No. 881,272. PATENTED MAR. 10, 1908.

H. J. WESTOVER.

AUTOMATIC DRAFT REGULATOR.

APPLICATION FILED JAN. 8, 1907.

4 SHEETS—SHEET 1.

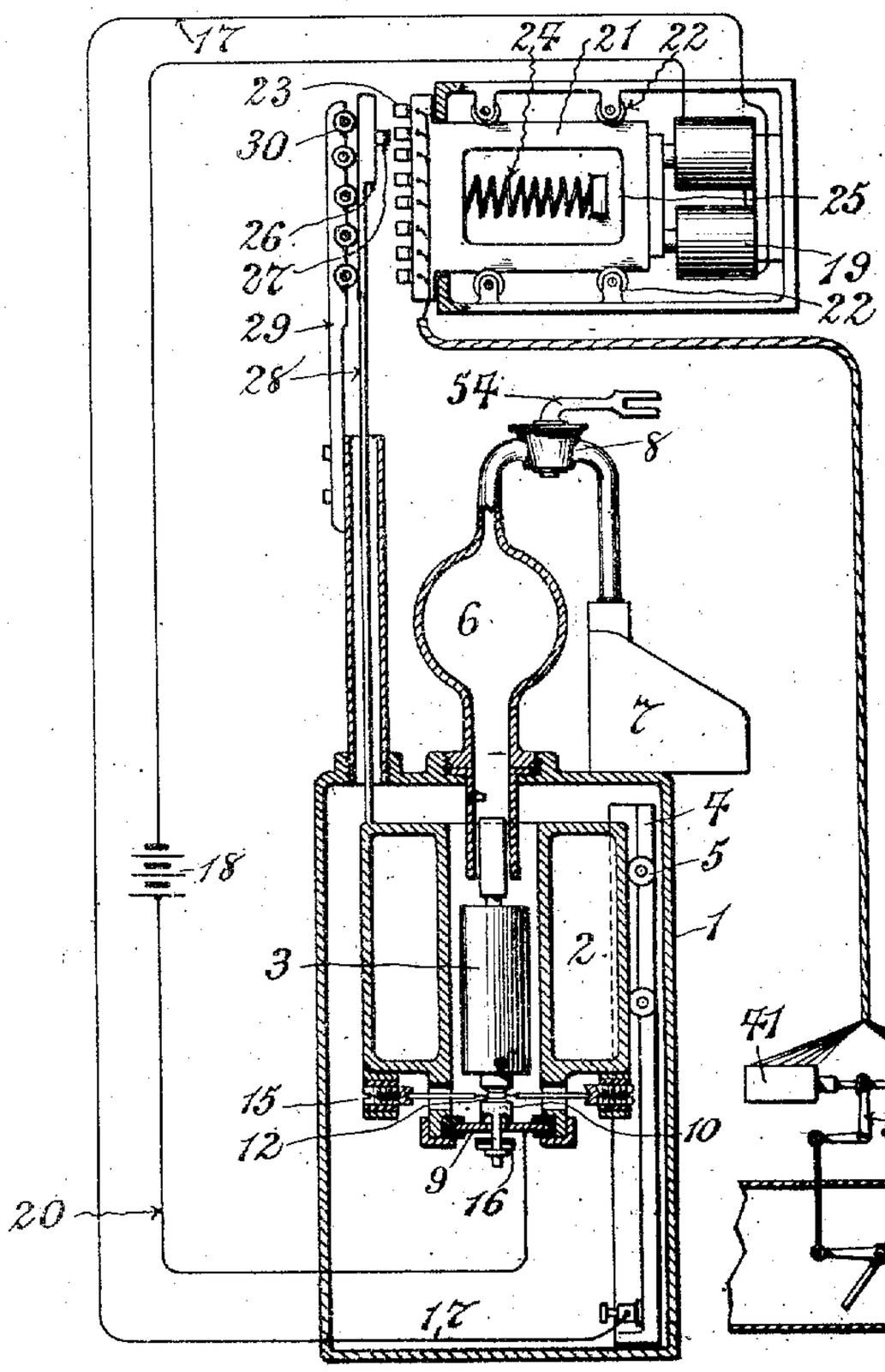
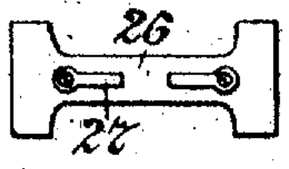


Fig. 1.

Fig. 4.



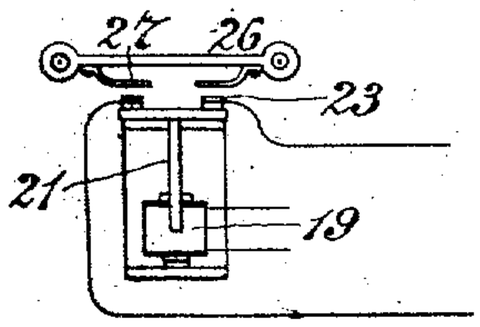


Fig. 5

Fig. 6.

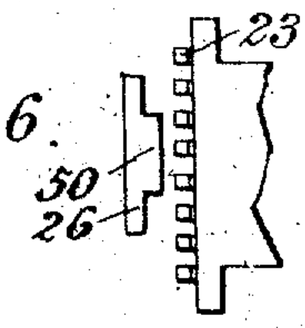
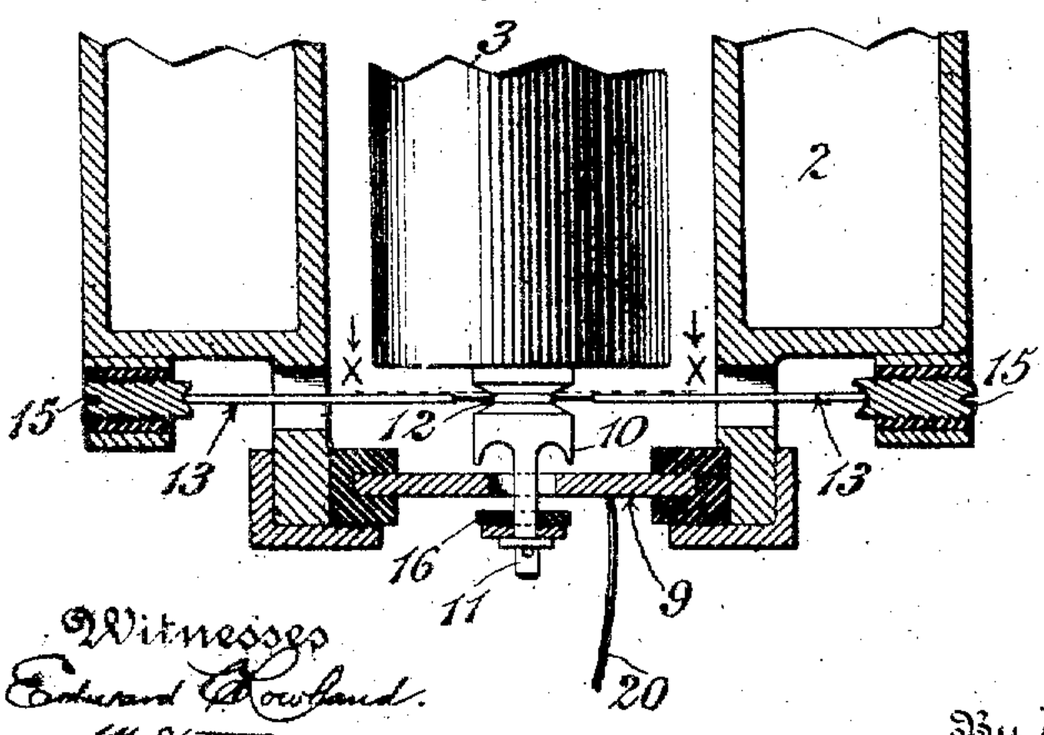
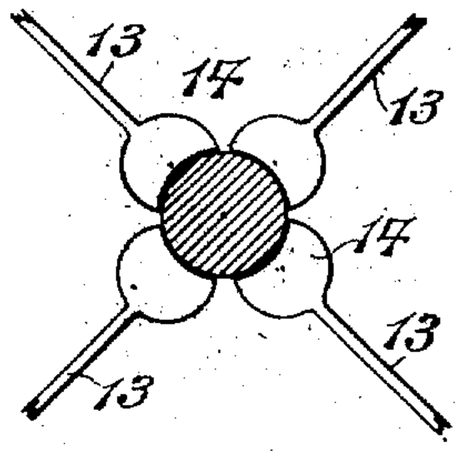


Fig. 2.



Witnesses
Edward Rowland.
M. Stern.

Fig. 7



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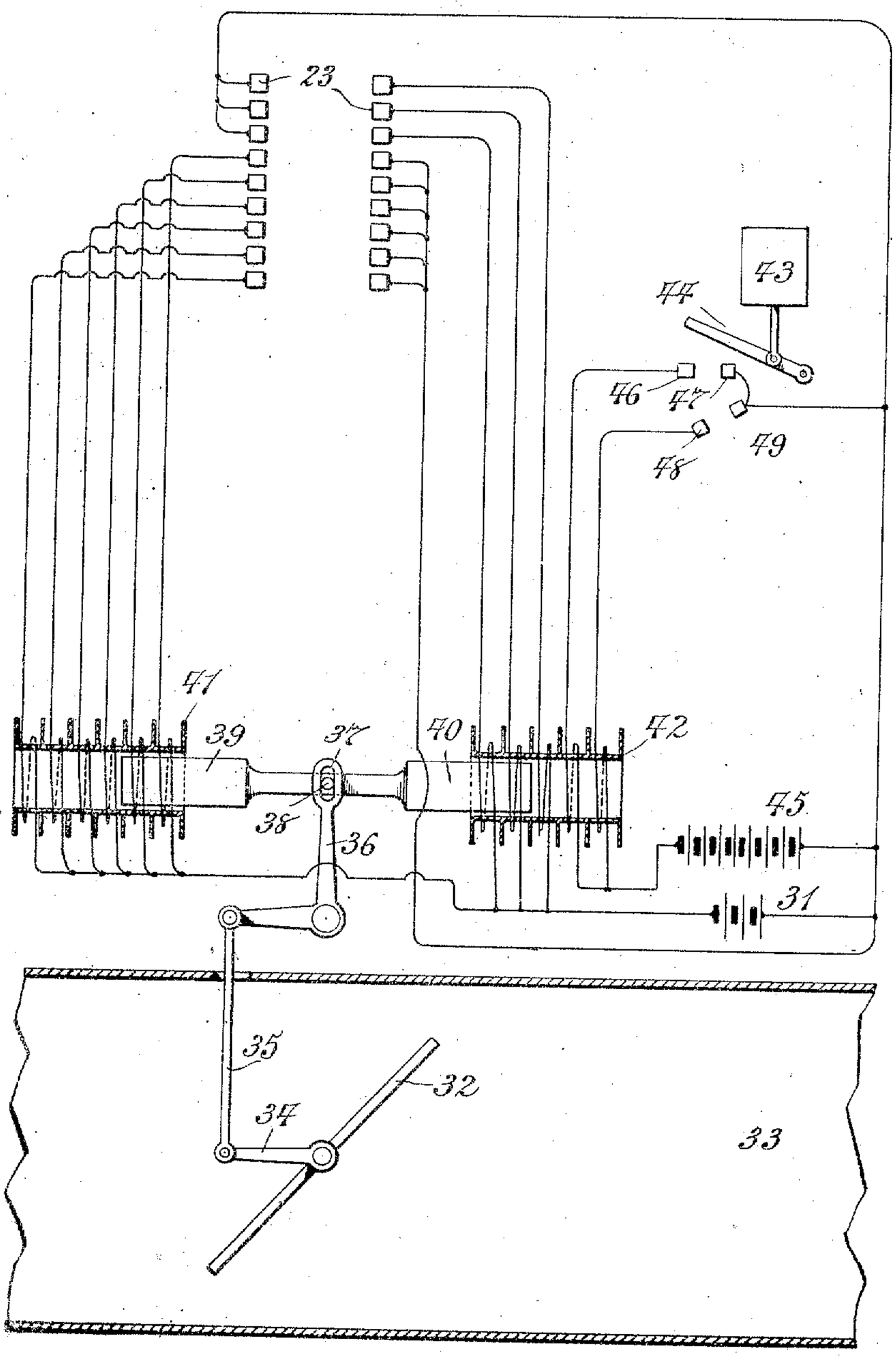
4 SHEETS—SHEET 2.

Fig. 3.



Witnesses
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4 SHEETS—SHEET 3.

Fig. 8.

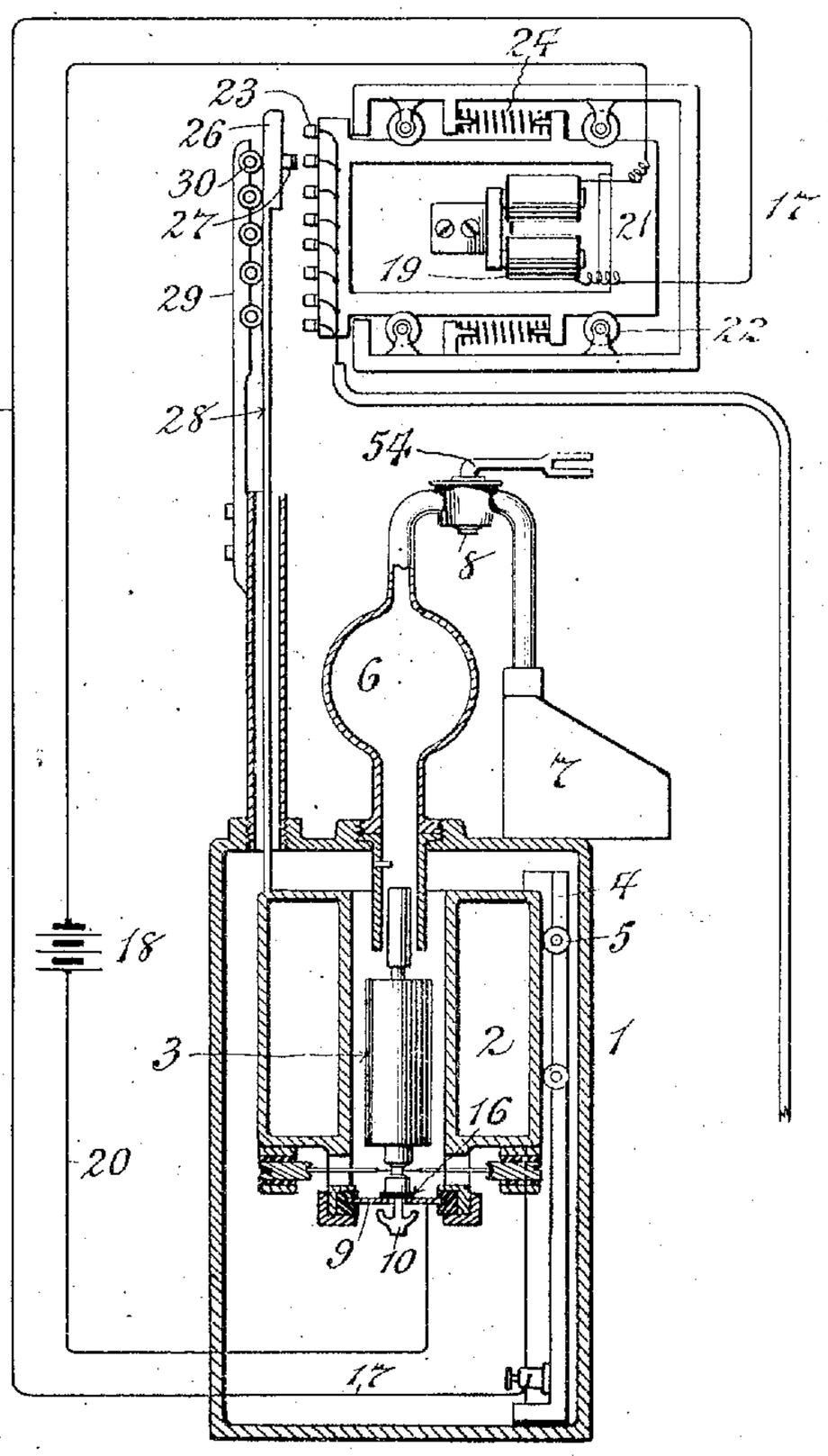
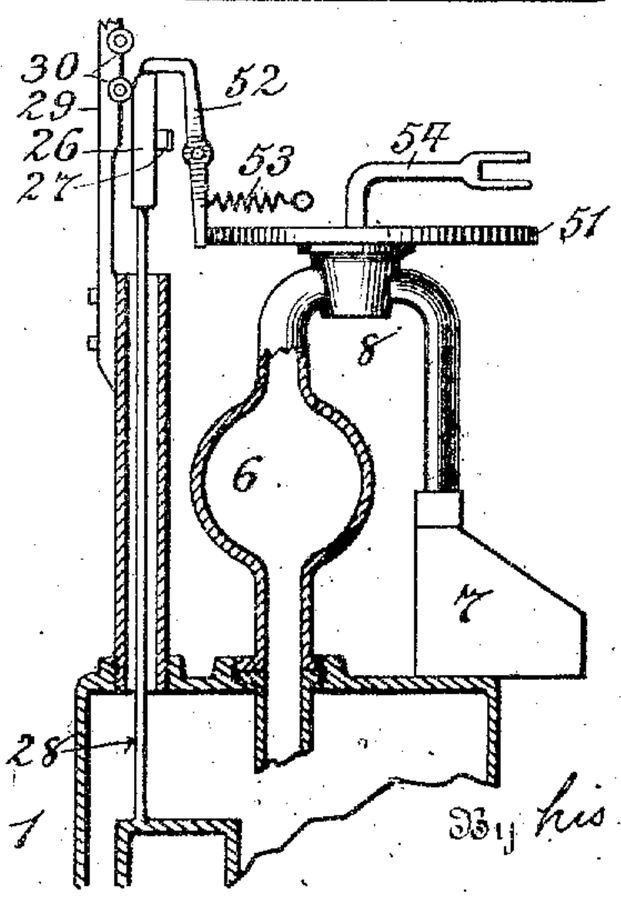


Fig. 9.



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4 SHEETS—SHEET 4.

Fig. 10.

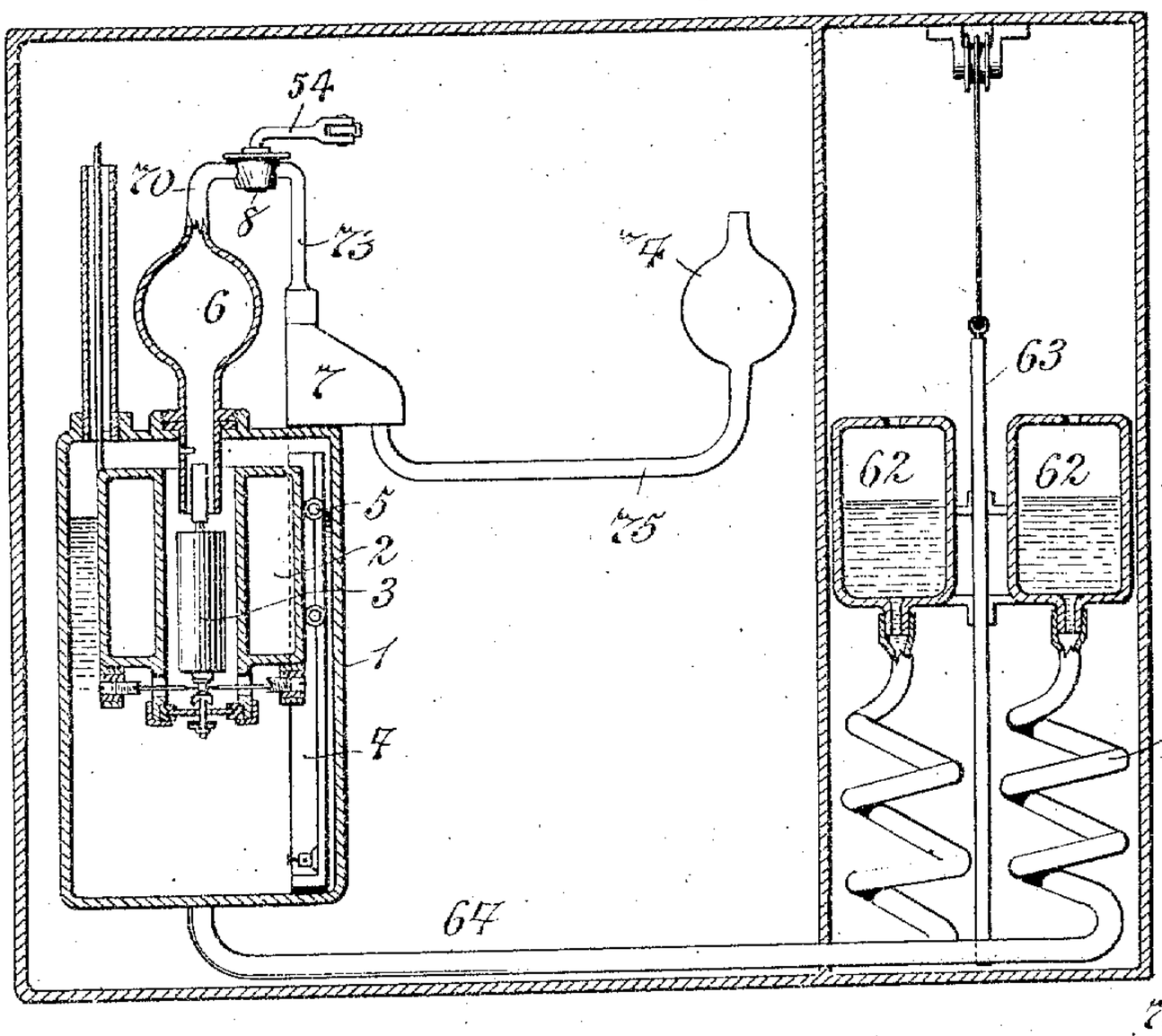


Fig. 12.

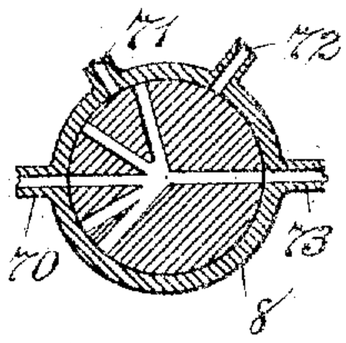


Fig. 13.

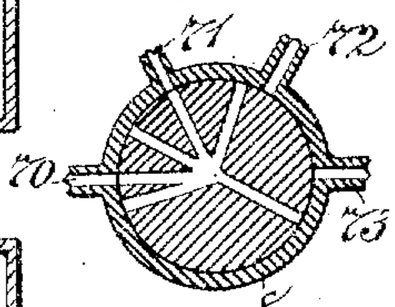


Fig. 11.

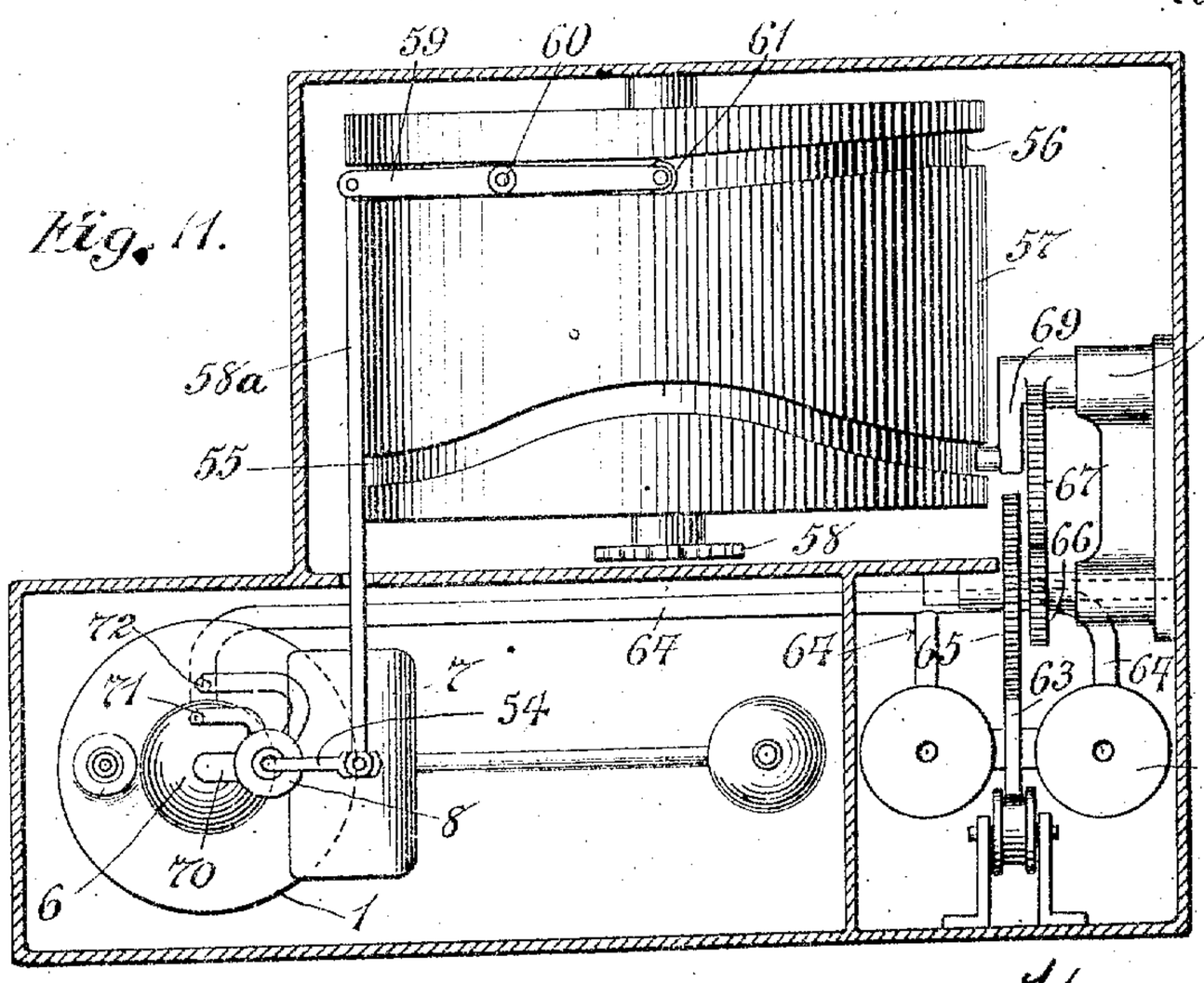
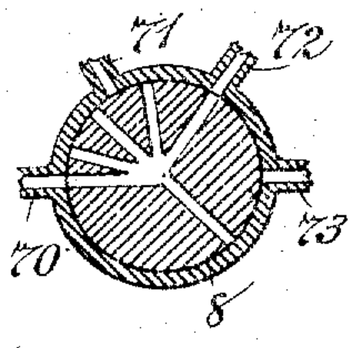


Fig. 14.



Witnesses:
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UNITED STATES PATENT OFFICE.

HENRY J. WESTOVER, OF NEW YORK, N. Y.

AUTOMATIC DRAFT-REGULATOR.

No. 881,272. Specification of Letters Patent. Patented March 10, 1908.

Application filed January 8, 1907. Serial No. 351,318.

To all whom it may concern:

Be it known that I, HENRY J. WESTOVER, a citizen of the United States, residing in the borough of Bronx, city and State of New York, have invented a certain new and useful Improvement in Automatic Draft-Regulators, of which the following is a specification.

For the purpose of burning coal economically under boilers and in other connections, it is recognized as highly desirable that the draft should be so related to the consumption of coal that, while, on the one hand the oxygen supplied should be sufficient for complete combustion, on the other hand an excess of draft should be avoided, in order that the heat produced may not be unduly wasted in the gases discharged through the chimney.

A variety of devices have been invented for testing the condition of draft, all of which depend upon determination of the proportion of CO_2 in the furnace gases. Some of these are automatic in nature, providing a continuous record of the proportion of CO_2 in the gases at all times. In my Letters Patent #833,274, dated Oct. 16th, 1906, I have described and claimed an improved apparatus for this purpose, and I shall employ the apparatus therein shown as illustrative of certain parts of my present invention.

The former types of apparatus above alluded to accomplish no more than the production of a record from which one may learn the condition of the gases at any given time. The practically continuous presence and services of a skilled engineer are required, in order that such modification of draft may be effected as is appropriate at a given time to the condition revealed by the apparatus in question.

My present invention relates to an apparatus whereby the draft is automatically regulated in conformity with the proportion of CO_2 present at any given time in the furnace gases. This apparatus dispenses with the continuous presence of an engineer to take action according to the CO_2 record, permitting him to attend only from time to time to check the operation of the machine. My invention is, therefore, analogous to the governor on an engine, since it regulates automatically the amount of draft by corresponding departures from ideal conditions in the furnace gases.

I believe my invention to be basic in character and it is therefore to be understood that, while I have shown in my drawings but one form which the same may take, this form is to be looked upon as merely illustrative of those which are covered by the spirit of my invention and the language of my claims.

The preferred form of my invention which I have chosen as illustrative thereof is shown in the accompanying drawings, wherein

Figure 1 is a sectional view of my automatic circuit maker with the damper mechanism in diagram; Fig. 2 is an enlarged sectional view of a part of the same; Fig. 3 is a diagrammatic view of the electrically controlled damper, showing the same as combined with well known means for regulation of draft by steam pressure; Fig. 4 is a front view of the movable electric bridge; Fig. 5 is a plan view of the bridge and magnetic circuit closer; Fig. 6 is side view of a modified form, Fig. 7 is a sectional view of a portion of the circuit closing floats showing a preferred non-frictional centering means, Fig. 8 is a sectional view of a modified form of circuit maker, Fig. 9 is a side view of the automatic latch mechanism, Fig. 10 is a sectional view of one end of the total analyzing apparatus, Fig. 11 is a top view of the same, Figs. 12, 13 and 14 are sectional views of the gas valve in different positions.

In my Letters Patent aforesaid, No. 833,274, I have shown a CO_2 recorder operated by electricity, the circuit being closed from time to time by the mutual operation of two concentric floats carried by the displacing liquid, the time of separation between the floats, and consequent breaking of electric circuit, being determined by the degree of loss in volume of imprisoned furnace gas due to absorption in an appropriate chamber. The whole or, if desired, only certain parts, of my aforesaid apparatus may be utilized in constructing an apparatus in conformity with my present invention. At the same time certain parts so utilized have been improved by me and I show, describe and claim these improved parts herein.

In the accompanying drawings the outer reservoir for the displacing liquid is shown at 1. Within this reservoir are the coöperating floats 2 and 3. The outer float 2 is preferably square or nearly so and is guided by insulated angle pieces 4 at diagonally opposite corners. Only one of these is shown in Fig.

1 as the other is removed by the plane of section. The standards 4 carry rollers or wheels 5 whereby the movement of the float 2 is guided up and down with a minimum of friction.

The chamber 6 may be called a "supplemental" chamber and communicates with the absorbing chamber 7 through the three-way valve 8. This latter chamber is a familiar feature in apparatus for gas analysis, being constructed in any well known manner to facilitate contact between the gases analyzed and the lye or other absorbing liquid used in a well known manner. The functions of these chambers and of the valve 8 are explained fully hereinafter.

The circuit whereby my apparatus is primarily controlled is made by contact between the perforated and insulated metal plate 9 and the contact points 10 carried on a stem 11 depending from the inner float 3 and passing through the hole in said plate 9. It is important that the inner float 3 should be carefully guided and centered in its movements relative to the outer float, and that these movements should be as little as possible obstructed by friction. I therefore employ one or more sets of centering bars for this purpose, and I have illustrated the use of one of these sets in Figs. 1, 2 and 7. Here the depending stem 11 is grooved annularly as shown at 12 forming a narrow circular neck which affords a bearing for the centering bars. These latter, preferably four in number, consist of light pins or wires 13 provided at their inner or converging ends with thin light sectors 14, which are supported within the groove 12 and bear lightly against the circular neck aforesaid as clearly shown in Fig. 7. The outer ends of the pins 13 abut against screws 15 whereby the centering of the float 3 may be accurately adjusted. When the stem 11 is in such a position that the pins 13 are in a horizontal plane, the inner edges of the sectors 14 fit against the cut out part of the stem fairly tightly. As the stem 11 rises or falls the sectors 14 follow it and maintain its central position practically without friction or other resistance. Inasmuch as the up and down movement of the stem 11 is very slight—being just enough to make or break the electric circuit—the contact between the stem and the sectors 14 is never interrupted, and there will be no more than a slight change in the tightness of fit or horizontal pressure, which is accommodated by the elasticity of the material. The vertical motion of the float 3 with relation to the float 2 is limited by the contact points 10 above the plate 9 and by the insulated lower stop 16, below said plate. The vertical movement of the pins 13 will therefore be very small and the depending stem will always be confined by the plates 14 to a central position.

As the controlling element of my device depends for appropriate operation upon the breaking of the electric circuit by relative movement of the two floats, means must be employed whereby current may be conveyed to the apparatus. For this purpose I prefer to make the outer float of thin hollow metal and to convey current to it and to the inner float through the standards 4 and wheels 5, which are connected by a wire 17 to one pole of a battery or other generator 18. In the form shown this connection is made through the energizing coils of the magnet 19. The insulated plate 9, carried by the outer float is connected by the wire 20 to the second pole of the generator. So long as the contact points 10 touch the plate 9 current will pass, and the magnet 19 will be energized. The weight of the inner float 3 tends to preserve this contact, and the two floats will only move separately when the difference between the pressures in the main reservoir 1 and the supplemental chamber 6 is sufficient to cause the inner float to linger behind the downwardly moving outer float.

Figs. 10 to 14 inclusive show enough of the entire instrument in question to illustrate the automatic operation thereof. The moving parts are preferably actuated by cams and in the form shown these take the form of suitably shaped grooves 55, 56 in a drum 57 which is constantly rotated through the sprocket 5[c] or otherwise. The valve lever 54 is governed by a rod 58[a] connected to a lever 59 pivoted at 60 and carrying a roller 61 which engages with the cam groove 56. The reservoir 62 for the displacing liquid is carried by a vertical rack 63 and is connected by a flexible tube 64 to the bottom of the displacing chamber 1. The reservoir is moved up and down by a pinion 65 engaging the rack 63 and impelled by a pinion 66 and toothed sector 67 pivoted at 68 and carrying an arm 69 which is swung back and forth by engagement as shown with the cam groove 55.

Figs. 12, 13 and 14 show one form of valve suitable to be used at 8. The pipe 70 connects with chamber 6, pipe 71 with atmosphere, pipe 72 brings the furnace gasses, and pipe 73 connects with the absorbing chamber, 7. The position shown in Figs. 10 and 11 is that assumed by the apparatus when the reservoirs are descending and the level of the liquid in chamber 1 is falling, carrying the floats down. The valve is as shown in Fig. 12 and the residual gas in 7 passes from 73 to 70, being followed by the absorbing liquid in the fixed reservoir 74, connected to chamber 7 by the pipe 75. As the liquid descends in chamber 1, and the residual gas in 6 expands, there will come a time when the difference in pressure existing between the chambers 6 and 1 will overbalance the gravitative tendency of the inner float 3 which tends to preserve electric contact at the plate

9, and the circuit through the magnet 19 is broken. The action of the groove 55 and sector 67 continues to further depress the reservoir 62 and lower the level of the liquid in chamber 1 and then the groove 56 acts to place the valve 8 as in Fig. 13. The groove 55 at the same time reverses the sector 67 and raises the reservoir 62 so that the liquid rising in chamber 1 expels the gas through chamber 6, tube 70, and tube 71 to atmosphere. This continues until all the gas is expelled through the valve 8. Thereupon groove 55 again reverses sector 67 and lowers reservoir 62, while groove 56 places valve 8 as in Fig. 14. The falling liquid then forms a vacuum which draws new furnace gas in from tube 72 to tube 70 and chamber 6. This continues until a predetermined volume of mixed furnace gases has filled chamber 6, when the reservoir 62 is again raised by the sector 67, and the valve 8 resumes the position shown in Fig. 12. The furnace gases are thus driven by the rising liquid through tube 70, valve 8, and tube 73 into the absorbing chamber 7, driving the absorbing liquid ahead of it into reservoir 74. This causes absorption of CO_2 and the cycle of operation above described begins again.

My present invention is broad enough to cover any device wherein the controlling means for the motive device which moves the draft regulator is itself governed by the differences in pressure due to absorption of CO_2. In the illustrative form of my invention herein shown this is accomplished electrically, and preferably by the following or equivalent means.

As shown in said former patent, at the moment that the two floats separate and contact is broken, the main float 2 will occupy a certain position within the vessel 1 depending upon the extent to which the total volume of gas acted upon within the absorbing chamber 7 has been diminished by absorption of the CO_2 contained therein. The greater the proportion of CO_2 present in the fixed initial volume of gas, the less residual gas will there be and the sooner will the two floats be made to separate as the displacing liquid descends in the chamber 6 and vessel 1. Consequently a high position of the main float 2 when separation of the floats occurs corresponds to a high percentage of CO_2 in the gas treated and the lower this percentage, the lower will the float 2 sink before the two floats separate and circuit is broken. In order to avail myself of this condition to cause proper automatic action of the draft regulator I prefer to employ the following means. Opposite the poles of the magnet 19 I place a frame 21 supported so as to move easily, for instance on rollers 22. At the outer end of the frame 21 there are carried pairs of contact buttons 23 placed one pair over the other as shown in Fig. 3. The spring 24, abutting at 25 tends to push the frame 21 away from the magnet, so as to close circuit across one or another pair of buttons 23, according as the electric bridge is placed opposite one or the other of said pairs of contact points.

The electric bridge may take a variety of forms, and I have shown one in Figs. 1, 4 and 5 which is suitable to my invention. Here a metal plate 26 carries springs 27 placed opposite the vertical lines of contact buttons 23. The plate 26 is carried upon an upright rod 28 which is in turn carried by the main float 2. Thus the level of the bridge is always determined by that of the main float. I prefer to place a fixed support 29 with friction rollers 30 behind the plate 26, to take the thrust of the frame 21 when pressed outward by the spring 24. It will thus be seen that, when circuit is opened at 10 by separation of the floats, and the magnet 19 is deenergized, the frame 21 will at once move forward and thus close circuit across one or the other pair of buttons 23. The position of the float 2 and bridge 26, 27, will be determined at that moment by the percentage of CO_2 in the gas treated, and this position will in turn determine which of the circuits through the buttons 23 will be closed.

It is not essential to my present invention that the operation of the main circuit closer should depend upon the opening of circuit by separation of the floats or equivalent devices.

In Fig. 8 I have shown a modified form of my invention wherein the magnet 19 acts positively to draw the frame 21 to the left to close circuit, while the springs 24 act to break this main circuit when the magnet is deenergized. This form of electro-magnetic apparatus is combined, as shown with a modified form of circuit controller on the floats. In this form the stem depending from the float 3 carries insulation above instead of below the plate 9 and this normally rests lightly on said plate. The contact-making points 10 are below the plate 9, and in consequence, when, on the downward movement, the float 2 begins to leave the float 3 behind, due to differences in pressures, the points 10 strike the plate 9, thereby closing circuit through the magnet 19 to cause closure of the main operating circuit. The operation of the motor actuating the draft regulator will be governed by the selection of buttons 23 thus accomplished. A great variety of means for causing the circuits so selected to regulate the draft might be constructed, all of which are within my present invention, but I prefer that shown in detail in Fig. 3, as the same lends itself to combination with a draft regulator simultaneously controlled by variations in steam pressure, and this arrangement has obvious advantages.

In the illustrative form shown in Fig. 3,

the successive pairs of buttons 23 are connected to opposite poles of a generator indicated diagrammatically at 31, and the connecting wires lead to electro-magnetic coils arranged to control the draft regulator substantially as follows:—The draft regulator, in this form, consists of a swinging damper 32 in the air flue 33, connected by the lever 34 and connecting rod 35 to the bell crank lever 36, one arm of which is slotted, as at 37, to take over a pin 38 on the double solenoid core 39, 40. The two enlarged ends of the core 39 and 40 are respectively acted upon by two series of separate solenoid coils wound on the insulating sleeves 41 and 42 as shown. In Fig. 3 the damper is in a middle position corresponding to the middle position of the solenoid core. If the core 40 is acted upon to draw it to the right the damper will be opened to a certain extent depending upon which of the solenoid coils on 42 is energized. If, on the contrary, the core 39 is drawn magnetically to the left, the damper will be closed to an extent depending upon which of the coils on 41 is energized. In the form shown the solenoid coil farthest to the right is energized when circuit is closed by the bridge across the top pair of buttons 23; thus causing the maximum opening of the damper when the percentage of CO_2 is at a maximum in the furnace gases. The next two right hand solenoid coils in order correspond to the next pair of buttons 23 and, as the core 40 will always tend to bring its neutral magnetic axis under that of the coil or coils energized at any time, it follows that when the second or third pair of buttons from the top is bridged, the solenoid core will move a corresponding distance to the left and partly close the damper. The succeeding pairs of buttons lower down are connected to battery 31 through solenoid coils progressively further and further to the left and therefore tend more and more to close the damper and diminish the draft. The arrangement of levers shown is such that equal movements of the cores 39, 40 to the left or right from the middle position shown produce progressively smaller changes in the position of the damper, thus increasing the delicacy of regulation as extremes are reached. This is desirable for obvious reasons.

The distribution of coils upon one side or the other of the solenoid, the strength of each, their total number, etc. will depend upon the specific results looked for in each case. In the form shown in Fig. 3, the CO_2 regulator is combined with an automatic damper regulator controlled by steam pressure and the two outermost coils on the right hand solenoid are employed in this connection. At 43 is diagrammatically shown the steam cylinder of a regulating device of any well known type intended to act so as to increase the draft in case the steam pressure in the boiler falls below a minimum.

The steam in 43 normally supports the pivoted contact-making lever 44. When the pressure falls unduly, this lever descends and makes contact through a generator, as 45, across the terminals 46. 47. This energizes the next to the last solenoid coil on the right and opens the damper. If the pressure continues to fall, circuit is closed across the terminals 48 and 49 and the extreme right hand solenoid coil acts to open the damper to its fullest extent. The details of construction of the steam actuated regulator form no part of this invention and require no illustration here. They may be of any type desired. I have merely shown one way of combining my CO_2 regulator with a steam pressure regulator, this combination being within the scope of my invention.

As keeping up the steam pressure is usually of paramount importance, the CO_2 regulation being purely for coal economy, it is best that the coils controlled by the steam pressure should be at all times capable, when energized, of over-powering the other coils, so that the air necessary for keeping up steam may always be available, whatever the position of the CO_2 apparatus. This may be accomplished in a variety of ways known to those skilled in the art, either where a common generator or separate generators are used for CO_2 coils and steam coils respectively. In the form shown I accomplish this by using a generator 45 for the steam controlled coils which is considerably more powerful than the generator 31 used for the CO_2 coils.

The result of combining the two forms or regulator as shown is that, if the steam pressure falls unduly the draft will be increased for producing increase of combustion irrespective of economy. As soon, however, as the steam resumes a proper predetermined pressure, the CO_2 coils take control of the damper and regulate combustion or maximum economy.

In Fig. 6 I have shown a modified form of bridging device for closing the primary controlling circuit. Here the plate 26 is provided with a contact face 50 sufficiently extended in a vertical direction to close circuit through a number of pairs of buttons 23 at once. This will result in greater certainty of action and will cause a number of solenoid sections to act simultaneously, so that the solenoid core will respond to the resultant action of all.

In Fig. 9 I have shown in detail an improvement which preferably forms a part of my complete invention.

In the apparatus shown in my former patent and so far described herein the floats rise and fall twice for each operation of the recording or regulating apparatus, as the

case may be. One up and down movement occurs when the displacing liquid rises in the vessels 1 and 6 for driving out waste gases between two operations. During this movement of the liquid, which may be termed the "idle movement" thereof, the main operating circuit should not be affected by separation of the floats. By occurrence of accidental variations in pressure, however, operative separation of the floats will possibly occur during the idle movement of the displacing liquid, and it is to prevent this that the construction shown in Fig. 9 is intended. For this purpose it is desirable to prevent the two floats from rising with the liquid in the vessel 1 during its "idle" movement,—that is to say, when the valve 8 is open to the atmosphere and the dead gases are about to be ejected. Many automatic attachments whereby this is accomplished by the appropriate movement of some part of the analyzing apparatus will occur to those skilled in the art and are within the scope of my broad invention.

In Fig. 9 I have shown one illustrative means for this purpose wherein a cam 51 on the stem of the valve controls the position of the pivoted latch or hook 52. The hook 52, when in the position shown in the figure, engages the top of the bridging piece 26 in its lowermost position and prevents the floats from rising. In this position the contacts 27 are not opposite any of the buttons 23 and when the liquid moves the inner float upward with relation to the outer float, this movement cannot cause closure of the main operating circuit. The tail of the latch is held always in contact with the cam 51 by the spring 53. In the position shown the valve operating lever 54 is in position to open the vessel 6 to the atmosphere to permit ejection of gases. When said lever is turned to admit fresh gas and afterward to close access to the gas supply during absorption, the cam 51, turning with it, turns the latch 53 on its pivot and liberates the floats to permit their rising. The means above described, while permitting independent relative movement of the two floats 2 and 3 when the displacing liquid is admitted, nevertheless prevent operative movement between said floats.

My invention is broad enough to cover any automatic means for preventing operative relative movement of the floats during idle movement of the displacing liquid, whether such means act by arresting the floats or otherwise or whether operated directly by movements of the valve 8 or not.

The utilization of electricity is preferred in carrying out the principal operations set forth herein, although this is not essential to my broad invention. Where electric circuits are used, however, they may be combined and arranged in many ways within my invention and the nature of the motive devices and mechanical features of the direct draft regulators may be indefinitely varied without departing from the scope of this invention.

In a variety of respects wide changes may be made in this device without departing from the spirit of my invention and I do not limit myself to the details herein shown and described.

What I claim is—

1. A draft regulator, a plurality of independent prime movers. for operating the same, a source of stored up energy, means for storing furnace gas and absorbing CO_2 therefrom and a device controlled by the residual gas for placing said source of energy in communication with one or another of said prime movers, substantially as described.

2. A boiler, a furnace and a draft regulator; in combination with two motive mechanisms for said regulator, means controlled as to operation by variations in steam pressure for controlling one of said motive mechanisms and means operated by variations in percentage of CO_2 in the furnace gases for controlling the second motive mechanism, substantially as described.

3. A draft regulator, a number of separately operative electro-magnetic prime movers therefor, and normally stationary mechanical means for transmitting motion from said prime movers to said draft regulator; in combination with separate circuit closing elements connected respectively to said separately operative prime movers, means for storing furnace gas and absorbing CO_2 therefrom and means controlled by the residual gas after absorption for selecting and closing circuit through one or another of said circuit closers for setting in operation one or another of said prime movers, substantially as described.

4. A furnace, a draft regulator therefor, a solenoid core operatively connected to said regulator, a number of solenoid coils for said core, a multiple switch for said coils, a gas-analyzing apparatus adapted to receive gas from the furnace, and a connection between said analyzing apparatus and said switch for selectively operating the latter by the movement of the former, substantially as described.

5. A boiler, a furnace and a draft regulator, in combination with two sets of solenoid coils, a magnetic core controllable thereby and operatively connected to said draft regulator, means operated by variations in steam pressure for closing circuit through one of said sets of solenoid coils and means controlled as to operation by variations in percentage of CO_2 in the furnace

gases for closing circuit through the second set of solenoid coils, substantially as described.

6. A furnace, a draft regulator, an electro-magnetic device for controlling the movement thereof, a displacing chamber arranged to receive gas from the furnace, floats in said chamber, a means for causing alternating idle and operative movement of liquid within said chamber, a circuit controlling means for said electro-magnetic device operatively connected to one of said floats, an automatic means for preventing operation of said circuit controlling means during idle movement of said liquid, substantially as described.

7. A furnace, a draft regulator, an electro-magnetic device controlling the same, a circuit changer in circuit with said electro-magnetic device, a gas analyzing apparatus adapted to receive gas from the furnace having a valve for controlling the movement of gas in and out of the same, and means operatively connected with said valve for locking said circuit changer so as to prevent its operation, substantially as described.

8. A furnace, a draft regulator, an electro-magnetic controlling mechanism for the regulator, a group of contact buttons in circuit with said controlling mechanism and movably supported, means for causing movement of the same, a gas analyzing apparatus adapted to receive gas from the furnace and an independent movable contact maker moved by said gas analyzing apparatus and adapted to make occasional contact with said buttons, substantially as described.

9. A furnace, a draft regulator, an electro-magnetic controlling mechanism for the regulator, two independently movable contact makers arranged to close an electric circuit for said controlling mechanism when brought together, a gas analyzing apparatus adapted to receive gas from the furnace and mechanically connected to one of said contact makers for moving it, and means for moving the other of said contact makers, substantially as described.

10. A furnace, a draft regulator, an electro-magnetic controlling mechanism for the regulator, two independently movable contact makers arranged to close an electric circuit for said controlling mechanism when brought together, a gas analyzing apparatus adapted to receive gas from the furnace and mechanically connected to one of said contact makers for moving it, an electro-magnetic device controlling movement of the other contact maker, and means operated by said analyzing apparatus for closing the circuit through said last named electro-magnetic device, substantially as described.

11. A furnace, a draft regulator, electro-magnetic controlling mechanism for the regulator, a number of pairs of circuit closing buttons in circuit with said controlling mechanism, a gas analyzing device adapted to receive gas from the furnace, and a bridging means placed opposite to said pairs of buttons and arranged to be moved by said gas analyzing device from one pair of buttons to another, substantially as described.

12. A furnace, a draft regulator, electro-magnetic controlling mechanism for the regulator, a number of pairs of circuit closing buttons in circuit with the controlling mechanism and arranged to be movable together, electro-magnetic means controlling the movement thereof, a gas analyzing device adapted to receive gas from the furnace and controlling the electric circuit of said electro-magnetic means, and a bridging means placed opposite said pairs of buttons and arranged to be moved by said gas analyzing device from one pair of buttons to another, substantially as described.

13. A furnace, a draft regulator, electro-magnetic controlling mechanism for the regulator, a chamber, means for causing rise and fall of liquid within said chamber, two floats carried by said liquid, a circuit closer operated by relative movement of said floats, a vessel adapted to receive gas from the furnace and arranged to determine the separation of said floats by the pressure of said gas upon said liquid, a movable bridging device operated by one of said floats, a movable circuit closer opposite the path of said bridging device and in circuit with said controlling mechanism, an electro-magnet for controlling movement of said last named circuit closer and an electric circuit through said magnet and including the circuit closer on said floats, substantially as described.

14. A furnace, a draft regulator, electro-magnetic mechanism for controlling the same, a movable frame, a series of pairs of buttons thereon in circuit with said controlling mechanism, an electro-magnet for moving said frame in one direction and means for moving said frame in the opposite direction; in combination with an automatic gas analyzer adapted to receive gas from the furnace, a bridging device movable opposite said buttons and operated by said gas analyzer and means also operated by said gas analyzer for controlling the electro-magnet which moves said buttons, substantially as described.

15. A furnace, a draft regulator, electro-magnetic controlling mechanism for the regulator, a gas analyzing device adapted to receive gas from the furnace, comprising a chamber, means for causing rise and fall of liquid therein, a float carried on said liquid, a contact making element carried by said float, a second contact making element arranged to be moved toward and away from said first named element, a support behind said first named element to resist the thrust of said second element, electric connections

between one of said elements and said controlling mechanism, and means controlled by said gas analyzing device for causing operative movements of said second element, substantially as described.

16. A furnace, a draft regulator, electromagnetic controlling mechanism for the regulator, a movable bridging device, a support with rollers behind the same, a movable frame in front of said device, a number of pairs of contact buttons on said frame in circuit with said controlling mechanism, a gas analyzer adapted to receive gas from the furnace and means controlled thereby for moving said frame toward and away from said bridging device, substantially as described.

17. A furnace, a draft regulator, electromagnetic controlling mechanism for the regulator, a number of pairs of contact buttons movably supported together and in circuit with said controlling mechanism, a movable bridging device opposite said buttons wide enough to touch more than one pair of buttons simultaneously, a gas analyzer adapted to receive gas from the furnace and operatively connected to said bridging device and means controlled by said gas analyzer for moving said pairs of buttons, substantially as described.

18. A furnace, a draft regulator, electromagnetic means for controlling the movements of the regulator, a displacing chamber adapted to receive gas from the furnace, a float therein, a supplemental chamber, a second float projecting into said supplemental chamber, circuit controlling means on said floats operated by relative movement thereof for controlling said electro-magnetic means, means for causing recurrent rising of liquid in said displacing chamber and automatic means for periodically preventing operative relative movement of said floats, substantially as described.

19. A furnace, a draft regulator, electromagnetic means for controlling the movement of the regulator, a chamber adapted to receive gas from the furnace, means for causing alternate rise and fall of liquid in said chamber, a float within said chamber carried by said liquid, a second float also in said chamber and carried by said liquid, circuit-controlling means on said floats operated by relative movement thereof for controlling said electro-magnetic means, and automatic means for periodically holding said floats out of operative position, substantially as described.

20. A furnace, a draft regulator, electromagnetic controlling mechanism for the regulator, a series of electric contacts in circuit with said controlling mechanism, a gas analyzer comprising a chamber adapted to receive gas from the furnace, means for causing rise and fall of liquid therein, a float carried on said liquid, an electric contact carried by said float so as to move opposite said first-named contacts and autoniatic means for periodically holding said movable contact out of the range of said first named contacts, substantially as described.

21. A furnace, a draft regulator, electromagnetic controlling mechanism for the regulator, a series of electric contacts in circuit with said controlling mechanism, an electro-magnetic device for controlling movement thereof, a displacing chamber adapted to receive gas from the furnace, floats therein, a circuit controller on said floats in circuit with said electro-magnetic device and automatic means for periodically preventing operation of said circuit controller, substantially as described.

22. A furnace, a draft regulator, electromagnetic controlling mechanism for the regulator, a displacing chamber adapted to receive gas from the furnace, means for causing rise and fall of liquid in said chamber, a valve controlling communication therewith, a float in said chamber, a circuit controller for said controlling mechanism controlled by said float, and means operatively connected with said valve for periodically preventing movement of said float, substantially as described.

23. A furnace, a draft regulator, electromagnetic controlling mechanism for the regulator, a displacing chamber adapted to receive gas from the furnace, means for causing rise and fall of liquid in said chamber, a valve controlling communication therewith, a float in said chamber, a rod on said float projecting from said chamber, a circuit controller for said controlling mechanism operated by said rod, a latch for engaging with said rod and means for operating said latch operatively connected with said valve, substantially as described.

24. A furnace, a draft regulator, electromagnetic controlling mechanism for the regulator, a displacing chamber adapted to receive gas from the furnace, means for causing rise and fall of liquid in said chamber, a valve controlling communication therewith, a float in said chamber, a circuit controller for said controlling mechanism controlled by said float, a latch for holding said float and a cam on said valve for operating said latch, substantially as described.

25. A furnace, a draft regulator, motive means therefor, a main circuit closer governing said means and an electro-magnet for holding the circuit open at said circuit closer; in combination with a CO_2 analyzer adapted to receive gas from the furnace and comprising a chamber, means for causing rise and fall of liquid within said chamber, two floats carried by said liquid and carrying electric terminals in the circuit of said magnet and normally in contact, whereby when said floats move in unison the main circuit closer is inactive, but is operated when said floats have independ-

ent movement, said analyzer also comprising means for causing a gas-displacing liquid to lift said floats intermittently, substantially as described.

26. A furnace, a draft regulator, motive means therefor and a main circuit controller governing said means; in combination with a CO_2 analyzer adapted to receive gas from the furnace and comprising a displacement chamber, means for causing rise and fall of liquid therein, two floats in said chamber and a mechanical connection between one of said floats and said circuit controller for operating the latter, substantially as described.

27. A furnace, a draft regulator and motive mechanism therefor; in combination with means for storing gas from said furnace and absorbing CO_2 therefrom, a displacement chamber for producing movement of said gas, a float within said chamber, means for causing rise and fall of liquid in said chamber and means controlled by movement of said float for governing the operation of said draft regulator by said motive mechanism, substantially as described.

H. J. WESTOVER.

Witnesses:
H. S. MacKaye,
M. Steven.