Oct. 4, 1949. E. BULLOCK 2,483,689

COMBUSTION CONTROL

Filed May 18, 1945 3 Sheets-Sheet 1

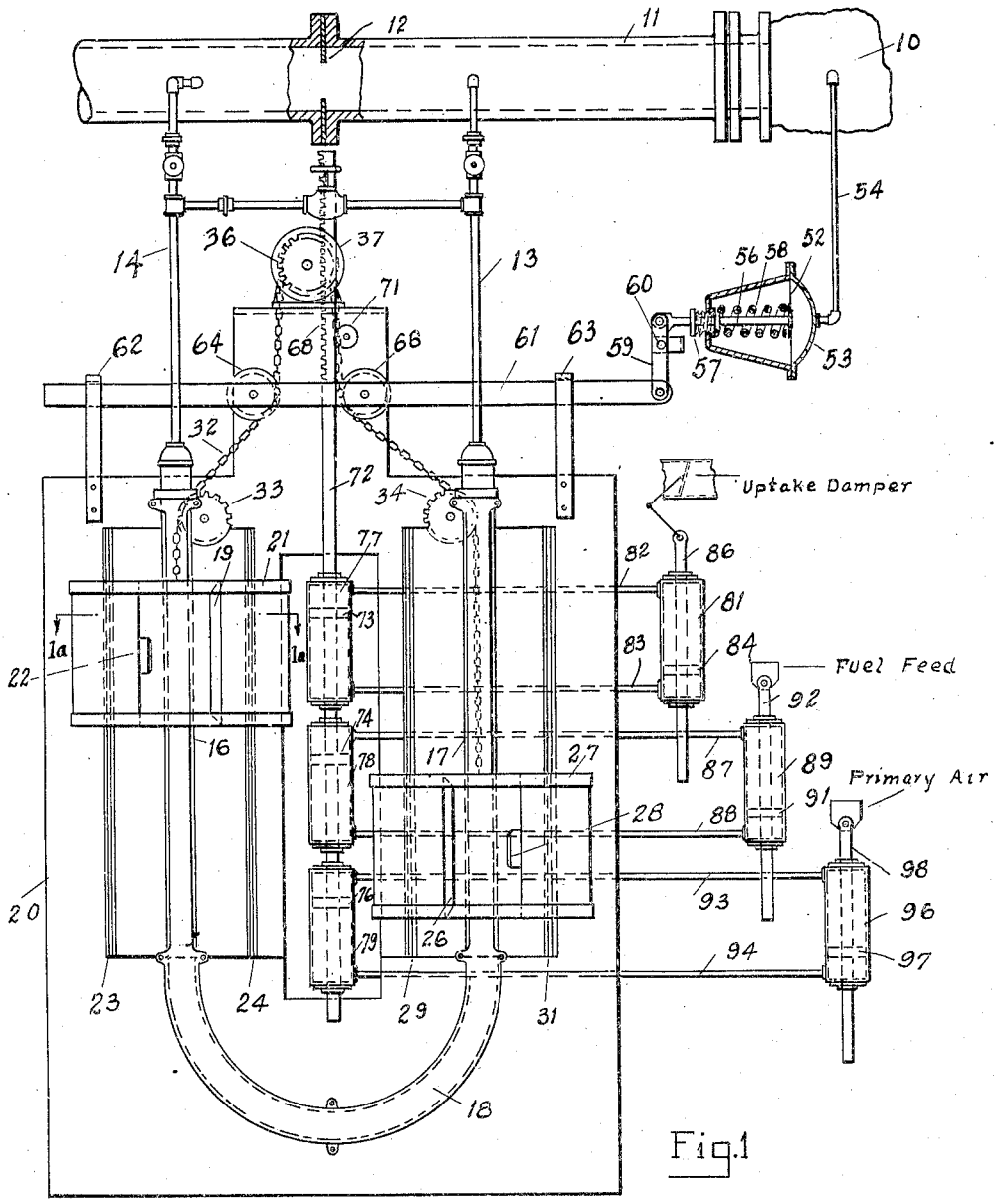

Fig. 1

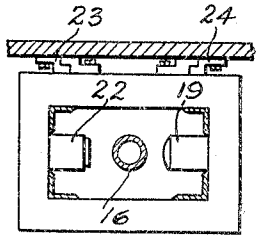

Fig. 1a

ELLIS. BULLOCK
INVENTOR.

BY Henry L. Jenning
ATTORNEY

Oct. 4, 1949. E. BULLOCK 2,483,689

COMBUSTION CONTROL

Filed May 18, 1945 3 Sheets-Sheet 2

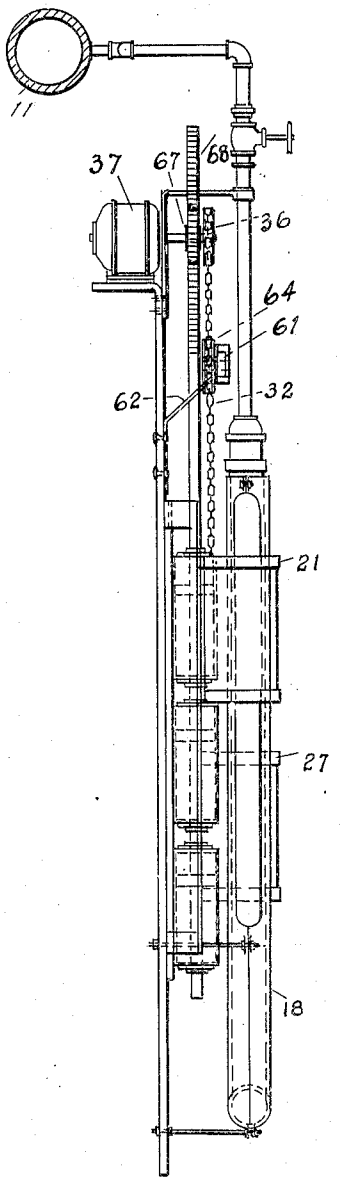

Fig 2

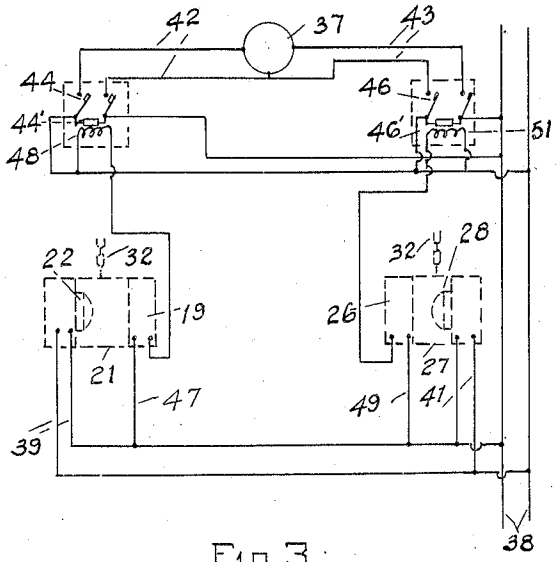

Fig 3

ELLIS BULLOCK
INVENTOR.

BY Henry L. Jennings
ATTORNEY

Oct. 4, 1949. E. BULLOCK 2,483,689

COMBUSTION CONTROL

Filed May 18, 1945 3 Sheets-Sheet 3

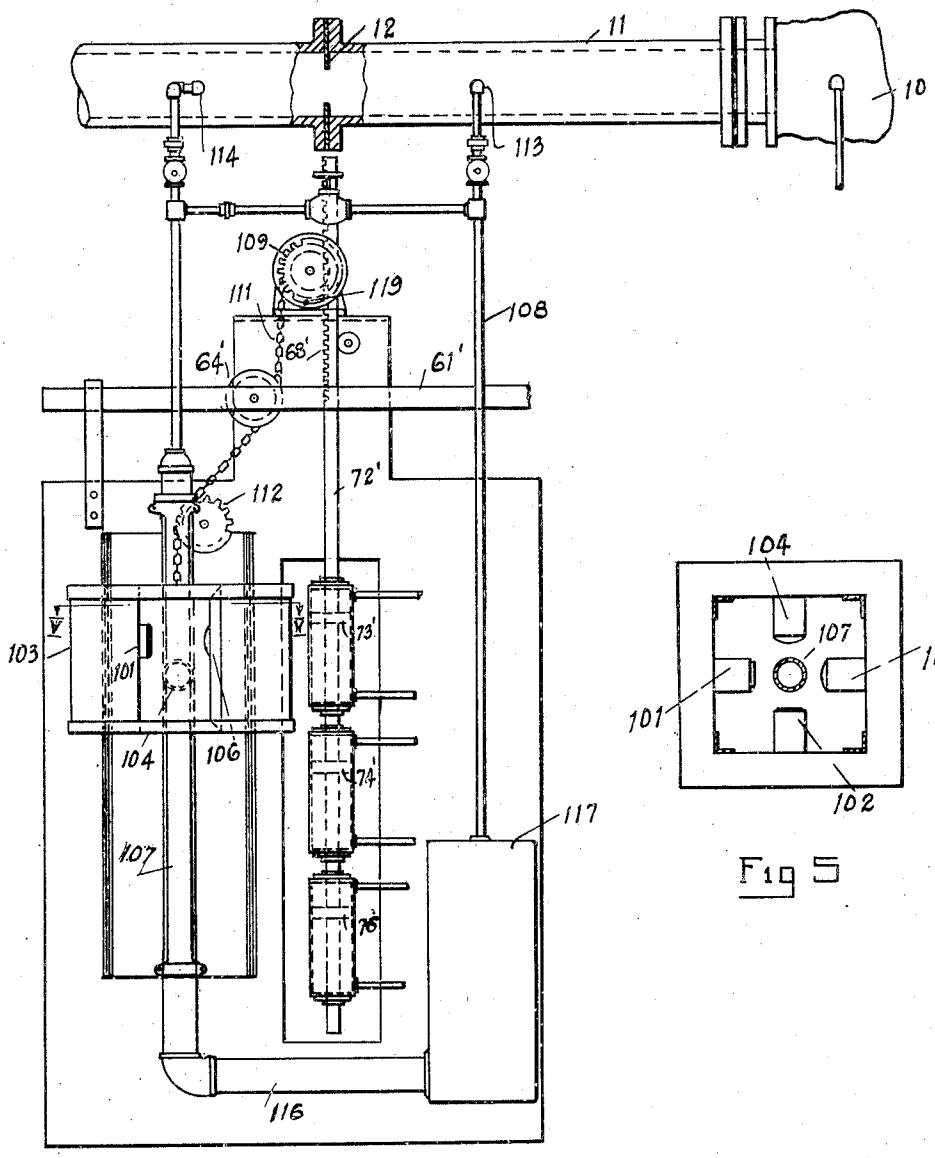

Fig 4

Fig 5

ELLIS. BULLOCK
INVENTOR.

BY Harry L. Spurrier
ATTORNEY

Patented Oct. 4, 1949

2,483,689

UNITED STATES PATENT OFFICE

2,483,689

COMBUSTION CONTROL

Ellis Bullock, Birmingham, Ala., assignor to Fly Ash Arrester Corporation, a corporation of Alabama

Application May 18, 1945, Serial No. 594,558

6 Claims. (Cl. 236—24.5)

1

This invention relates to a boiler furnace control governed jointly by the pressure in the boiler and the flow of steam being used. One object of my invention is to provide mechanism of the character described which shall be sensitive to changes in pressure and flow, and positive in its action to operate a controlling element associated with the furnace.

A further object of my invention is to provide a boiler furnace control which shall be adapted, upon a variation of the static pressure, or in the flow of steam from the boiler, or both, to exercise a controlling function over a plurality of furnace control devices.

A still further object of my invention is to provide a boiler furnace control utilizing a manometer tube in which the liquid level in the tube is a function of the flow of steam, together with photo-electric cells disposed to initiate a control movement responsive to a change of liquid level in the manometer tube which movement changes the positions of the said cells, together with means operable responsive to a change of static pressure in the boiler to further vary the relative positions of the photo-electric cells relative to the tube.

Briefly, my invention comprises a manometer tube which may be a single tube or a U tube disposed to register the flow of steam in a steam supply conduit from the boiler, in a manner well understood, by the height of mercury in the tube. I mount a pair of photo-electric cells, each with an associated movable light source, each cell and its associated light source being movable vertically alongside the tube. The photo-electric cells and their associated light sources are mounted on a frame for joint movement and are suspended from a pulley by a flexible suspension member, the pulley being driven by an electric motor controlled by the photo-electric cells responsive to the height of mercury in the tube. The positions of the photo-electric cells and their associated light sources are further modified by means of a device responsive to the static pressure in the boiler. Operatively connected to the motor are a plurality of furnace control devices which are actuated by the motor responsive to the positions assumed by the photo-electric cells. I thus provide a boiler furnace control which operates responsive to the flow of steam from the boiler, modified by the static pressure of steam in the boiler.

Apparatus embodying features of my invention is illustrated in the accompanying drawings, forming a part of this application, in which

2

Fig. 1 is an elevational view, partly diagrammatic;

Fig. 1ª is a detail section taken along line Iª—Iª of Fig. 1;

Fig. 2 is an elevational view taken at right angles to Fig. 1;

Fig. 3 is a wiring diagram showing the motor controls;

Fig. 4 is a view similar to Fig. 1 showing a modified form of my invention; and

Fig. 5 is a sectional view taken along the line V—V of Fig. 4.

Referring now to the drawings for a better understanding of my invention, I show in Fig. 1 a fragment of a boiler 10 having a steam supply line or conduit 11 leading therefrom. The steam supply conduit 11 has disposed therein an orifice 12 and connected to the upstream side of the orifice is a conduit 13, and to the downstream side a conduit 14, the conduits 13 and 14 being connected at their lower ends to glass tube sections 16 and 17 joined together at their lower ends by a shorter U connection 18, all being secured to a panel 20.

At 19 I show a photo-electric cell mounted in a frame 21 which also carries a light 22 which directs its beam through the glass section 16 of the U tube toward the cell 19. The frame 21 is adapted to move vertically in guides 23 and 24, which are mounted on the panel 20. At 26 I show a similar photo-electric cell mounted on a frame 27 which also carries a light 28 similar to the light 22 and which is directed through the glass section 17 of the U tube towards the photo-electric cell 26. The frame 27 is mounted to move vertically in guides 29 and 31, which are mounted on the panel 20 and are similar in all respects to guides 23 and 24. Both the frames 21 and 27 are suspended from a sprocket chain 32 which passes upwardly over idler sprockets 33 and 34 and thence around a driving sprocket 36 driven by a geared reversing motor 37.

In Fig. 3 I show by way of example, an electric supply circuit 38 from which circuits 39 and 41 lead to the light sources 22 and 28 respectively. The motor 37 is controlled by means of circuits 42 and 43, opened and closed respectively by magnetic switches 44 and 46. The switches 44 and 46 are operated respectively by the photo-electric cells 19 and 26, and preferably include delayed closing dashpots 44' and 46'. The switches 44 and 46 are normally open when the cells 19 and 26 are energized. Such arrangements of magnetic switches and photo-electric cells are well known in the art and are commercially available. Ac-

cordingly, no detailed description thereof is deemed necessary. A conductor 47 leads from the circuit 33 through the photo-electric cell 19 to the coil 48 of the switch 44 and thence back to the circuit 38. A conductor 49 leads from the circuit 38 through the photo-electric cell 26 to the coil 51 of the switch 46 and thence back to the circuit 38. When the mercury in the glass sections 16 and 17 of the U tube is at such level that the light beams from the light sources 22 and 28 strike their associated photo-electric cells 19 and 26, the switches 44 and 46 are both opened, as shown in Fig. 3. When the mercury rises in either glass section sufficiently to intercept the beam of light from the light source to the associated photo-electric cell, the associated switch and motor circuits are closed. This action is utilized to actuate the furnace controls as more particularly pointed out hereafter.

It will be understood that the electrical circuits herein shown and described are for the purpose of illustration only and that the details thereof form not part of my invention. Various changes may be made therein and still effect the control of the motor 37 by the photo-electric cells as herein contemplated.

At 52 I show a diaphragm mounted within a casing 53 connected to the boiler 10 by means of a conduit 54. The diaphragm 52 actuates a stem 56 connected thereto which passes outwardly through an adjusting sleeve 57. A spring 58 is disposed between the diaphragm 52 and the sleeve 57 to resist the outward movement of the diaphragm 52, and is adjusted by means of the sleeve 57. The stem is connected to a lever 59 pivoted at 60 which in turn is connected to a yoke 61, mounted in guides 62 and 63. Mounted on the yoke 61 are idler pullers 64 and 66, which bear against the two reaches of the sprocket chain 32. Upon an increase of boiler pressure, the diaphragm causes the yoke 61 to move slightly to the right, as viewed in Fig. 1, thereby slightly raising the frame 21 with its photo-electric cell 19 and lowering the frame 27 with its photo-electric cell 26. Upon a decrease of steam pressure in the boiler 10, a reverse of the movement just described occurs. The diaphragm 52 is moved toward the right by the spring 58, thereby moving the yoke 61 with its idlers 64 and 66 toward the left, thus raising the frame 27 with its photo-electric cell 26 and lowering the frame 21 with its photo-electric cell 19.

Driven by the motor 37 is a pinion 67 which meshes with a rack 68, mounted to move vertically and held in place by a roller 71. The rack 68 is connected to a rod 72, which in turn has mounted thereon pistons 73, 74, and 76 mounted, respectively, in hydraulic cylinders 77, 78, and 79. The hydraulic cylinder 77 is connected at its ends to a similar hydraulic cylinder 81 by means of conduits 82 and 83. A piston 84 in the cylinder 81 is mounted on a rod 86 extending out at the ends thereof so that any movement of the piston 73 in the cylinder 77 effects a similar, opposite movement of the piston 84 in the cylinder 81. The cylinder 78 is likewise similarly connected by means of conduits 87 and 88 to a hydraulic cylinder 89 having a piston 91 mounted therein which is mounted on a piston rod 92 extending out of the ends thereof. Thus any movement of the piston 74 in the hydraulic cylinder 78 effects a similar movement, in an opposite direction, of the piston 91 in the cylinder 89. The cylinder 79 is similarly connected by means of conduits 93 and 94 to a hydraulic cylinder 96 having a piston 97

therein mounted on a piston rod 98 which extends out through the ends thereof. Thus any movement of the piston 76 in the hydraulic cylinder 79 effects a similar movement in an opposite direction, by the piston 97 in the cylinder 96. Any suitable furnace controls may be connected to the piston rods 86, 92, and 98, such as the up-take damper, fuel feed, and primary air supply indicated in the drawing.

From the foregoing description, the operation of my improved apparatus as so far described will be readily understood. With constant steam flow and pressure, the mercury in the sections 16 and 17 of the U tube will be in such a position that the beams from the light sources 22 and 28 strike the photo-electric cells 19 and 26, and the relay switches 44 and 46 remain open. Assume now an increased flow of steam due to an increased demand, the pressure in the section 16 of the U tube decreases relative to the pressure in the section 17 so that the mercury falls in the section 17 and rises in the section 16 thus intercepting the rays of light from the light source 22 to the photo-electric cell 19. When this occurs, the switch 44 is closed thus energizing the motor 37, which begins turning clockwise to raise the frame 21 and lower the frame 27. This movement continues until the light rays from the source 22 again strike the photo-electric cell 19 whereupon the switch 44 is again opened and the motor stopped. If, during the movement just described, the boiler pressure increases, the diaphragm 52 moves toward the left with the rod 56, which causes the yoke 61 with the idlers 64 and 66 to move to the right. This raises the frame 21 and lowers the frame 27, and thus modifies the movement produced by an increased flow, just described. As the motor 37 turns clockwise, as described, the rack 68 is forced downward with the piston rod 72 and pistons 73, 74 and 76 thus effecting movement of the pistons 84, 91 and 97 and simultaneously changing the setting of the furnace control devices indicated, for example, by opening the uptake damper, and by increasing the supply of fuel and primary air.

Should there be a decrease in steam demand, thus bringing about a decrease in flow of steam, there is a relative increase in pressure in the section 16 of the U tube. This causes the level of the mercury in the section 16 to be lowered and the level in the section 17 to be raised. Raising the level of the mercury in the section 17 intercepts the light beam from the light source 28, whereupon the switch 46 is closed, closing the circuit 43 to the motor 37. This causes the motor 37 to rotate counterclockwise, raising the frame 27 with the photo-electric cell 26 and light source 28 until the beam from the light source 28 again strikes the photo-electric cell 26, whereupon the photo-electric cell 26 is again energized and the relay switch 46 is opened stopping the motor 37. As the motor 37 rotates counter-clockwise, it raises the rack 38 with the piston rod 72 and pistons 73, 74 and 76, which brings about a lowering of the pistons 84, 91, and 97 in the cylinders 81, 89 and 96, thus changing the setting of the furnace control devices to compensate for the decreased demand.

While in the foregoing description, I have set forth my invention as including a U tube type of manometer, it is equally applicable to a single tube type. In Figs. 4 and 5 of the drawing, I show a modified form of my invention in which photo-electric cells 101 and 102 are located in a frame 103

having mounted therein light sources 104 and 106, the light sources being directed across a single glass manometer tube section 107. The frame 103 in which the photo-electric cells are mounted is suspended from a pulley or sprocket 109, driven by the motor 37. A sprocket chain 111 connects the sprocket 109 to the frame 103 and passes over an idler 112.

The light source 104 and the photo-electric cell 102 are disposed in the frame 103 at a slightly lower level than the light source 106 and the photo-electric cell 101. The glass tube section 107 forms a part of a well-known form of manometer which is connected to the conduit 11 at 114 on the downstream side of the orifice 12. The glass section 107 is connected at its lower end to a horizontally extending conduit 116 leading to a vessel 117 containing mercury. The vessel 117 is connected to the conduit 108 and with the conduit 11 at connection 113. It will thus be seen that the level of the mercury in the glass section 107 rises and falls responsive to the flow of steam in the conduit 11. The control of the motor 37 is the same as previously described and as illustrated in Fig. 3 of the drawing, the photo-electric cells 101 and 102 exercising the same control as the photo-electric cells 19 and 26 in the previously described embodiment, with the exception that the photo-electric cell 102 which is normally below the level of the mercury in the glass section 107 acts to close the magnetic switch 46 when the level of the mercury falls below the light source 104. The photo-electric cell 101 acts to close the magnetic switch 44 when the level of the mercury in the glass section 107 rises above the level of the light 106. The end of the sprocket chain 111 in connected at 119 to the sprocket 109 whereby, as the motor 37 is rotated responsive to the action of the photo-electric cells 101 and 102, when the mercury level rises and falls in the glass section 107, the frame 108 is raised and lowered accordingly. A rack 68' is connected to a piston rod 72' which in turn is connected to pistons 73', 74' and 76', as described in the previous modification of my invention. The furnace controls may be connected to the pistons in the manner already described in the previous modification. Also, a yoke 61' connected to a pressure responsive device, not shown, carries an idler 64' which acts against the sprocket chain 111 to modify the action of the photo-electric cells.

From the foregoing, it will be apparent that I have devised an improved boiler furnace control which is simple of design, sturdy of construction, and one which is extremely sensitive to changes of flow, or steam demand, and to pressure in the boiler, or source of supply.

While I have shown my invention in but two forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications, without departing from the spirit thereof, and I desire, therefore, that only such limitations shall be placed thereupon as are specifically set forth in the appended claims.

What I claim is:

1. In a control for a steam boiler furnace, a steam supply conduit from the boiler, a manometer tube disposed to register the flow of steam in the conduit by the height of a liquid in the said tube, a motor, photo-electric cells together with light sources therefor for controlling the motor and mounted for up and down movement along said manometer tube by the motor responsive to the rise and fall of liquid in said tube, furnace control devices actuated by the motor, and a device having an element movable responsive to pressure in the boiler and operatively connected to the photo-electric cells to modify their positions.

2. In a control for a steam boiler furnace, a steam supply conduit from the boiler, a manometer tube disposed to register the flow of steam in the conduit by the height of a liquid in said tube, a pair of photo-electric cells together with associated light sources associated with the tube and movable up and down along said tube, said cells being so disposed that one with its associated light source is normally below the level of the liquid in the tube and the other is normally above the liquid level in the tube, a reversible motor operatively connected to the cells and controlled by the energization and de-energization of the cells to raise and lower them responsive to variations in the level of liquid in the tube, a device movable responsive to static pressure in the boiler operatively connected to the cells to modify the positions thereof, and furnace control devices actuated by the motor.

3. In a control for a steam supply conduit from the boiler, a manometer tube disposed to register the flow of steam in the conduit by the height of a liquid in said tube, a pair of photo-electric cells together with associated light sources positioned for movement along said tube and suspended from a pulley by a common flexible member, said cells being disposed whereby one with its associated light source is normally below the liquid level in the tube and the other is normally above the liquid level in the tube, a reversible motor operatively connected to the pulley and controlled by the energization and de-energization of the cells to move them up and down responsive to variations in the level of liquid in the tube, a rack actuated by the motor, a plurality of hydraulic transmission devices actuated by the rack, and a plurality of furnace control devices operatively connected to the hydraulic transmission devices.

4. In a control for a steam boiler furnace, a steam supply conduit from the boiler, a U tube disposed to register the flow of steam in the conduit by the height of a liquid in the legs of said tube, a pair of photo-electric cells together with associated light sources mounted one each opposite a leg of the U tube and suspended from a pulley by a common flexible member, each of said cells being adapted to be energized when the liquid level in the associated leg of the tube falls below the level of the cell, a relay controlled by each cell, a reversible motor operatively connected to the pulley and so connected to the relays that deenergization of the respective cells causes rotation of said motor in opposite directions to move said cells vertically responsive to variations in the level of liquid in the legs of the U tube, means movable responsive to variations in static pressure in the boiler for modifying vertically the positions of the photo-electric cells, a plurality of furnace control devices, a hydraulic cylinder and piston for operating each of said devices, a rack actuated by the motor, and a plurality of hydraulic cylinders and pistons connected to the rack and hydraulically connected each to one of the first mentioned hydraulic cylinders.

5. Apparatus as defined in claim 2 in which the photo-electric cells are suspended from a pulley actuated by the motor to rise and fall with variations in the height of liquid in the tube together with the furnace control devices actuated by the motor.

6. In a control for a steam supply conduit from the boiler, a manometer tube disposed to register the flow of steam in the conduit by the height of a liquid in said tube, a pair of photo-electric cells together with associated light sources positioned for movement along said tube and suspended from a pulley by a common flexible member, said cells and their associated light sources being disposed for one to be normally below the liquid level in the tube and the other is normally above the liquid level in the tube, a reversible motor operatively connected to the pulley and controlled by the energization of the cells to move them up and down responsive to variations in the level of liquid in the tube, a rack actuated by the motor, a plurality of hydraulic transmission devices actuated by the

rack, a plurality of furnace control devices operatively connected to the hydraulic transmission devices, and means movable responsive to variations in static pressure in the boiler for modifying vertically the positions of the photo-electric cells.

ELLIS BULLOCK.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,093,161	Wilkinson	Apr. 14, 1914
1,250,832	Fisher	Dec. 18, 1917
1,805,012	Sandison	May 12, 1931
1,976,298	Richter	Oct. 9, 1934
2,023,627	Underwood et al.	Dec. 10, 1935
2,038,385	Podbielniak	July 27, 1937
2,118,029	Boyd	May 24, 1938
2,335,163	Smith	Nov. 23, 1943