent, so as to put too high a drain upon the steam-supply, the throttle V closes and wire-draws the supply, with the effect of adjusting the speed of climbing the grade, and thus the condition of steam-supply in the boiler or generator controls that of steam-supply in the engine. This, in fact, is an important feature of my invention, for instead of making the adjustment depend upon the engine only the speed becomes self-adjusting to the conditions of steam generation as the engine slows and waits to get its steam through the wire-drawing valve V instead of drawing an unlimited amount from the boiler or generator, such as might be the case with the valve V absent. Moreover, the care of this condition is removed from the operator or he is relieved from any thought of the maintenance of steam-supply, the only control being the opening and closing of the valve V^2 at intervals by simple motion, the range of which need not be accurately adjusted. In going down grade (as when the weight of the vehicle driven by the engine may be sufficient to drive the whole plant) the handle H may be moved so as to entirely cut off the steam, in which case the engine acts in a measure as a brake, or the sleeve D^2 may be moved by the operator so as to make the response of the governor G G to speed more sensitive—in other words, a lower speed being attained, will cut the steam off by diminishing the cut-offs to the limit.

Instead of the valve V being at the start slightly open, as described, there can be a by-pass opening, such as y, Fig. 6, or a by-pass valve and operating-lever, such as y^2, Fig. 7, this valve being adjusted to the desired degree of opening for the same purpose as before described.

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

1. In combination with a variable-speed engine, an automatic regulator acted upon by changes in speed, a cut-off valve, a throttle-valve, means for decreasing the period of opening of the cut-off as the speed rises, and means for correspondingly increasing the opening of the throttle as the closing of said cut-off takes place.

2. In combination with a variable-speed engine, an automatic regulator for governing the engine which acts progressively over a wide range of speed, a cut-off valve, a throttle-valve, and means actuated by the regulator for correspondingly decreasing the period of opening of the cut-off and increasing the opening in the throttle as the speed of the engine rises.

3. In an automatic regulating device for variable-speed steam or vapor engines, the combination of a cylinder a variable cut-off for admitting steam to the cylinder, a valve in the steam-supply pipe adjusted to be slightly open at the start, a speed-responsive device acting automatically, a means actuated by the device, which during the increase in speed, is arranged to vary the cut-off in a manner to

diminish the time of steam admission, and also to open the throttle-valve in the steam-supply pipe, and manual means for varying the action of the speed-responsive device during operation.

4. In combination, an engine having a cylinder, a throttle and a cut-off valve with an automatic regulator for maintaining a constant engine torque comprising a speed-responsive device progressively operative over a wide range of speed, means actuated by the regulator as the speed rises for gradually opening the throttle-valve, means for actuating the cut-off valve, and a connection between said means and the regulator whereby as the throttle-valve is opened under an increase of speed, the opening of the cut-off valve is correspondingly decreased at or about the same instant, whereby a new and definite relation of the valves is established for each change in speed.

5. In an automatic regulating device for steam or vapor engines, the combination of a variable cut-off or steam admission, a throttle-valve in the steam-supply pipe adjusted to be slightly opened at the start, a speed-responsive device which, during an increase of speed, adjusts the cut-off so as to diminish the time of steam admission, and also acts to open the throttle-valve in the steam-supply pipe, thereby admitting more steam to the steam-chest of the engine, a manually-operated throttle for turning on and off the steam-supply, a reversing mechanism, and manually-operated means for operating the said mechanism.

6. In an automatic regulating device for steam or vapor engines, the combination of a main throttle-valve, an operating-handle therefor, a subsidiary throttle-valve normally open to a slight extent even when the engine is at rest, a variable cut-off controlling the steam admission to the cylinder, a speed-responsive device, and mechanism for opening the subsidiary throttle, and at the same time acting on the variable cut-off to diminish the steam admission as the speed rises.

7. In an automatic regulating device for steam or vapor engines, the combination of a main throttle-valve, an operating-handle therefor, a subsidiary throttle-valve normally opened to a slight extent even when the engine is at rest, a variable cut-off controlling the steam admission to the cylinder, a speed-responsive device, mechanism actuated by the device for opening the subsidiary throttle and at the same time diminishing the steam admission at the cut-off as the speed rises, and manually-controlled means for adjusting the speed-responsive device for varying the position which it takes under different speeds of running, thereby changing its sensitiveness.

8. In an automatic torque-regulator device for steam or vapor engines, the combination of a speed-responsive device, a subsidiary throttle-valve normally opened to a slight extent, puppet-valves for regulating the admission of steam to the engine, cams for actuating the valves, and a lever which is acted upon by the speed-responsive device for simultaneously opening the subsidiary throttle and adjusting the cams so as to decrease the interval that the admission-valves are opened on an increase in speed.

9. In an automatic regulating device for engines the combination of a main throttle-valve, a handle for actuating the throttle, valves for regulating the admission of steam to the engine, means actuated by the throttle-lever for varying the opening and closing of these valves, a subsidiary throttle-valve arranged to be opened at all times, a speed-responsive device, a pivotally-supported lever acted upon by the speed-responsive device for opening the subsidiary throttle and closing the steam-admission valves, the valves being so arranged that as the throttle-valve opens the admission-valves remain closed for a longer period of time, means for opposing the action of the lever, and a spring or its equivalent for adjusting the effect of said means on the lever.

In witness whereof I have hereunto set my hand this 31st day of October, 1899.

ELIHU THOMSON.

Witnesses:
DUGALD MCKILLOP,
CHAS. B. BETHUNE.