(No Model.) 2 Sheets—Sheet 1.

H. A. HOUSE.

AUTOMATIC REGULATOR FOR STEAM ENGINES.

No. 533,595. Patented Feb. 5, 1895.

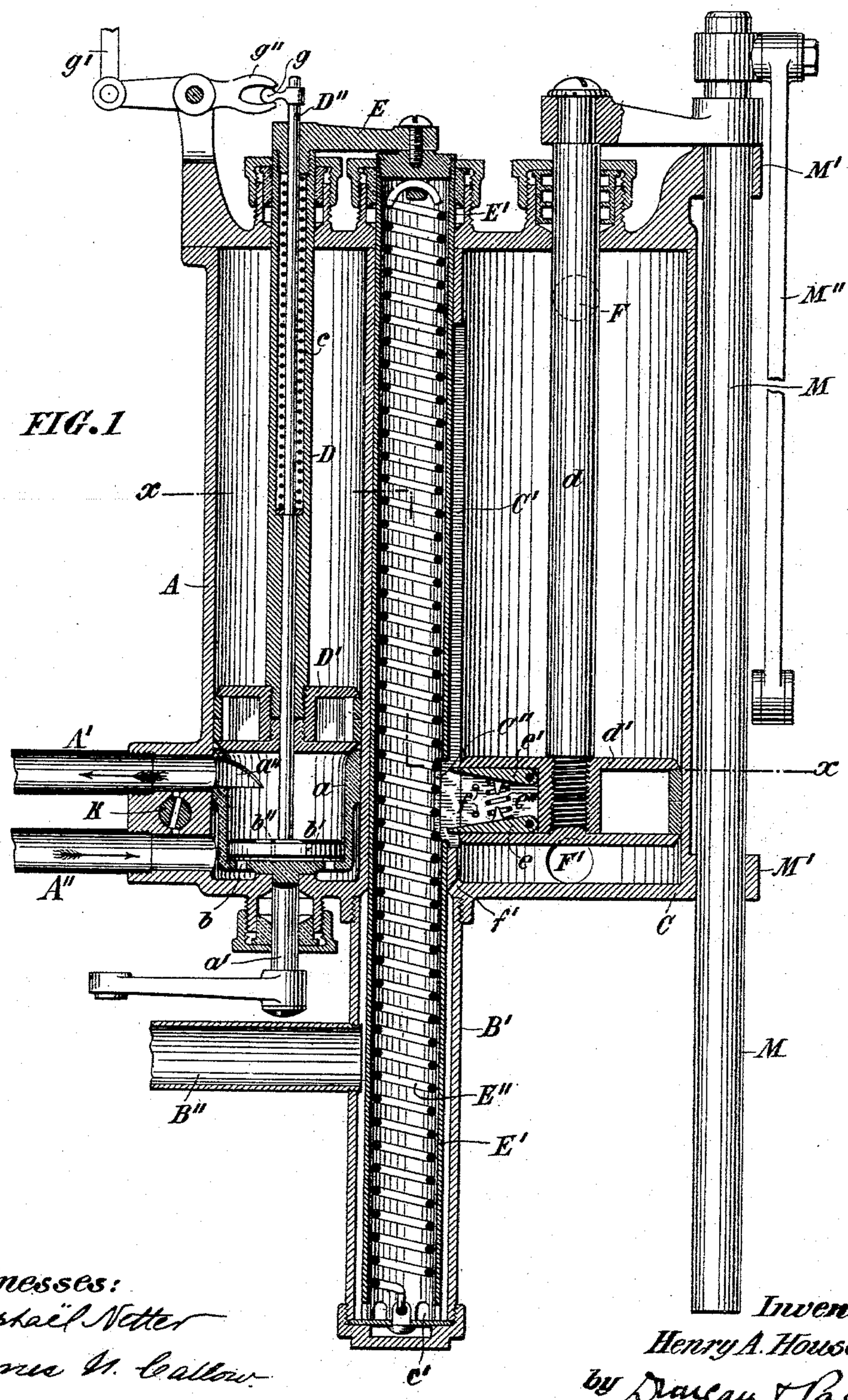

FIG. 1

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(No Model.) 2 Sheets—Sheet 2.

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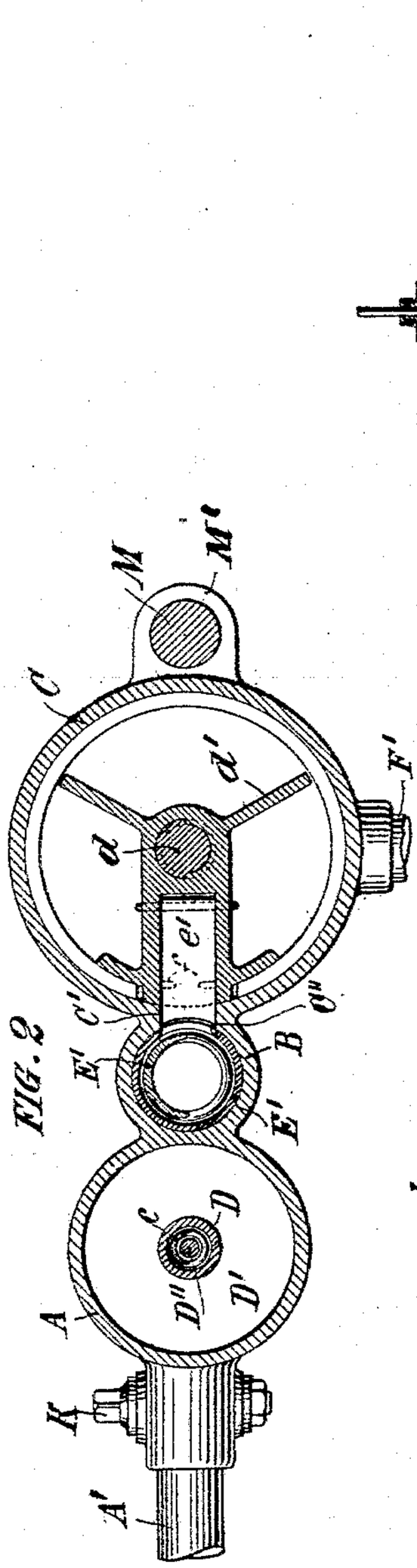

FIG. 2

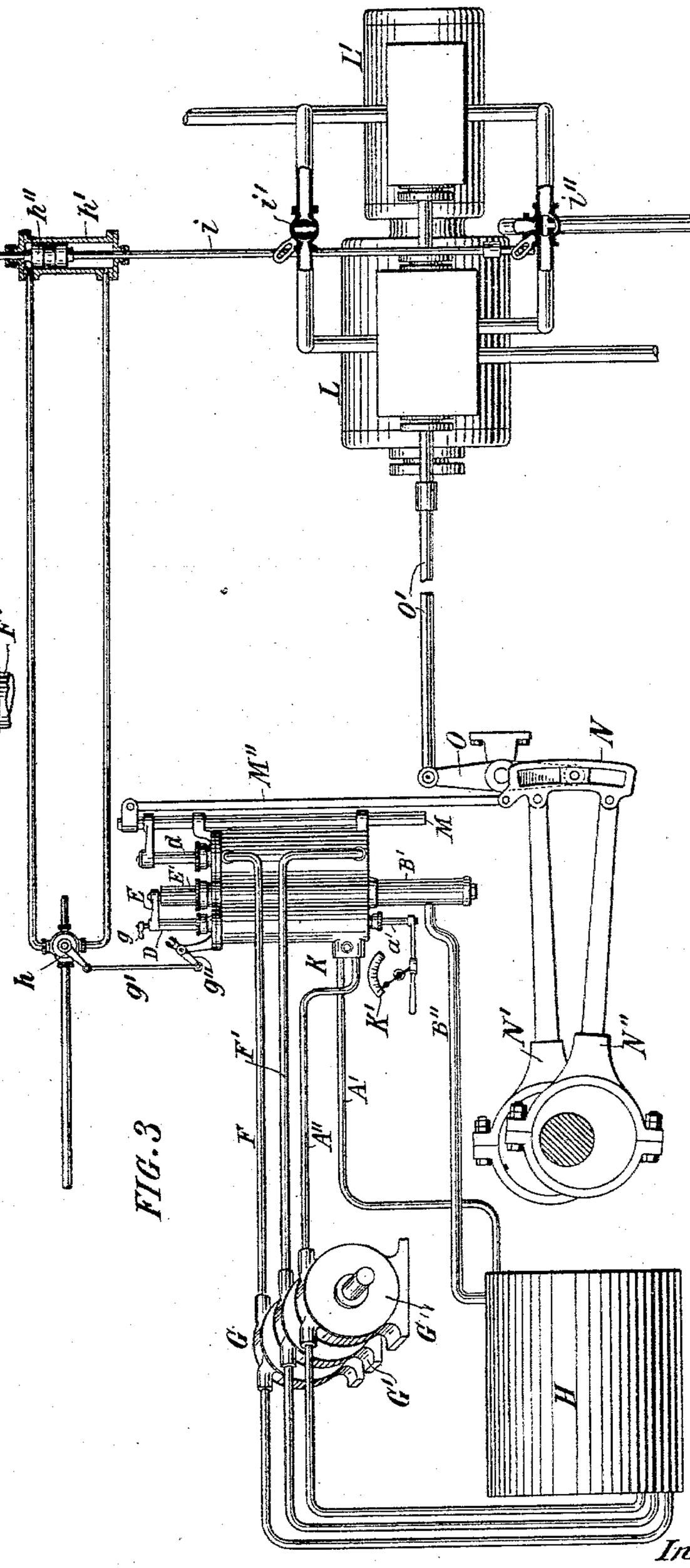

FIG. 3

Witnesses:
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UNITED STATES PATENT OFFICE.

HENRY A. HOUSE, OF BRIDGEPORT, CONNECTICUT.

AUTOMATIC REGULATOR FOR STEAM-ENGINES.

SPECIFICATION forming part of Letters Patent No. 533,595, dated February 5, 1895.

Application filed April 24, 1894. Serial No. 508,799. (No model.)

To all whom it may concern:

Be it known that I, HENRY A. HOUSE, a citizen of the United States, and a resident of Bridgeport, in the county of Fairfield, State of Connecticut, have invented certain new and useful Improvements in Automatic Regulators for Steam-Engines, of which the following is a specification, reference being had to the drawings accompanying and forming a part of the same.

The invention which forms the subject of this application is an improvement in automatic regulating mechanism for engines more especially for the steam motors of street cars and other locomotives, the general objects of the invention being to provide for the automatic operation of the intercepting valve of the engine whereby, without attention on the part of the engineer, the engine may be converted from single to compound, and, secondly, to automatically regulate with reference to a predetermined rate, the speed of such engine.

The nature and objects of the invention will be more fully understood from the description hereinafter contained of the application of the same to street cars, where its special advantages are perhaps most clearly apparent, but in the description of the construction and mode of operation of the same it will be understood that the combination of mechanical elements comprising the regulator proper may be used with other forms of engine and for other and analogous purposes.

In the drawings hereto annexed Figure 1 is a central vertical section of the regulating mechanism proper. Fig. 2 is a horizontal section on line x—x of Fig. 1; and Fig. 3 is a view in side elevation and part section of all the essential parts of a steam engine and such other devices as are required in the practical application and use of my said invention.

The regulator pertains to the general class of hydraulic regulators or those the operation of which depends upon fluid pressure. The mechanism comprises three cylinders, A, B, and C, properly secured together or forming independent compartments of a single casting of suitable design. The tubes A′ A″ enter the bottom of the cylinder A at different levels. In the interior of the cylinder is a cup-shaped device a carried by a spindle a' working in a stuffing-box in the bottom of said cylinder A. This device has in its side, which fits smoothly the inner surface of the cylinder A, a tapered slot a'' that registers with the opening of the tube A′. By turning the stem a' the area of the passage through the slot a'' and the tube A′ is regulated as desired. The lower portion of the cup-shaped valve a is of somewhat reduced diameter affording a space between its walls and those of the cylinder A, into which space the tube A″ opens. In the bottom of the valve a are a series of perforations b through which a passage is afforded for fluid entering the pipe A″ into the upper portion of the cylinder A.

Through a stuffing box at the upper end of the cylinder A works a piston rod D carrying a piston D′ smoothly fitting the bore of the cylinder A. Said piston rod D is tubular and through it works a smaller piston rod D″ carrying a piston b' fitting the bore of the cup-shaped valve a. A small perforation b'' is provided in the piston b'.

The upper end of the piston-rod D carries an arm E which screws into the open end of said piston-rod. Between the head thus formed and a shoulder on the piston rod D″ is a spiral spring c that acts upon the rod D″, tending to hold it down in its lowest position, that is, close to the bottom of the cup-shaped valve a.

The arm E extends horizontally from the piston rod D and is connected to the closed end of a tube E′ that works through a stuffing box at the upper end of the cylinder B. The said cylinder B is extended below the two cylinders A and C and a spiral spring E″ contained within tube E′ is connected respectively to the bottom of such prolongation and the upper end of the tube E′, said spring operating to restrain the tube E′ from movement out of its cylinder.

The tube E′ is fitted closely to the bore of the cylinder B except in the extension B′ of the latter, where the respective diameters of the two are such as to afford an annular space around the tube E′. The lower end of the tube E′ is open and is furthermore provided with perforations or serrations c' so that there is at all times free communication for fluid from the interior of said tube into the annular space around the same in the extension

B′. A tube B″ is joined to the portion B′ of the cylinder.

The two cylinders B and C communicate through a vertical slot C′, which slot registers with an opening C″ in the side of the tube E′.

In the cylinder C is a piston rod *d* carrying a piston *d′* occupying a vertical space in the cylinder approximately equal to the height of the opening C″ in the tube E′. Said piston *d′* fits closely the bore of the cylinder C and in order to close the passage which would otherwise be provided between opposite sides of said piston through the slot C′, there are pivoted to or between the heads of the piston two plates *e′* which extend out beyond the side of the piston into said slot, ending nearly in the surface line of the exposed side of the tube E′ as shown in Fig. 2. To retain these plates in proper position in the slot, a spiral spring *e″* is interposed between them, and to prevent them from being forced to close together stops *f* may be interposed in their path as an additional precaution. Two pipes F and F′ enter the cylinder C near the top and bottom of the same respectively. A small perforation *f′* affords a passage or communication between the lower end of the cylinder C and the annular space in the extension D′ of cylinder B.

The above constitute the main features of mechanical construction of my improved regulator.

I refer now to Fig. 3 for a description of the operation of the device and a general description of such other elements as are to be used in the preferred application of the same to practical use.

Combined with the regulator are three hydraulic force pumps of any proper character represented in the usual conventional manner and designated by the letters G, G′ and G″. The pumps are coupled in any suitable manner to a movable part of the engine with which the regulator is used so as to be in operation whenever the engine is in motion and so that their speed and the amount of fluid maintained in circulation by them will be in proportion to the speed of said engine. The pumps draw their supply from any suitable reservoir H and the fluid after performing its proper functions is returned to said reservoir so that there is no sensible waste of the fluid employed.

The pump G″ forces fluid through the pipe A″ into the annular space around the valve *a* in cylinder A. The return passage for this fluid is through the perforations *b* in the valve *a*, the slot *a″*, when the piston *b′* is raised, and the pipe A′. The pump G′ forces fluid into the lower portion of the cylinder C, the pump G forces fluid into the upper end of said cylinder and the return for both of the pipes F and F′ is through the opening in tube E′ and the tube B″, there being sufficient space between the hinged plates *e e′* and the edges of the opening C″ when the piston *d′* exactly registers with said opening C″ to permit of its passage. This passage will be somewhat enlarged by a higher pressure of liquid acting on the plates *e e′* and tending to force their free ends closer together.

Previously to starting the engine in operation a valve K controlling a by-pass between the pipes A′ and A″ is adjusted to permit a predetermined leakage or proportion of the water to pass directly from the pipe A″ to the pipe A′. The spindle *a′* is also turned to adjust the area of the passage through the slot *a″* into the pipe A′. A graduated scale and pointer K′ may be combined with the spindle to indicate the position to which it should be set for a given speed. The adjustable by-pass and the valve *a* are supplementary to each other in obtaining a nice adjustment.

Assume that the engine is started in operation by the admission of live steam to the two cylinders L, L′, which are adapted in the well known manner to operate in tandem either as the two cylinders of a single or of a compound engine. The movement of the engine starts in operation the three force pumps, and fluid is forced through the pipe A″ under the valve *a*. Thence it passes up through the perforations *b* under the piston *b′* and raises the latter until an outlet back to the reservoir through the pipe A′ is afforded. The raising of the piston rod D″, which as is obvious, does not occur until the engine has fairly started, is utilized to control the intercepting valve which cuts off live steam from the cylinder L and converts the two cylinders from a single to a compound engine. To accomplish this, a stud *g* on the upper end of piston rod D″ engages with the bifurcated end of a lever *g″* which is connected by a link *g′* with the stem of a three-way steam cock *h*. This latter cock according to its position controls the admission of steam to the upper or lower portions of a small cylinder *h′* in which works a piston *h″* having a long rod *i*. To this rod are connected the levers of the valves *i′*, *i″*, which control, in the ordinary and well understood manner, the admission of live or exhaust steam to the cylinder L. The special arrangement of these connections and of the valves and the means employed for effecting their operation by the vertical movement of the piston rod D″ may be very greatly varied without departure from my invention, and do not form in themselves essential features of my improvement. It will be understood from the description which I have given of these parts, that when the piston rod D″ is raised the cock *h* is turned so as to raise the piston *h″* and convert the engine from single to compound.

The remaining portions of the regulator are used in controlling the cut-off. If the speed of the engine be such that more water finds its way into the cylinder A through the perforations *b* than can readily escape through the slot *a″* and pipe A′ or can leak through

the by-pass both pistons D′ and d' are forced up in the cylinder A. An upward movement of the piston rod D raises the tube E′ in the cylinder B, and this determines the elevation of the piston d' and piston rod d, in the following manner: Normally the liquid forced into the opposite ends of the cylinder C, being at equal pressure, tends to maintain the piston d' in an exactly central position with reference to the opening C″ in the pipe E′, so that the passages for the escape of water into the tube E′ from opposite sides of the piston d' shall be equal. This state of equilibrium is preserved until the tube E′ is moved either upward or downward. Any movement of said tube in either direction varies to a corresponding degree the area of the respective passages for the fluid above or below the piston D′, so that the pressure upon one side or the other of said piston will be increased and on the opposite side diminished, whereby the piston will be moved up or down until it again reaches the position of equilibrium determined by the elevation of the tube E′. A higher speed will therefore raise the tube E′ and with it the piston d. Such movement of the piston and piston rod d is communicated to a rod M movable vertically in guides M′ and rigidly connected with the piston rod d. The rod M is connected in any suitable manner, as by a bar M″, with the link N operated by the eccentrics N′, N″ and connected with the rocker O that operates the valve-stem rod O′ of the cut-off. The function of the rod M″ is, as is well understood, to vary the cut-off by adjusting the link N in the same manner as is done by hand or by the steam controlled piston now in use.

From the nature of the operation of the devices described, it will be seen that the piston D and cylinder A constitute a relay to the piston d', serving merely to determine the position of the latter. By this means the first or primary piston is relieved of nearly all load and acts with correspondingly greater sensitiveness. The secondary piston however, is held in equilibrium by the two pressures and not only has great power, but little or no tendency to move of itself.

It will be understood that the special mechanism or connections between the piston rod d and the cut-off may be very greatly modified without departure from the invention.

The utility and advantages of the regulator described result mainly from its capability of purely automatic action, not only in converting an engine from single to compound at any predetermined moment after starting or at any rate of speed which it may have acquired, but also in determining absolutely the limit of speed at which it can run. These features render the invention especially useful in the propulsion of street railway cars. For example, the limit of speed of a street car in the crowded sections of a city may not exceed four miles an hour. Cars which are used in such sections or while running through such sections, if equipped with my improved regulator, may be prevented from exceeding such limit by the proper adjustment of the valve a and once for all. This implies that the valve is so set, and the index K′ may be readily used for this purpose, that when the speed of the engine reaches the predetermined limit, more liquid will be forced into the cylinder A than can escape through the slot a'' and in consequence the period of cut-off is varied as above described. The speed of the engine may in this way raise the link N to the position of mid-gear when no steam will be admitted to the cylinders. Any tendency to increase speed beyond this point which might result for instance by the engine running down grade, would result in a still further adjustment of the link and actual reversal of the engine. Thus it is evident that the use of brakes and the constant attendance of an engineer in controlling the speed of the engine is rendered largely unnecessary.

The operations of starting and stopping the engine are all that it is necessary to perform by hand.

It is desirable that after every stoppage of the engine it should return to the condition of a single engine and that the cut-off should be at full stroke. This is accomplished in my device by the instrumentalities which I have already described and comprising mainly the spiral spring E″, which tends to restore to normal position the tube E′ and piston rod D. The piston b' is returned to its normal position by the spring c, such water as may be under the piston and below the orifice of pipe A′ leaking through the perforation b'' in the piston b' as the latter descends. The piston d' is returned to its normal position by gravity, the perforation f' permitting the gradual escape of water directly from the cylinder C to the discharge B″.

Having now described my invention, what I claim is—

1. The combination with a primary cylinder and a piston acted upon by fluid pressure varied in accordance with the speed of the engine, of a secondary cylinder and a piston connected with the devices for controlling the motive power of the engine, and controlled as to position by the movement of the primary piston, as set forth.

2. The combination with a cylinder and two pistons contained therein, a pump driven by the engine and arranged to force fluid into the cylinder below the pistons, an adjustable outlet for the fluid from the cylinder, and connections from the pistons to the intercepting valve, and to the devices for controlling the motive power respectively, as described.

3. The combination with a cylinder and a piston connected with the devices for controlling the motive power such as the link of the cut-off mechanism, of means for controlling the position of said piston comprising, two force pumps connected with the cylinder on

opposite sides of the piston, a tube having an opening in its side but otherwise closing a slot in the cylinder, a piston raised by fluid pressure in proportion to the speed of the engine and connected with the said tube, as set forth.

4. The combination in a regulator of the kind described of a primary cylinder and piston, a force pump connected with the cylinder and driven by the engine whereby the position of the piston and pressure thereon will vary as the speed of the engine, a cylinder and a piston connected with the devices for controlling the motive power, two force pumps acting upon opposite sides of said piston, and an outlet port connected with and moved by the primary piston, substantially as set forth.

5. The combination with a piston connected with the motive power controlling devices, two force pumps acting upon opposite sides of the same a controlling piston for varying the said pressures and a force pump driven directly by the engine and acting upon the controlling piston, as set forth.

6. The combination in an engine regulator with the motive power controlling mechanism, and the intercepting valve of the engine, of a cylinder A, a piston D′, the rod of which connects with the motive power controlling mechanism, the piston *b′* the rod of which passes through the piston D′ and connects with the intercepting valve, a force pump driven by the engine an inlet pipe from said pump entering the bottom of the cylinder, an outlet pipe above the level of the inlet and a valve *a* for adjusting the capacity of the outlet, as set forth.

7. An engine regulator comprising in combination, a cylinder A and piston D′, a force pump adapted to maintain a pressure under the piston proportioned to the speed of the engine to be controlled, a cylinder C, and piston *d′* connected with the motive power controlling mechanism of the engine, force pumps maintaining a normally equal pressure on opposite sides of piston *d′*, a cylinder B communicating with cylinder C through a vertical slot, the tube E′ working in the cylinder B and connected with the piston D′ and formed with an opening that registers with the slot in the wall of the cylinder, as set forth.

8. The combination with the two cylinders B and C communicating through a vertical slot, the tube E′ having an opening C″, the piston *d′* working in cylinder C, and the two plates *e e′* pivoted to the piston and extending into the slot, as and for the purpose set forth.

9. The combination with the primary or controlling cylinder and piston of an engine regulator, and a secondary or working cylinder and piston, of fluid pumps connected with the cylinders, the cylinders or pistons being provided with small leakage ports or passages to enable the pistons to return to their normal position on the stoppage of the pumps, as set forth.

10. The combination with the cylinder A, the piston D′, the inlet and outlet pipes below the piston, the cup shaped valve *a* with perforated bottom through which fluid is admitted into the cylinder, and formed with a tapered slot *a″* for varying the area of the outlet, as set forth.

11. The combination with a cylinder and a piston connected with the motive power controlling mechanism of an engine, of a force pump driven by the engine, inlet and discharge pipes connecting the pump with the cylinder, a valve for varying the rate of the discharge, a by-pass between the two pipes, and a valve contained therein.

In testimony whereof I have hereunto set my hand this 23d day of April, 1894.

HENRY A. HOUSE.

Witnesses:
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PARKER W. PAGE.