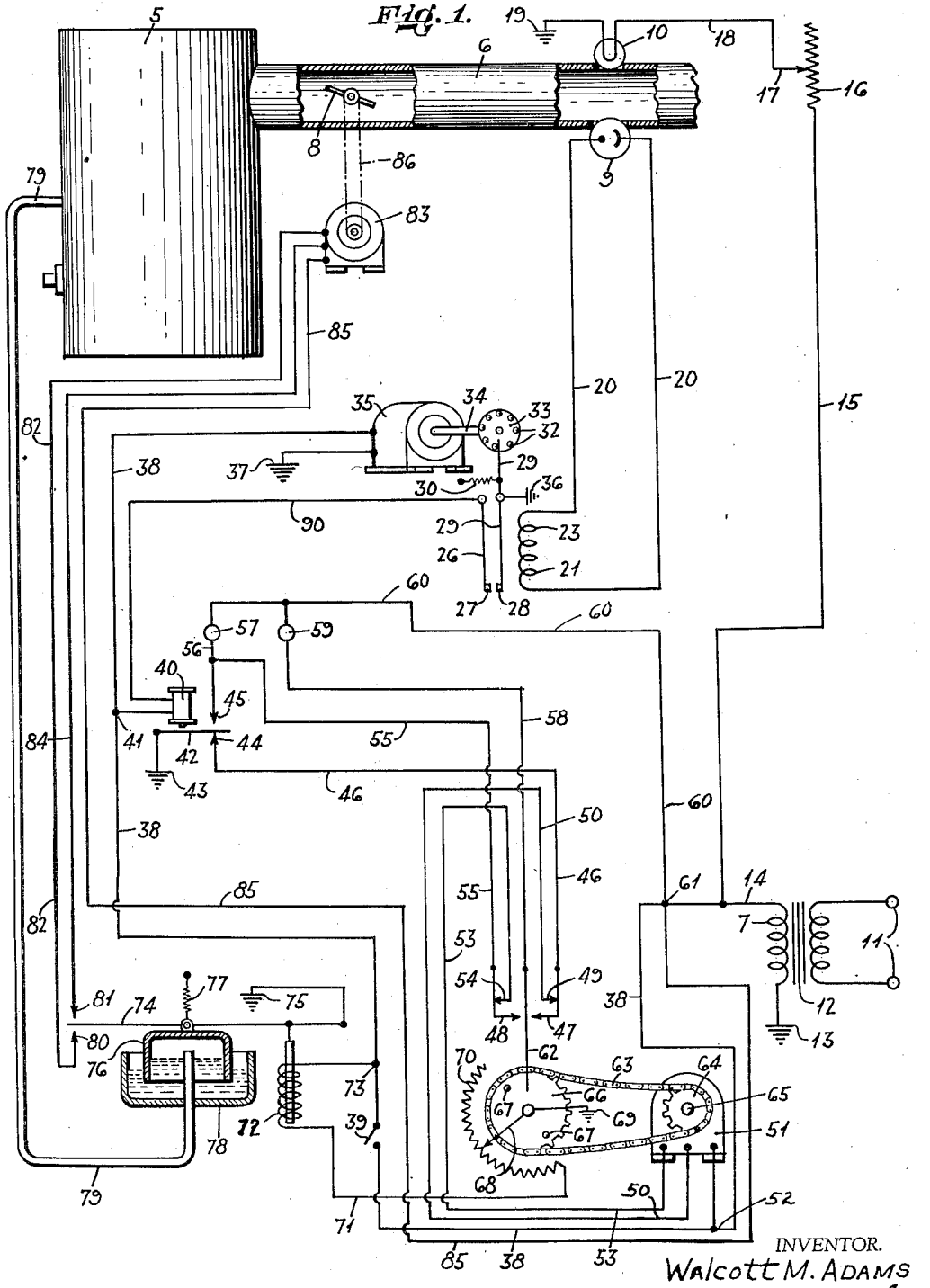
March 10, 1942. W. M. ADAMS 2,275,833

BOILER DRAFT CONTROL

Filed Aug. 7, 1939 2 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

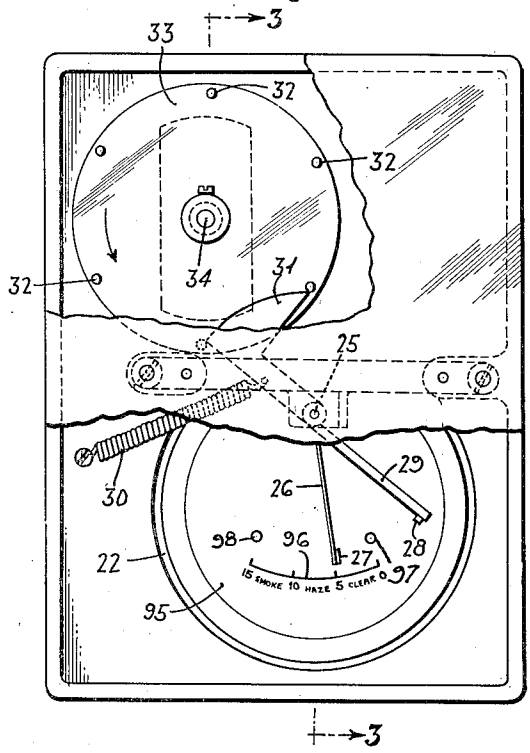


Fig. 3.

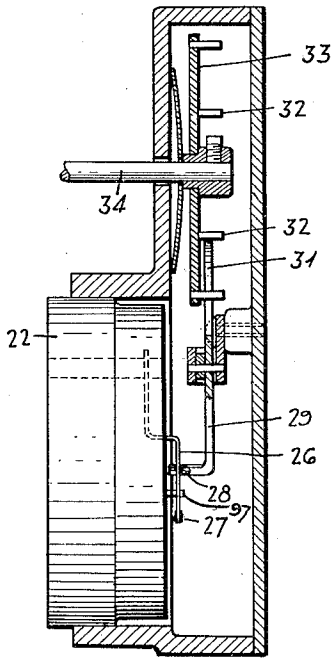
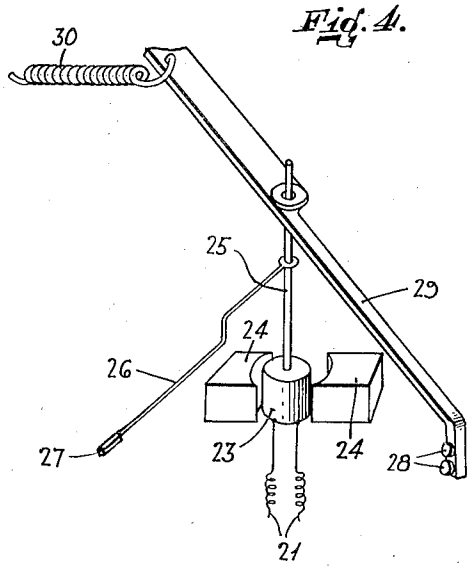


Fig. 4.



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2,275,833

BOILER DRAFT CONTROL

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Application August 7, 1939, Serial No. 288,819

10 Claims. (Cl. 236—15)

This invention relates to a boiler or furnace draft control and refers, more particularly, to a device utilizing a light sensitive cell for the purpose of automatically controlling the boiler or furnace draft and thereby the secondary air admitted to the boiler or furnace in a proportion to the combusted fuel to maintain accurately a predetermined constant light density of the flue gases in the breeching of the boiler independently of any changes in stack draft or firing rate.

If a quantity of air exceeding the amount required to support complete combustion of the fuel is passed through the boiler, a certain amount of heat is wasted in raising the temperature of the excess air from the boiler-room temperature to stack gas temperature. Furthermore, since the cross-sectional areas of the boiler flues are constant, excessive amounts of air will often increase the speed of flow of the hot gases through the boiler, with the result that the rate of transfer of heat is lowered, thus reducing the efficiency of the boiler and increasing the stack temperature.

If, however, the amount of air flowing through the boiler is insufficient to cause complete combustion, a certain amount of fuel remains unburned and objectionable smoke is produced.

The present invention is based in part on the discovery that when the quantity of air admitted to the boiler is sufficient to produce complete combustion free from objectionable smoke and excess air, so that maximum efficiency of the boiler is secured, there will be visible in the breeching of the boiler a very slight haze or smoke, and that the density of this smoke or haze may be utilized for the purpose of automatically regulating the amount of air supplied to the furnace by controlling the amount of furnace draft.

An object of the present invention is the provision of an automatic draft control wherein various adjustments are automatically made by the control itself in such a way as to maintain in the flue or the breeching of the boiler a light haze condition regardless of changes in firing rate or chimney draft condition by maintaining the flue gases at a fixed predetermined light density which produces the greatest possible boiler efficiency.

A further object is the provision of a draft control system which will prevent losses in the boiler and save fuel by giving warning by means of a red light or bell in the event circumstances beyond the range of this control to correct are causing either an excess of air or an excess of smoke.

Other objects will become apparent in the course of the following specification.

The objects of the present invention may be realized through the provision of a light sensitive device such as a photo-electric or selenium cell which may be mounted on one side of the breeching and which cooperates with a source of light mounted on the other side; as the smoke or haze increases or diminishes from a predetermined set value or density, the cell receiving more or less light causes a change in its electrical current which through the intermediary of various electrical devices causes the operation of a reversible motor attached to the breeching damper to increase or decrease the draft to an extent which is just sufficient to restore the original condition of light density.

The devices by means of which the current of the photo-electric cell causes an operation of the reversible damper motor may include a pair of contacts one of which is moved through a predetermined arc at regular intervals, while the other contact is positioned within the same arc by the amounts of the cell currents, so that the contacts remain in engagement with each other an amount of time which depends upon the density of the flue gases. The two contacts control the circuit of a relay and the energization and deenergization of that relay causes a reversal in the direction of movement of a motor connected with a movable contact engaging a resistance.

This resistance is included in the circuit of a solenoid which is attached to the contact lever of an inverted bell type static pressure regulator, the contacts of which control the circuit of the reversible damper motor and cause this motor to adjust the position of the damper in the flue. A variation in the time of closing and opening of the two contacts will result in a change in the operative value of said resistance, with the result that the forces exerted by said solenoid upon said lever will be changed, and the said lever is allowed to close the damper motor circuit.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings showing by way of example a preferred embodiment of the inventive idea.

In the drawings:

Figure 1 is a diagram illustrating a draft con-

trol device constructed in accordance with the principles of the present invention;

Figure 2 shows the two contacts in front view, with some parts broken off;

Figure 3 is a section along the lines 3—3 of Figure 2; and

Figure 4 is a diagram illustrating in a perspective view the operation of the two contacts.

The draft control illustrated in the drawings is used in conjunction with a boiler 5 (Figure 1) having a flue 6 and a flue damper 8 rotatably mounted within the flue 6.

The draft control comprises a photo-electric cell 9 situated within an opening provided in the flue 6, while an exciter lamp 10 is mounted within another opening of the flue, the two openings being diametrically opposed to each other, so that the light emitted by the lamp 10 reaches the cell 9 after passing across a portion of the flue.

The electrical energy is supplied by an alternating-current source having terminals 11 which are connected to the primary side of a transformer 12. The secondary coil 7 of the transformer 12 is grounded at 13, while its other terminal is connected with a wire 14, which is connected with a wire 15 leading to a variable rheostat 16. The movable contact 17 of the rheostat 16 is connected by a wire 18 to the lamp 10, while the other terminal of the lamp 10 is grounded at 19. Thus the lamp 10 is supplied with electrical energy by the transformer 12.

Wire 20 connects the photo-electric cell 9 with the coil 21 situated in a casing 22 shown in Figure 3.

As shown in Figure 4, the coil 21 includes an armature 23 which is situated between a pair of magnets 24. The armature 23 is rotatable along with a rod 25 which is firmly connected with a meter needle 26 carrying a contact 27.

Magnetic contacts 28 are carried by one end of a contact arm 29 which is maintained in place by a spring 30.

As shown in Figure 2, that end of the contact arm 29 which adjacent the spring 30 is integral with a cam 31. The contact arm 29 and the needle 26 are movable in front of a face 95 which may be provided with indicia 96 on a scale and stops 97 and 98 at opposite ends of said scale.

The cam 31 is actuated by a plurality of pins 32 carried by and rotatable with a disc 33 which is firmly mounted upon a shaft 34 driven by a synchronous motor 35 illustrated diagrammatically in Figure 1. The contact 29 is grounded at 36.

One of the terminals of the motor 35 is grounded at 37, while the other terminal is connected with a wire 38 which is connected to the wire 14 of the transformer 12 and which includes a normally closed switch 39. Thus the motor 35 is supplied with electrical current by the transformer 12.

The contact needle 26 is connected to one end of a relay 40 by the wire 90. The other end of the relay 40 is connected at 41 to the wire 38. Therefore, when the two contacts 27 and 28 are in engagement with each other, the relay 40 is supplied with electrical current by the transformer 12.

The relay 40, when energized, actuates a switch 42 which is grounded at 43. The switch is movable between two contacts 44 and 45. As shown in Figure 1, the switch 42 is in engagement with the contact 44 when the relay 40 is deenergized. When the switch 42 is attracted by the relay 40, it engages the contact 45.

The contact 44 is connected by a wire 46 to a contact 47 of a limit switch. Another movable contact 48 is situated opposite the contact 47 and is separated therefrom by a swingable lever 62. The limit switch also includes a contact 49 which is normally in engagement with the movable contact 47 and which is connected to one end of a wire 50. A contact 54 is usually in engagement with the contact 48.

The wire 50 leads to a reversible motor 51. The second terminal of the motor 51 is connected at 52 to the wire 38 leading to the wire 14 and the transformer 12.

In order to provide for a reversal of the direction of the motor 51, the latter is provided with a terminal which is connected by wire 53 to the contact 54.

One end of a wire 55 is connected to the contact 48. The opposite end of the wire 55 is connected to a wire 56, one end of which is connected to a preferably green signal lamp 57 while its opposite end is connected to the contact 45.

Another wire 58 includes a red signal lamp 59 and is connected with the lever 62. A warning bell may, of course, be substituted for the lamp 59. A wire 60 which is connected to one terminal of the green lamp 57 and one terminal of the red lamp 59 is connected at 61 to the wire 14 leading to the transformer 12.

In the illustrated position the circuit of the motor 51 is connected with the transformer 12 by the wire 14, the wire 38, the connecting point 52, the motor itself, the wire 50, the contact 49, the contact 47, the wire 46, the contact 44, the switch 42 and the ground 43.

The motor 51 is used to operate an endless chain 63 having a slight amount of slack therein passing over a gear wheel 64 which is mounted on the motor shaft 65. The endless chain 63 also passes over a gear wheel 66 carrying pins 67 adapted to engage an end of the lever 62.

The gear wheel 66 is rotatable along with an indicator or contact 68 which is grounded at 69 and which is movable over a resistance 70.

The resistance 70 is connected by a wire 71 with the coil of a solenoid 72, the opposite end of which is attached at 73 to the wire 38.

The movable armature of the solenoid 72 is connected with a lever 74 one end of which is grounded at 75. The lever 74 is also connected with an inverted bell 76 which is maintained in its position by a spring 77. The bell 76 is movable within a container 78 and both the bell 76 and the container 78 are adapted to be partly filled with a liquid. A draft tube 79 connects the boiler 5 with the interior of the bell 76, so that a certain negative pressure is maintained within the bell 76.

The lever 74 is movable between two contacts 80 and 81. The contact 80 is connected by a wire 82 with a reversible damper motor 83. The contact 81 is connected by a wire 84 with the same motor. Thus the lever 74 and the contacts 80 and 81 constitute a two-way switch.

The third terminal of the motor 83 is connected by a wire 85 with the wire 14 at the connecting point 61. Thus when the lever 74, which is grounded at 75, is in engagement with either one of the contacts 80 and 81, the motor 83 is supplied with electrical energy by the transformer 12.

The motor 83 is equipped with an internal limit switch, not shown in the drawings, to restrict the

movement of the damper 8 to a 90° rotation. The motor 83 is connected to the damper 8 by an endless drive 86, which is indicated diagrammatically in Figure 1, so that a turning of the motor shaft of the motor 83 will cause an adjustment in the position of the damper 8 within the flue 6.

The device is operated as follows:

When the switch 39 is on, the synchronous motor 35 is supplied with electrical current from the secondary coil 7 of the transformer 12, since the wire 38 connects one terminal of the motor 35 with one terminal of the secondary side of the transformer 12, while the other terminals of the motor 35 and of the transformer 12 are grounded at 37 and 13 respectively.

Therefore, in the course of the operation of the device, the motor 35 will continue to rotate and will rotate the shaft 34, the disc 33, and the pins 32 carried by that disc.

Each of the pins 32 will engage at predetermined intervals the cam portion 31 (Figure 2) of the contact arm 29 and will turn the contact arm 29 around the rod 25, moving it over the face of the scale 95 in the direction toward the needle 26. The spring 30 will oppose this movement. The two contacts 27 and 28 will be brought into engagement with each other and will remain in engagement until the pin 32 disengages cam 31 and the spring 30 returns arm 29 back to its original position, whereupon the engagement of contacts 27 and 28 will be interrupted when the needle 26 engages the stop 97, the needle 26 assuming its position as governed by the amount of cell current flowing through the armature 23.

It is thus evident that with little cell current the needle 26 will be at the smoke side of the scale 95 and the period during which contacts 27 and 28 are disengaged will be very great in proportion to the period in which they are in engagement, while with maximum cell current the needle 26 will be at the clear side of scale 95 and the opposite condition will exist. Thus with the normal cell current as produced by the correct haze condition the needle 26 will be at half scale and the period of engagement of the contacts 27 and 28 will be exactly equal to the period of disengagement.

This operation is repeated every few seconds as each pin 32 is moved into engagement with the cam portion 31 of the contact arm 29.

The needle 26 carrying the contact 27 is connected by the wire 90 to the relay 40 which is attached at 41 to the wire 38 leading to the secondary coil 7 of the transformer 12. Thus when the two contacts 27 and 28 are in engagement with each other, their circuit is connected to the transformer 12, with the result that the relay 40 is energized.

In the position shown in Figure 1, the switch 42, which is grounded at 43, is in engagement with the contact 44 connected by the wire 46 to the contacts 47 and 49 of the limit switch, the contact 49 being connected by the wire 50 to one of the terminals of the motor 51. The second terminal of the motor 51 is connected at 52 to the wire 38 leading to the secondary coil 7 of the transformer 12. Thus in the position shown in Figure 1, the motor 51 is actuated and turns its shaft 65 and the gear wheel 64 carried thereby in a predetermined direction.

When, however, the two contacts 27 and 28 are in engagement with each other and an electrical current flows through the relay 40, this relay will attract the switch lever 42 which will move toward the relay and engage the contact 45. Then the wire 53 connected to the motor 51 will be included in the circuit, since this wire is connected by the contacts 54 and 48 with the wires 55 and 56 connected to the contact 45; the wire 60 will connect the contact 45 with the transformer 12. The green signal lamp 57 will be lighted and the motor 51 will rotate in a direction opposite to that in which it was rotated at the time the switch 42 was in engagement with the contact 44.

When the cell current is such as to maintain the needle 26 at half scale position, the period of time during which the switch lever 42 is in engagement with the contact 44 is substantially equal to the period of time during which the switch lever 42 is in engagement with the contact 45. Therefore, the motor 51 will run in opposite directions for the same length of time and will fluctuate a very slight distance either side of a given point, the distance of fluctuation either side of the given point being equal and just sufficient to take up the lost motion in the chain, so that there is no substantial movement of the contact 68. If, however, a change in the smoke density deflects the needle 26 either side of the half scale position, the motor 51 will run longer in one direction than in the other, the difference or net amount of movement of the contact 68 being proportional to the amount of deflection of the needle 26. Thus it is evident that in any given time the contact 68 will move a distance on resistance 70 in proportion to the deflection of needle 26 which, in turn, is responsive to the changes in flue gas density.

The arrangement used to limit the movement of the motor 51 and of the contact 68 includes pins 67 carried by the gear wheel 66 and adapted to engage the swinging lever 62 which is a conductor and which is connected by the wire 58 with the wire 60 leading to the transformer 12.

When one of the pins 67 engages the lever 62, it will move, for instance, toward the contact 47 and engage this contact. In the course of further movement, the lever 62 will interrupt the engagement between the contacts 47 and 49.

If it be assumed that at that time the switch 42 is in engagement with the contact 44, then this movement of the lever 62 caused by a pin 67 will interrupt the connection between the wires 46 and 50 and will establish an electrical connection between the wire 46, the contact 47, the lever 62, the wire 58, and the wire 60. Then the electrical current will flow from the wire 14 through the wire 60, the red signal lamp 59, the wire 58, the lever 62, the contact 47, the wire 46, the contact 44, and the lever 42 to the ground 43, while, as already stated, the other terminal of the transformer is grounded at 13. Thus the motor 51 will be cut off from the supply of the electrical current and will stop while the red signal light will remain on.

If it be assumed that the switch lever 42 is in engagement with the contact 45 and that the gear wheel 66 is rotated by the motor 51 in the opposite direction, then the engagement of a pin 67 with the lever 62 will cause this lever to move into engagement with the contact 48 and to move the contact 48 out of engagement with the contact 54, thus stopping the rotation of the motor 51.

The winding of the solenoid 72 is connected with the transformer 12 through the wire 14,

the connection point 61, the wire 38, and the connection point 73 as well as through the wire 71, the resistance 70, the movable contact 68, and the ground 69. The solenoid will therefore exert a force of attraction upon the lever 74 in a direction opposed to that of the spring 77. While the contact 68 remains substantially stationary, the energization of the solenoid 72 and the force exerted on lever 74 will remain substantially the same. However, movement of contact 68 in either direction on resistance 70 will change the force exerted on lever 74 by an amount proportionate to the change in position of contact 68.

The bell 76, attached to lever 74, is connected to the interior of furnace 5 by a draft sampling tube 79, so that any variation of furnace pressure or draft will be reflected in a change in pressure on bell 76 and also on lever 74 attached thereto. This change in pressure on bell 76 and lever 74 will engage either contact 80 or 81 and will operate damper motor 83 and damper 8 to adjust damper 8 to change the draft or pressure sufficiently to restore the position of balance of lever 74. Assuming that the force exerted on lever 74 by spring 77 is a constant or fixed amount, it is evident that the combined forces exerted in the opposite direction by the bell 76 and the solenoid 72 must equal the force exerted by spring 77 in order to balance lever 74 between contacts 80 and 81 and that a change in the force exerted by solenoid 72 will cause either contact 80 or 81 to energize and operate damper motor 83 and damper 8 until the force of the draft on bell 76 has changed by an amount equal to but in opposite direction to the initial change in force of solenoid 72 at which point balance of arm 74 between contacts 80 and 81 will be restored.

In the illustrated neutral position, the reversible damper motor 83 is disconnected, since the lever 74 is out of engagement with either the contact 80 or the contact 81.

Let it be assumed now that excessive smoke enters the flue 6. The light rays of the lamp 10 which pass across the flue 6 and reach the photoelectric cell 9 will be dimmed by the smoke with the result that the cell 9 will generate less electricity. Then a smaller electrical current will flow through the wires 20, the coil 21 and the armature 23 (Fig. 4) connected to the coil 21. This change in the electric current flowing through the armature 23 situated in the field of the magnet 24 will produce a turning moment causing the armature 23, the rod 25 and the needle 26 carried thereby to swing in a direction away from the contact 28 carried by the arm 29 by an amount proportionate to the amount of smoke. Thus the distance between the contacts 27 and 28 will be increased.

Now when a pin 32 (Figure 2) engages the cam portion 31 of the contact arm 29 and swings the arm 29, the contact 28 will be moved a greater distance before it is brought into engagement with the contact 27 and, therefore, the period of time during which the two contacts 27 and 28 are in engagement with each other will become shorter than heretofore and also shorter than the time during which they are out of engagement.

Since the relay 40 (Figure 1) is energized solely while the contacts 27 and 28 are in engagement with each other, the period of time during which the relay 40 is energized will also become shorter. Since the relay 40 causes a movement of the lever 42 from the contact 44 to the contact 45, the period during which the lever 42 will be in engagement with the contact 45 will be correspondingly shorter than the period during which the lever 42 is in engagement with the contact 44.

As already stated, the motor 51 turns in one direction while the lever 42 is in engagement with the contact 44, and it turns in the opposite direction while the lever 42 is in engagement with the contact 45. Therefore, due to the fact that the lever 42 now remains a longer period of time in engagement with the contact 44 than with the contact 45, the motor 51 will turn a longer time in one direction than in the opposite direction.

Since the motor 51 operates the movable contact 68 through the medium of the gears 64 and 66 and the chain drive 63, contact 68 will move a distance toward, for instance, the open end of the resistance 70, so that the operative length of the resistance 70 will be increased.

Due to the increase of the resistance 70, the electrical current flowing through the solenoid 72 will be diminished; therefore, the pull exerted by the solenoid 72 upon the lever 74 will be lessened. The balance of forces between the solenoid 72 and the spring 77 will be disturbed and the spring 77 will pull the bell 76 towards it, thereby causing the lever 74 to engage the contact 81. Then the motor 83 will be included in the electrical circuit, since one terminal of the motor 83 is connected by the wire 85 to the wire 14, and since the other terminal of the motor 83 will be connected by the wire 84 and the contact 81 to the lever 74 and the ground 75. The motor 83 will be actuated and, by means of the drive 86 will turn the damper 8 allowing more draft through the flue 6.

The increase in draft in flue 6 will be transmitted by tube 79 and will be reflected in an increase in the pull of bell 76 on arm 74. When this increase in pull on bell 76 equals the decrease in the pull exerted by solenoid 72 caused by the movement of contact 68, the contact 81 will be broken. This operation will be repeated until the increased draft is sufficient to reduce the smoke in flue 6 to a point where the needle 26 comes to rest at half scale position.

Obviously, the operation of the device will be reversed when not enough smoke passes through the flue 6.

It is apparent that the specific illustration shown above has been given by way of illustration and not by way of limitation, and that the structures above described are subject to wide variation and modification without departing from the scope or intent of the invention, all of which variations and modifications are to be included within the scope of the present invention.

What is claimed is:

1. A boiler draft control, comprising a light-sensitive cell responsive to the density of smoke in a boiler flue, means regulating the amount of boiler draft, electrical means connected with the first-mentioned means for actuating the same; a pair of contacts, means connected with at least one of said contacts for causing said contacts to remain in and out of engagement with each other for substantially uniform time periods, said uniform time periods occurring, when the smoke density is at the desired value, means operatively connecting the contacts with said electrical means and causing said electrical means to remain inoperative only while said contacts re-

main in and out of engagement with each other for substantially uniform time periods, and means operatively connecting said photo-electric cell with at least one of said contacts, said contacts to remain in and out of engagement with each other for substantially non-uniform time periods when there is a change in the density of said smoke.

2. A boiler draft control comprising in combination with a source of electrical energy; a circuit connected to said source and including a source of light rays passing through the boiler flue; a second circuit connected to said source and including means regulating the amount of boiler draft and a switch; a third circuit connected to said source and including two contacts and a relay; means connected to said source and the third circuit for causing said contacts to engage each other and to remain out of contact with each other for predetermined uniform time intervals; a fourth circuit including a light-sensitive cell receiving said light rays, whereby the current in the fourth circuit is varied depending upon the density of smoke in the boiler draft, and means varying the relative distance between the two contacts when said current is varied, whereby the time intervals during which said contacts are engaged and the time intervals during which said relay is energized are made non-uniform; a fifth circuit connected to said source and to the third circuit and including a reversible motor and switch actuated by said relay to reverse the direction of rotation of said reversible motor when said relay is energized or de-energized; a sixth circuit connected to said source and to the third circuit and including a resistance, a movable contact contacting said resistance and electro-magnetic means for actuating the first-mentioned switch; and means connecting the movable contact with the reversible motor to vary the operative value of said resistance when the time intervals between which the reversals of the direction of rotation of said reversible motor take place are non-uniform.

3. A boiler draft control, comprising a light-sensitive cell responsive to the density of smoke in the boiler flue, means regulating the amount of the boiler draft, electrical means connected with the first-mentioned means for actuating the same; a pair of contacts, resilient means connected with one of said contacts to maintain it at a predetermined distance from the other contact, means intermittently engaging the first-mentioned contact, for predetermined time intervals to move it into engagement with the other contact, whereby the two contacts remain in and out of engagement with each other for uniform time intervals, means operatively connecting the two contacts with said electrical means and causing said electrical means to remain inoperative only while said contacts remain in and out of engagement with each other for substantially uniform time intervals, and means operatively connecting said light-sensitive cell with the other contact to cause it to change its distance from the first-mentioned contact when there is a change in the density of said smoke, whereby the contacts are caused to remain in and out of engagement with each other for substantially non-uniform time intervals.

4. A boiler draft control, comprising a light-sensitive electric cell responsive to the density of smoke in the boiler flue, means regulating the amount of the boiler draft, electrical means connected with the first-mentioned means for actuating the same, a contact arm, a contact carried by said arm, a needle, another contact carried by said needle, resilient means connected with said contact arm to maintain the contact carried thereby at a predetermined distance from the other contact, a cam portion operatively connected with the contact arm, a plurality of pins, means connected with said pins to cause them to engage consecutively said cam portion and to swing intermittently said contact arm to move the contact carried thereby into engagement with the other contact, whereby the two contacts remain in and out of engagement with each other for substantially uniform time periods, means operatively connecting the two contacts with said electrical means and causing said electrical means to remain inoperative only while said contacts remain in and out of engagement with each other for substantially uniform time periods, and electromagnetic means operatively connecting said light-sensitive cell with said needle to actuate the needle and cause the contact carried by the needle to change its distance from the contact carried by the contact arm when there is a change in the current generated by said light-sensitive cell resulting from a change in the density of said smoke, whereby the contacts are caused to remain in and out of engagement with each other for substantially non-uniform time intervals.

5. A boiler draft control, comprising a light-sensitive cell responsive to the density of smoke in the boiler flue, means regulating the amount of the boiler draft, electrical means connected with the first mentioned means for actuating the same and including a switch; electro-magnetic means exerting a magnetic force upon said switch to maintain it normally in an off position and including a resistance and a movable contact contacting said resistance; oscillating means connected with said contact for maintaining it substantially immovable in relation to said resistance only when these oscillations are substantially uniform, a relay, means connected with said relay for substantially uniformly energizing and de-energizing the same, means operatively connecting said relay with the oscillating means for actuating the latter, and means co-operating with the relay-energizing and de-energizing means and connected with said light-sensitive cell for causing the energization and de-energization of the relay to become non-uniform to vary said resistance and thereby vary said magnetic force depending upon the change in density of said smoke.

6. A boiler draft control, comprising a light-sensitive cell responsive to the density of smoke in the boiler flue, means regulating the amount of the boiler draft, electrical means connected with said first-mentioned means for actuating the same and including a switch; electro-magnetic means exerting a magnetic force upon said switch to maintain it normally in an off position and including a resistance and a movable contact contacting said resistance; a reversible rotary motor, means connected with said motor for causing it to reverse the direction of its rotation at uniform intervals, means connecting said motor with slack therein with the movable contact, whereby uniform reversals of the direction of rotation of said motor do not change substantially the operative value of said resistance, and means co-operating with the means which reverse the direction of rotation of the motor and connected with said photo-electric cell for causing the reversals of the direction of rotation of the motor

to become non-uniform to vary said resistance and thereby vary said magnetic force depending upon the change in density of said smoke.

7. A boiler draft control, comprising a light-sensitive cell responsive to the density of smoke in the boiler flue, means regulating the amount of the boiler draft, electrical means connected with said first-mentioned means for actuating the same and including a switch; electro-magnetic means exerting a magnetic force upon said switch to maintain it normally in an off position and including a resistance and a movable contact contacting said resistance; a reversible rotary motor, means connected with said motor for causing it to reverse the direction of its rotation at uniform intervals, means connected with said motor and constituting a limit switch for stopping the motor when a predetermined extent of movement of the motor is exceeded, means connecting the last-mentioned means with slack therein with the movable contact, whereby uniform reversals of the direction of rotation of said motor do not change substantially the operative value of said resistance, and means cooperating with the means which reverse the direction of rotation of the motor and connected with said light-sensitive cell for causing the reversals of the direction of rotation of the motor to become non-uniform to vary said resistance and thereby vary said magnetic force depending upon the change in density of said smoke.

8. A boiler draft control comprising a light-sensitive cell responsive to the density of smoke in a boiler flue, means regulating the amount of boiler draft, a pair of contacts, means connected to at least one of said contacts for moving said contact through a given distance at regular time intervals, means causing the second contact to be positioned within the same distance at a point proportional to the cell response so that the time of engagement of the two contacts is in a predetermined proportion to the position of the second contact, electrical means for actuating said boiler draft regulating means, said electrical means being controlled by said contacts to be ineffective upon said boiler draft regulating means when the time of engagement of said contacts is equal to the time of disengagement thereof and effective in a degree proportionate to the difference between the time of engagement of said contacts and the time of disengagement thereof when the same are unequal.

9. A boiler draft control comprising a light-sensitive cell responsive to the density of smoke in a boiler flue, means regulating the amount of boiler draft, a pair of contacts, means connected to at least one of said contacts for moving said contact through a given distance at regular time intervals, means causing the second contact to be positioned within the same distance at a point proportional to the cell response so that the time of engagement of the two contacts is in a predetermined proportion to the position of the second contact, means for actuating said boiler draft regulating means, said means being controlled by said contacts to be ineffective upon said boiler draft regulating means when the time of engagement of said contacts is equal to the time of disengagement thereof and effective in a degree proportionate to the difference between the time of engagement of said contacts and the time of disengagement thereof when the same are unequal.

10. A boiler draft control comprising a light-sensitive cell responsive to the density of smoke in a boiler flue, means regulating the amount of boiler draft, a pair of contacts, means connected to at least one of said contacts for moving said contact through a given distance at regular time intervals, means causing the second contact to be positioned within the same distance at a point proportional to the cell response so that the time of engagement of the two contacts is in a predetermined proportion to the position of the second contact, oscillating means for actuating said boiler draft regulating means, said oscillating means being controlled by said contacts to be ineffective upon said boiler draft regulating means when the time of engagement of said contacts is equal to the time of disengagement thereof and effective in a degree proportionate to the difference between the time of engagement of said contacts and the time of disengagement thereof when the same are unequal.

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