No. 817,438. PATENTED APR. 10, 1906.

E. McLEAN.

REGULATION OF FURNACES.

APPLICATION FILED MAY 23, 1904.

4 SHEETS—SHEET 1.

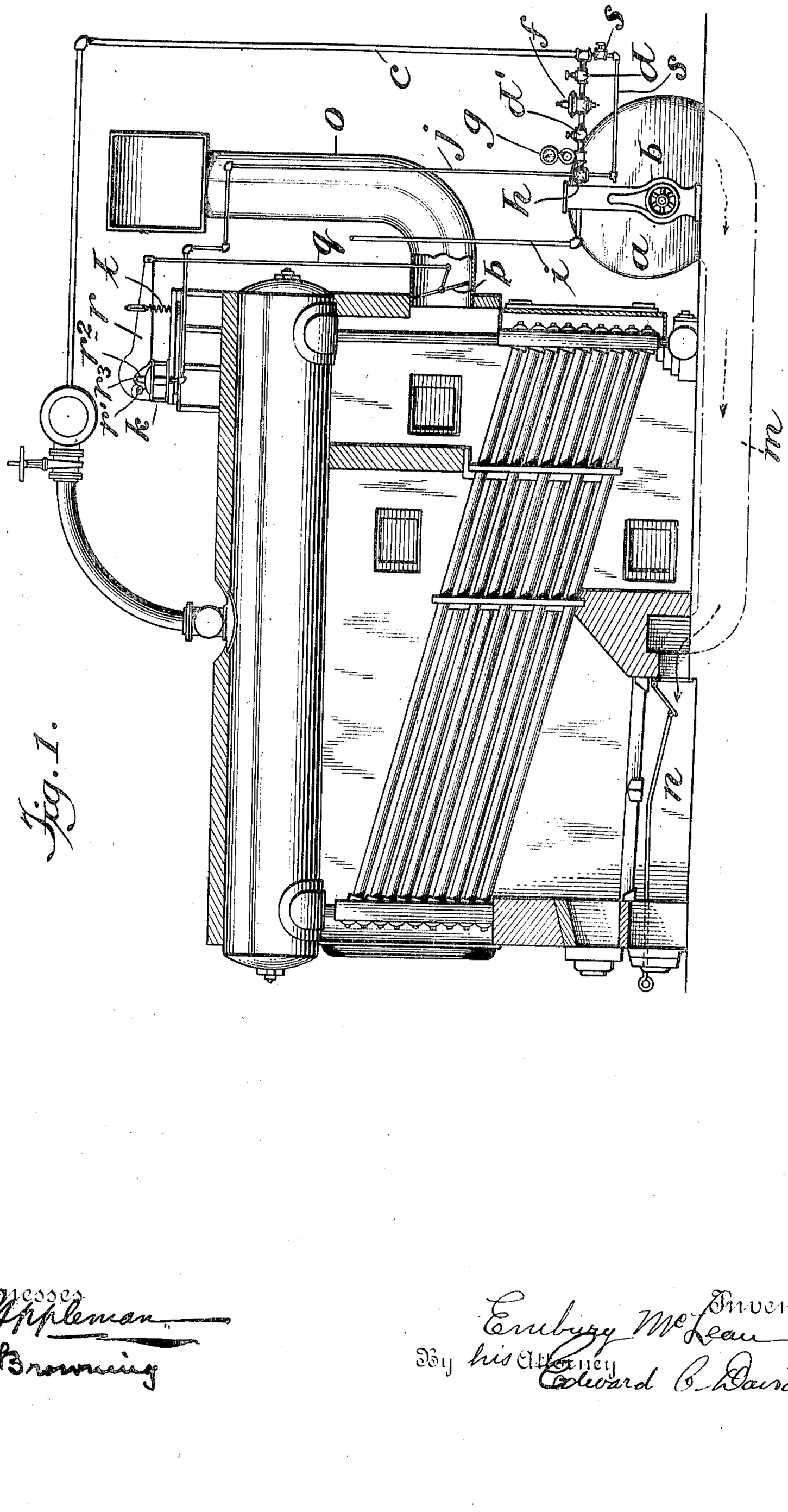

Fig. 1.

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4 SHEETS—SHEET 2.

Fig. 6.

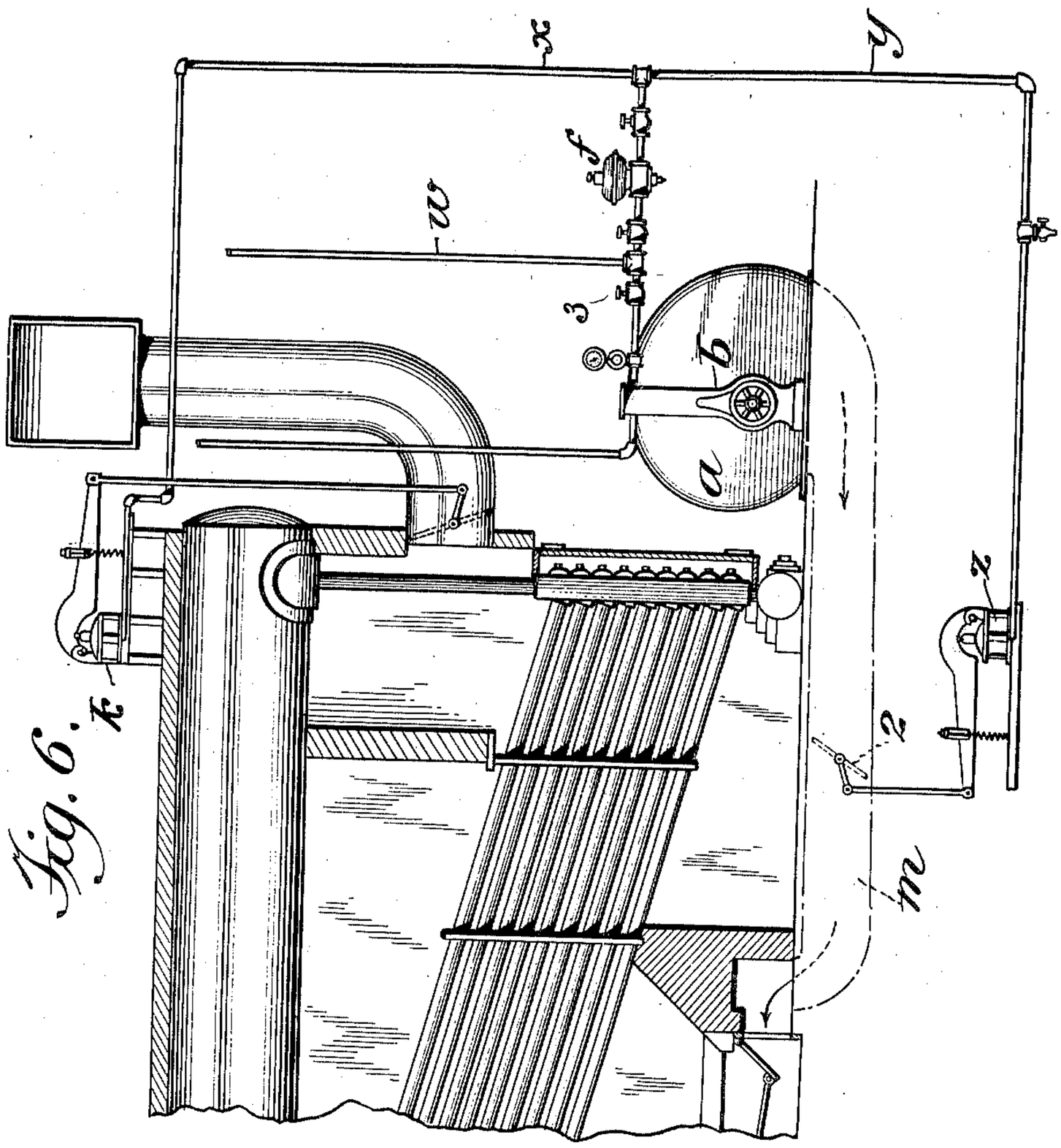
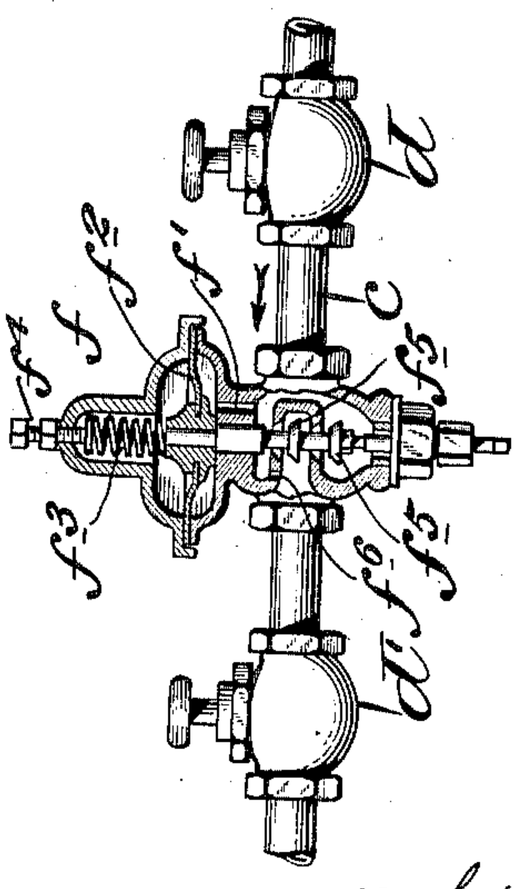


Fig. 2.



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4 SHEETS—SHEET 3.

Fig. 5.

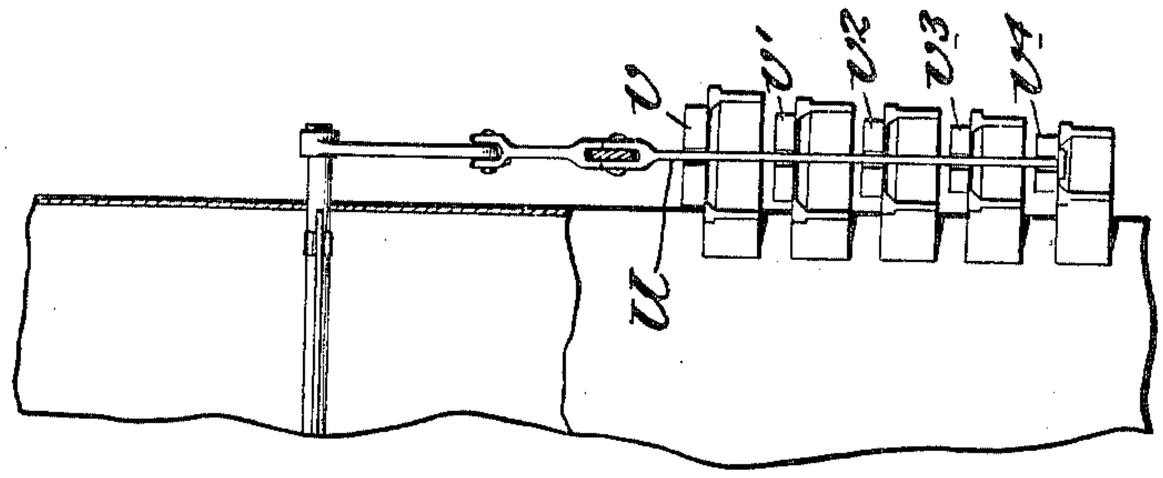


Fig. 3.

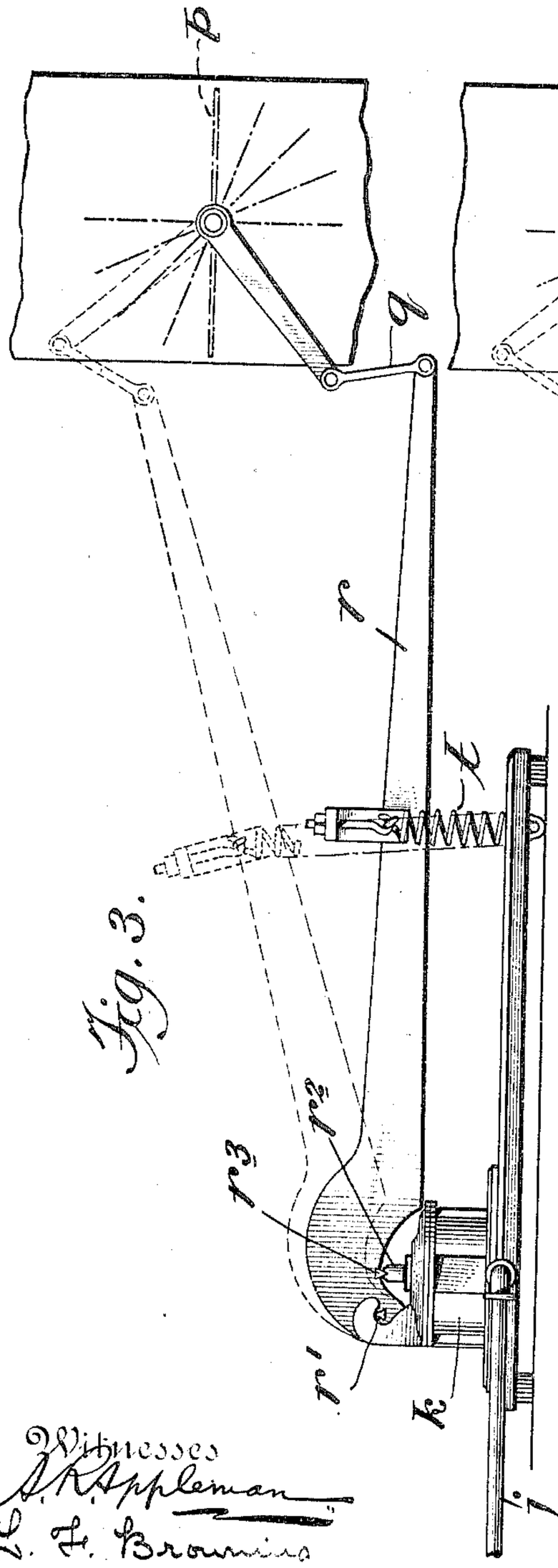
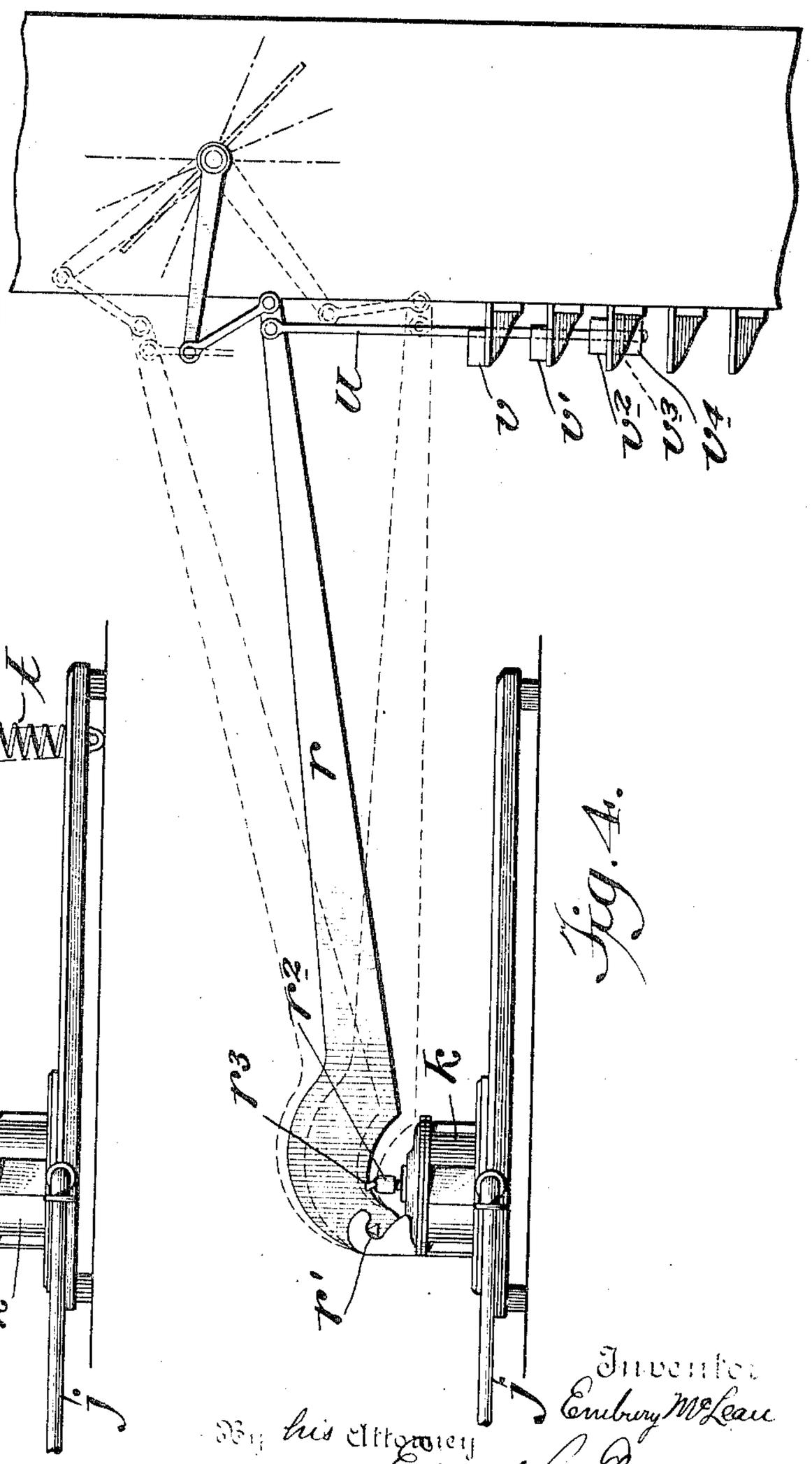


Fig. 4.



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4 SHEETS—SHEET 4.

Fig. 7.

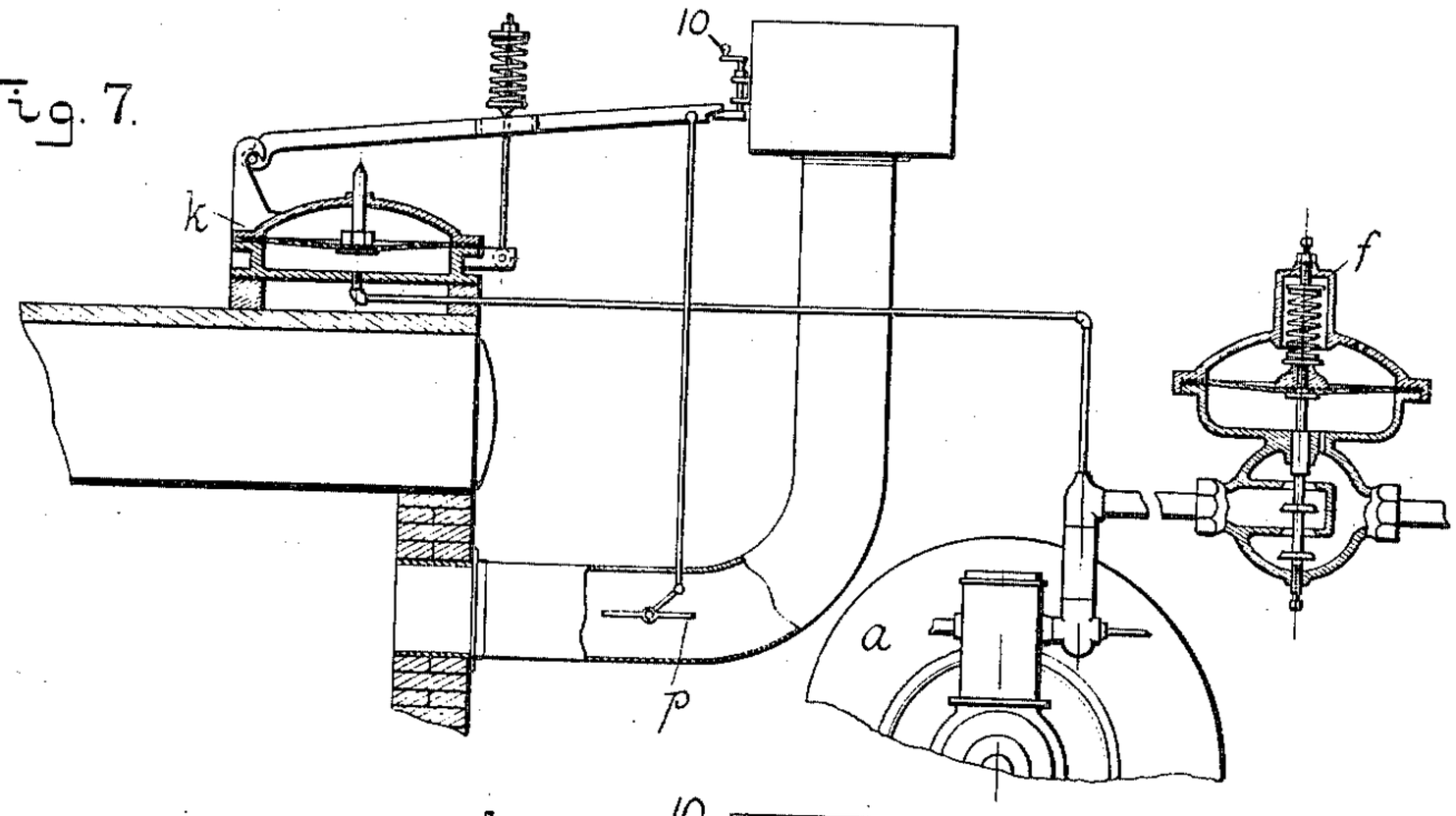


Fig. 8.

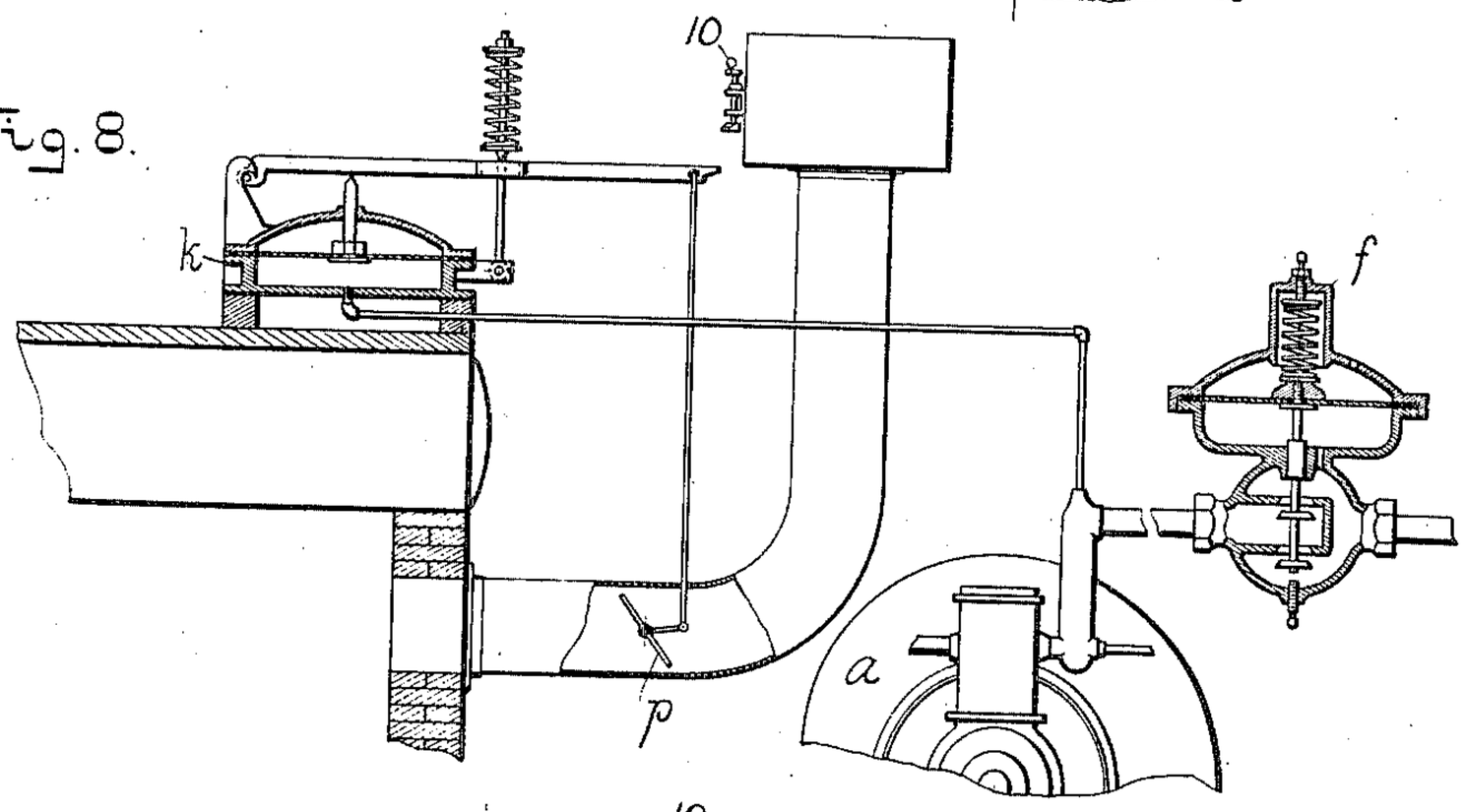
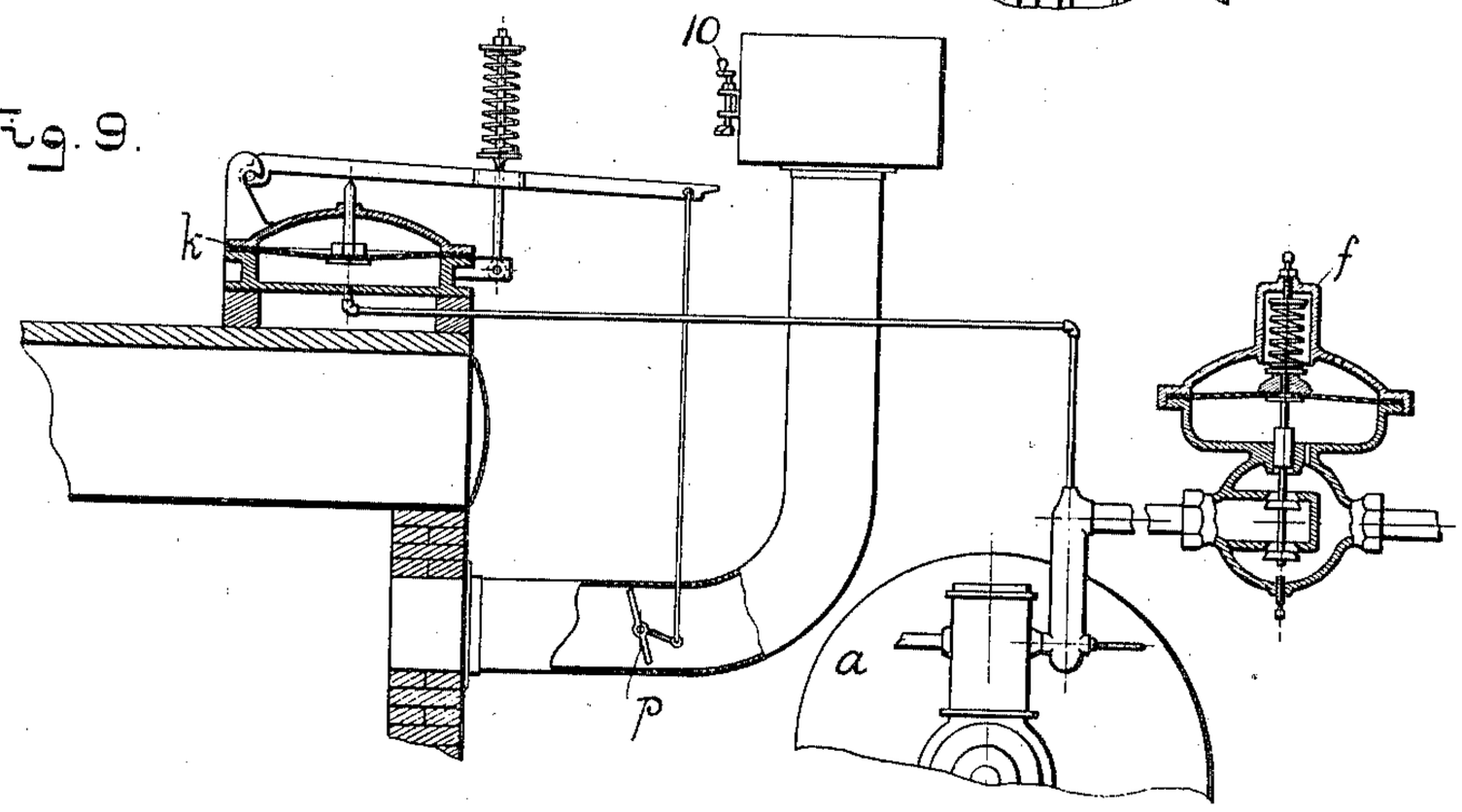


Fig. 9.



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UNITED STATES PATENT OFFICE.

EMBURY McLEAN, OF NEW YORK, N. Y.

REGULATION OF FURNACES.

No. 817,438. Specification of Letters Patent. Patented April 10, 1906.

Application filed May 23, 1904. Serial No. 209,256.

To all whom it may concern:

Be it known that I, EMBURY McLEAN, a citizen of the United States, residing in the borough of Brooklyn, city of New York, State of New York, have invented certain new and useful Improvements in Regulation of Furnaces, of which the following is a specification.

This invention consists in automatically maintaining in the fire-chamber of a forced-draft furnace a uniform or substantially uniform pressure that may be equal or substantially equal to that of the outside atmosphere of the furnace-room. The attained result is maximum efficiency, maximum economy of fuel consumption, and minimum liability of injury to the furnace or associated apparatus by inrush of cold air when the door of the furnace fire-box is opened. The operation or result is accomplished by regulating the outlet for products of combustion correspondingly with and commensurate to the regulation of the forced draft with graduated rate of combustion between the extremes.

The invention may be practiced in various ways or by the utilization of various kinds of apparatus and is applicable to furnaces for various purposes.

One of the objects of the invention is to maintain substantially uniform steam-pressure with maximum economy of coal consumption and minimum liability of injury to the boiler by inrush of cold air when the door of the fire-box is opened and of dilution and cooling of the gases by air drawn in through crevices in the door or furnace-setting. This latter is accomplished by maintaining in the fire-box a pressure equal or substantially equal to the atmospheric pressure in the boiler-room, while at the same time supplying to the fire-box the full amount of air required for effective combustion of the fuel. Under these conditions when the door of the fire-box is open there is an absence of inward or outward draft, as may readily be determined by suspending a light cloth across the open door. The instrumentalities by which this may be accomplished are a flue or stack of sufficient capacity and draft, (and in any case where the stack draft and capacity are insufficient an exhaust-fan may be connected to the stack,) means for supplying air under pressure to the fire-box, a damper in the stack, and means for automatically effecting as the boiler-pressure varies correlative adjustments of the damper and regulation of the volume and pressure of air supplied to thereby maintain uniform or substantially uniform pressure in the fire-box.

One organization that experience has demonstrated to be effective in producing automatically the conditions described comprises a draft-blower and coöperating stack-damper, both controlled by the steam-pressure in such way that a comparatively minute reduction of pressure causes a corresponding acceleration of speed of the blower and increase of volume and pressure of air supplied to the fire-box by the blower, and an actuation of the damper to afford a corresponding increase of the stack outlet area commensurate with the increased air-delivery from the blower—that is to say, there is in the operation of this system minute or gradual changes of the position of the damper corresponding to variations of speed of the blower. In this way the seam-pressure may be held at a substantially uniform point, and the pressure within the fire-box may exactly or substantially balance atmospheric pressure in the boiler-room, so that on the opening of the fire-box door there will be no inrush of cold air with the usual accompanying boiler contraction. In this particular organization steam from the boiler is passed through a regulating-valve, from whence it passes to the blower-engine and to a diaphragm-motor having the characteristic operation hereinafter described.

Another way of practicing this invention is to operate the blower at uniform or substantially uniform speed and throttle the air-supply passing therefrom to the fire-box.

In the accompanying drawings I have shown my invention embodied in forms at present preferred by me; but it will be understood that various modifications and changes may be made without departing from the spirit of my invention and without exceeding the scope of the claims.

In the accompanying drawings, Figure 1 is a vertical longitudinal section, somewhat diagrammatic, through a steam-boiler and fire-box provided with apparatus for the practice of this invention; Fig. 2, a detail enlarged section through the steam connection containing the regulating-valve; Fig. 3, an enlarged detail view showing the stack-damper and diaphragm damper-motor; Fig. 4, a similar view showing a modification; Fig. 5, a view of the left-hand side of Fig. 4; Fig. 6, a vertical longitudinal section similar to Fig. 1,

showing a modification of the general organization. Figs. 7, 8, and 9 show diagrammatically the position of the damper, the damper-motor, and the blower-engine-regulating valve at the condition of starting before there is steam in the boiler, the condition of running below normal steam-pressure and the condition of running above normal steam-pressure, respectively.

The following is a description of the apparatus shown in the accompanying drawings as examples of forms embodying my invention.

In Fig. 1 a draft-blower *a* is driven by an engine *b*, supplied by steam from the boiler through pipe connection *c*, which contains steam-cocks *d* and *d'* and between them a steam-regulating valve *f*, and also has applied to it a steam-gage *g*, beyond which one branch of the pipe *h* passes to the blower-engine, of which *i* is the exhaust-pipe, and another branch *j* passes to the diaphragm-motor *k*, that controls the damper. Air from the blower passes through the duct *m* into the ash-pit *n*, while the products of combustion pass through flue *o*, in which is located the damper *p*. The axis of the damper is turned by rod *q* with a lever-arm *r*, hinged upon a knife-edge at *r'* and engaged by the piston r^2 of the diaphragm-motor *k*. Preferably, to assure desirable delicacy of operation, the end of the piston r^2 is engaged by knife-edge r^3, carried by the lever *r*. The diaphragm-motor *k* is or may be of any suitable ordinary type, but the lever *r* thereof is controlled, as hereinafter described, relatively to the steam-pressure exerted upon the diaphragm of the motor—that is to say, its movement is a graduated one between its two extreme positions, one being the closed position in which the damper may be entirely closed or only partly closed, according to the special requirements in any given case, and the other the open position in which the damper may be entirely or only partly open, or the lever of the damper-motor may be so controlled that the changes in the position of the damper occur as a series of relatively minute steps or increments of movements either from the open or closed position of the damper, as the case may be. Around the parts *d d' f g* is a shunt or by-pass-pipe connection *s*, containing an ordinary steam-cock *s'*, which may be opened in starting to allow steam at full boiler-pressure to pass to the blower-engine, as well as to the lower side of the diaphragm of the damper-motor *k*, and thereby cause the opening of the damper. Steam from the boiler enters the regulating-valve *f*, as indicated by the arrow, Fig. 2, and passes by opening *f'* to the under side of a diaphragm f^2, which is normally urged downwardly by a spring f^3, adjusted by screw-bolt f^4, and carries a valve-spindle with two valves f^5, seating in the same direction upon two valve-seats through which steam from the boiler passes. The steam-outlet side of the regulating-valve is connected by an opening f^6 with the steam-inlet side. The opening f^6 is of such capacity as to deliver a determined quantity of steam when steam from the boiler is at a given pressure. Thus if the valves f^5 be seated a volume of steam, determined by the capacity of opening f^6, will pass to the blower-engine, causing the blower to operate at minimum speed, and to the under side of the damper-motor, causing minimum opening of the damper. This condition of course only occurs when the boiler-pressure is at a maximum. As the boiler-pressure falls the diaphragm f^2, moving downward, opens the valves f^5, permitting additional steam to pass to the blower-engine and damper-motor and causing increase of speed of the blower and a corresponding extent of opening (or increase of opening) of the damper. A further fall of steam-pressure produces a corresponding further opening of valves f^5, resulting in corresponding further increase of speed of blower and opening of damper. As steam-pressure increases reverse conditions are brought about.

From the above description of the operation of the regulating-valve *f* it will be seen that in construction it is substantially a pressure-reducing valve; but instead of the positions of the diaphragm and the valve being controlled by the outlet-pressure, as in reducing-valves, they are controlled by the pressure on the inlet side, and this is brought about by simply reversing the direction of flow of steam through the valve. The pressure of steam on the outlet side of the said regulating-valve *f* therefore decreases as the pressure on the inlet side increases. Hence the valve not only reduces pressure, but reverses the variations of pressure, so that as pressure increases in the boiler it diminishes in the blower-engine and also diminishes in the damper-motor. In other words, the increase or decrease of blower speed and corresponding damer-opening correspond to variations of boiler-pressure, and the changes occur on such minute changes of boiler-pressure that the latter is maintained substantially uniform. Since in any boiler which is to be worked at a given pressure the required amount of air and the required stack capacity to carry off the products of combustion at the various possible speeds of the blower may readily be arrived at, the pressure of gases in the fire-box and of air in the boiler-room may be equal or substantially so, and when the fire-door is opened there will be therefore no inrush of cold air to lower the temperature of the furnace and injure the boiler. As the boiler-pressure and blower speed vary, the damper-opening correspondingly varies, the opening being increased in one case to carry off the increased volume of

gases without material increase of pressure in the fire-box and in the other decreased to prevent material reduction of pressure in the fire-box. Such retardation of gas and products of combustion by this action of the damper allows time for intimate mixture of the heated air with the gases, insuring substantially complete combustion and a substantially smokeless stack. If the boiler is properly proportioned for the work it has to do, there is also a maximum absorption by the boiler of heat from the gases, so that the temperature of the stack may be very little above the temperature of the boiler.

The described control of the lever-arm r of the damper-motor may be accomplished by means of a suitably-constructed coiled spring t of such character and dimensions that the strength of its reaction through the entire required range of its distension shall, in cooperation with the regulated steam-pressure beneath the diaphragm of its motor, result in the graduated or gradual changes of position of the damper, as already described. Like results may approximately be effected by the arrangement of weights shown in Figs. 4 and 5. A pendent rod u, pivoted upon the end of the lever r, passes through a series of weights v' v^2 v^3 v^4, (of which, however, there may be any desired number,) supported upon brackets w. The weights are graded as to size, the upper ones of the series being larger, and the rod u is headed at its lower end, so that as the lever is moved upwardly by the strain of the damper-motor the weights v^4, v^3, v^2, v', and v are picked up in succession, corresponding positions of the damper p being indicated by the dotted lines on Fig. 4, as they are also indicated by the dotted lines in Fig. 3, wherein in lieu of the series of blocks of different weight the spring t above described is employed. To locate the brackets and adjust the weights shown in Figs. 4 and 5 to assist in maintaining constantly atmospheric pressure in the fire-box, the following method may be employed: Let the blower be run at minimum speed and by hand adjust the damper until atmospheric pressure in the fire-box is attained. This may be determined by suspending a sheet of light material in front of the open furnace-door. The position of the lower end of the rod u is then noted and the weight required to hold the damper stationary in that position ascertained. This determines the position of the lowest bracket and the required amount of the weight v^4 resting thereon. Next let the blower be run at maximum speed and by hand adjust the damper until atmospheric pressure in the fire-box is attained. The position of the lower end of the rod u is then noted and the weight required to hold the damper stationary in that position ascertained. This determines the position of the uppermost bracket and the required aggregate amount of the weights v v' v^2 v^3 v^4. Next repeat these proceedings with as many intermediate speeds of the blower as desired, thereby determining the positions of the intermediate brackets and the weights to be carried thereby. By this means the apparatus may be adjusted so that substantially constant atmospheric pressure will be maintained in the fire-box for all working speeds of the blower.

Theoretically and practically the best results are obtained by supplying to the fire-box sufficient air for perfect combustion and maintaining a balance, or substantially so, between the pressures in the fire-box and boiler-room. The apparatus may, however, be so adjusted that any desired substantially uniform pressure below that of the boiler-room may be maintained. This may be desired in some cases for the purpose of ventilation notwithstanding a loss in efficiency and possible injury to the boiler. Of course a fire-box pressure above that of the boiler-room might be obtained, but is not at the present time desirable.

Another way of practicing this invention is shown in Fig. 6. There steam passes from the boiler by pipe w', through the regulating-valve f, and thence by pipe x to the diaphragm-motor k of the stack, and by pipe y to a diaphragm-motor z, controlling a damper 2 in the air-duct m, through which air passes from the blower to the ash-pit. Both these damper-motors are controlled by springs or weights in the manner already described. The blower-engine, however, is connected direct to the boiler and runs, therefore, at a substantially uniform speed, the quantity of steam admitted thereto being fixed by setting the hand-operated valve 3.

I am aware that heretofore systems of boiler regulation in some respects resembling that herein disclosed have been proposed. In such systems, however, while the blower-engine has been controlled to control the blower relatively to the steam-pressure of the boiler the stack-damper has been so constructed and operated as to have really but two positions, one open and the other closed—that is to say, on a rise of pressure above normal the stack-damper will close and the blower slow down until a condition is established resulting in the increased speed of the blower, accompanied by full opening of the damper. Such systems while having advantages and being comparatively efficient, affording an economy in coal consumption not obtained in unregulated boilers, nevertheless necessarily permit of a somewhat-marked variation of boiler-pressure, render liable expulsion of the gases from the fire-box into the boiler-room when the blower speed is increased and before the damper opens, and also tend at times when the damper is open to cause a reduction of pressure in the fire-box below that of the boiler-room atmosphere, causing in-

rush of a large quantity of cold air should the furnace-door be opened.

Instead of a blower-engine actuated by steam from the boiler the motor or engine of the blower may be of a different character and may be actuated from another source of power. For instance, an electric motor could be used, the speed of which may be controlled by a rheostat and the contact device of the rheostat be controlled by a governing-motor—such, for instance, as the damper-motor *k* or *z*.

In Figs. 7, 8, and 9 I have shown diagrammatically the damper *p*, the damper-motor *k*, and the regulating-valve *f* in the positions which they occupy, respectively, first, when the fire is starting and there is no steam on the boiler; second, when the pressure in the boiler is below the normal, and, third, when the pressure in the boiler is above the normal. Thus referring to Fig. 7, which shows the parts when the fire is starting and there is no steam on the boiler, it will be observed that the damper *p* is wide open, so as to allow the fire to start under natural draft. It is shown as held open in this case by a hook 10, for which of course any suitable device performing the function may be substituted. The damper-motor *k* is then performing no function, while the regulating-valve *f* is wide open (there being no pressure under the diaphragm) and ready to admit a free passage of steam, when it is generated, to the blower-engine. Fig. 8 shows the position of the parts when the pressure in the boiler is so far below normal that the speed of the blower is at its maximuin, the damper-motor being brought into action by releasing the hook 10. In this case, owing to a small steam-pressure on the under side of the diaphragm of the regulating-valve *f*, the maximum amount of steam is permitted to pass on the one hand to the blower-engine *a* and on the other hand to the damper-motor *k*, thus holding the damper *p* in the position where it will balance the draft at the maximum blower speed. Fig. 9 shows the position of the parts when the steam-pressure is sufficiently above normal to reduce the blower to its minimum speed. In this case the increased pressure under the diaphragm of the regulating-valve *f* almost closes the passage through the regulating-valve, reducing on the one hand the amount of steam admitted to the blower-engine to the minimum and on the other hand reducing the pressure under the diaphragm of damper-motor *k* sufficiently to bring the damper *p* to the position where it will balance the draft at this speed of the blower. At intermediate steam-pressures, as will be readily understood, the positions of the parts shown in Figs. 8 and 9 will be simultaneously and correspondingly varied between the limits there shown, so that the pressure in the fire-chamber will always be maintained substantially constant and preferably equal to the pressure of the atmosphere.

In the claims I have used the term "blower" to include any apparatus for supplying air to the furnace at a pressure above atmospheric pressure.

Instead of automatically controlling the volume of air supplied to and the volume of gases discharged from the furnace by the steam-pressure or other function of the furnace it is obvious that one of these may be controlled by hand or in any other manner (including steam-pressure) provided the other is simultaneously and automatically controlled correspondingly by any suitable means, so as to maintain a substantially uniform pressure in the furnace under varying rates of combustion, as already described.

I do not claim the methods of operation described herein, as the same form the subject of an application for patent pending contemporaneously herewith, Serial No. 259,241, filed May 6, 1905, which is a division of this application.

I claim as my invention—

1. The combination with a combustion-chamber of a blower for supplying air thereto and means for establishing therein a predetermined pressure and for automatically maintaining substantially constant said pressure under varying rates of combustion.

2. The combination with a combustion-chamber of a blower for supplying air thereto and means for establishing therein a substantially atmospheric pressure and for automatically maintaining substantially constant said pressure under varying rates of combustion.

3. The combination with a combustion-chamber, of a blower for supplying air thereto, and means for establishing therein a predetermined pressure and for automatically maintaining substantially constant said pressure under varying rates of combustion, which means comprise apparatus which varies the supply of air to the furnace from the blower and substantially simultaneously varies the exhaust of gases from the furnace in quantities substantially corresponding to the quantities of air supplied by the blower.

4. The combination with a furnace, a blower, means for varying the supply of air to the furnace from said blower, means for varying the exhaust of gases from the furnace in quantities substantially corresponding to the quantities of air supplied by the blower, the parts being automatically controlled and so proportioned that a substantially atmospheric pressure is maintained in the furnace.

5. In combination with a furnace, a blower, means for varying the supply of air to the furnace from said blower in quantities graduated between the extremes, means for varying the escape of gases from the furnace

in quantities graduated between the extremes, and substantially corresponding to the graduated quantities of air supplied to the furnace by the blower, the parts being automatically controlled and so proportioned that a substantially uniform pressure is maintained in the furnace.

6. In combination with a furnace, a blower, means for varying the supply of air to the furnace from said blower in quantities graduated between the extremes, means for varying the escape of gases from the furnace in quantities graduated between the extremes, and substantially corresponding to the graduated quantities of air supplied to the furnace by the blower, the parts being automatically controlled and so proportioned that a substantially atmospheric pressure is maintained in the furnace.

7. In a furnace, the combination with a combustion-chamber, of a blower for supplying air thereto, and means for establishing therein a predetermined pressure and for automatically maintaining substantially constant said pressure under varying rates of combustion, said means being controlled by a function of the furnace, as steam-pressure.

8. In combination with a furnace, a blower and means controlled by a function of the furnace, as steam-pressure, for automatically varying the rate of combustion while maintaining a substantially atmospheric pressure in said furnace, thereby maintaining the function of the furnace substantially constant.

In testimony whereof I have hereunto subscribed my name.

EMBURY McLEAN.

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LILLIE F. BROWNING.