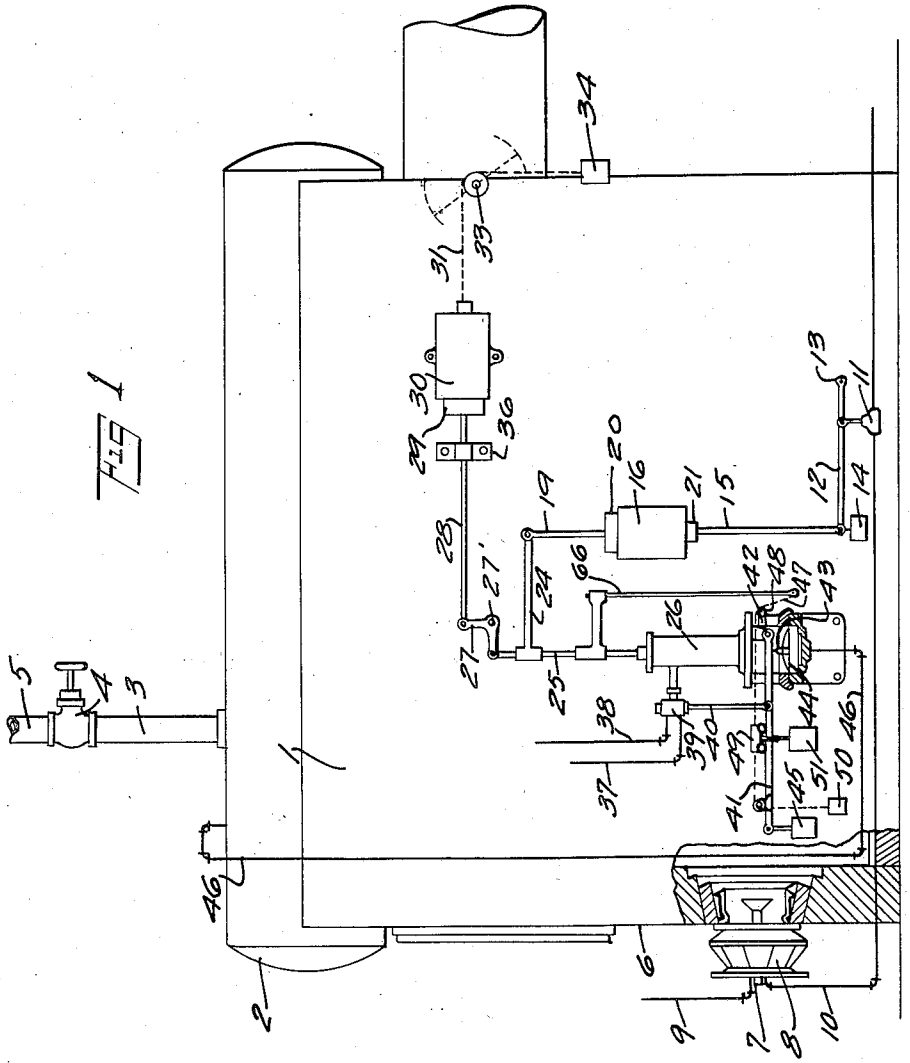
April 26, 1932. E. H. PEABODY 1,855,559

METHOD AND APPARATUS FOR THE CONTROL OF BURNING LIQUID FUEL

Filed Aug. 31, 1923 2 Sheets-Sheet 1

FIG 1



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FIG 2

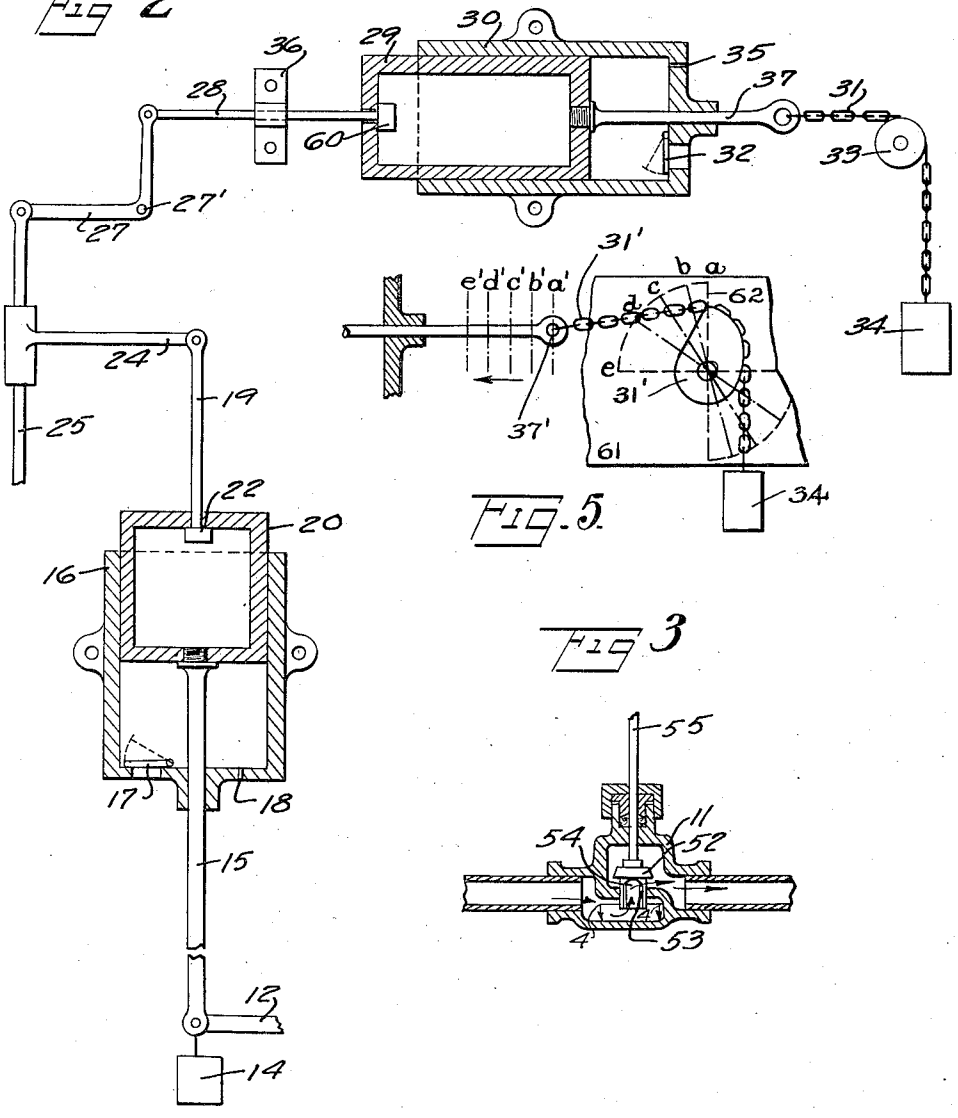


FIG. 5.

FIG 3

FIG 4



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METHOD AND APPARATUS FOR THE CONTROL OF BURNING LIQUID FUEL

Application filed August 31, 1923. Serial No. 660,324.

This invention relates to automatic regulation of fuel, and air for combustion in connection with a boiler furnace, whereby the control mechanism is actuated by the variation in the steam pressure. Two essential points are necessary in this character of regulation.

First, during steady operating conditions at various rates in capacity the air supply must be exactly proportioned to the fuel supply, the air necessary being usually slightly in excess of the exact theoretical amount necessary for complete combustion. The exact theoretical amount is desirable, but owing to imperfection in mixture, it is not possible to obtain complete combustion without providing for a slight excess of air.

Second, during any change in load conditions, which in turn requires increased or decreased fuel supply, it is necessary temporarily to provide for an increase in the supply of air over that required for regular operation. This is on account of the fact that in order to prevent smoke or imperfect combustion during the change, air must always be in excess of the amount required for the fuel. Therefore, there should be a slight increase in air supply in anticipation of an increase in fuel supply to meet the increased capacity requirements, that is, when the steam pressure is falling; and vice versa, when the fuel supply is reduced to meet a decreased capacity requirement, (that is, when the steam pressure rises) the fuel supply should first be reduced and the air supply reduced immediately thereafter. In this connection it is to be noted that the aim sought for theoretically is to reduce and increase the air supply and the oil supply simultaneously, maintaining the exact proportions at all times, but in practice this is so difficult of attainment that it is better to cause the increase in fuel to lag slightly behind the increase in air on a falling steam pressure and an increasing load, and for the decrease in air supply to lag behind the decrease in fuel supply on the decrease in the fires to suit an increased steam pressure. This is accomplished in my invention by means of introducing mechanism between the regulator and the control valves for controlling the air and the oil, whereby this desired lag is obtained both on increasing and decreasing loads. Other objects of my invention will be obvious from the following drawings.

Figure 1 is the side elevation of a boiler and furnace showing the control mechanism in elevation.

Figure 2 is an elevation of the intermediate mechanism for securing the desired lag in control, the lag mechanism being shown in section.

Figure 3 is a section through a special valve for securing delicate regulation of the fuel where said fuel is of a character which will permit of forcing it through a pipe, as in the case of oil fuel.

Figure 4 is a section through the valve shown in Figure 3 on the line 4—4.

Figure 5 shows the damper operating mechanism which might be used to secure a special movement of the damper by means of a cam 33′ in place of the ordinary sheave shown at 33, (Fig. 2.)

The steam boiler 1 is provided with a steam drum 2 with an outlet pipe 3, fitted with a valve 4 and connected with the pipe 5, through which the steam flows to the machinery in the plant. The furnace front 6 is fitted with a fuel supplying mechanism 7 and with an apparatus for admitting air 8. The fuel is delivered to the apparatus through the pipe 9 and a portion of the oil may be returned through the pipe 10, which leads back to the pump suction or storage tank (not shown). In this pipe 10 is fitted a control valve 11, operated by the lever 12, pivoted at the point 13. At the opposite end of the lever is a counter-balance weight 14 and a rod 15 is attached to the lever so that when the rod 15 moves upward, the valve 11 will be opened decreasing the amount of oil injected into the furnace through the apparatus 7. When the tension on the rod 15 is released, the counter-balance weight 14 will close the valve 11 and increase the supply of fuel injected into the furnace.

The device shown in Figure 2 comprises a lag mechanism through which valve 11 is operated. This consists of an outer cylinder

16 which is immovable and fixed to some part as the boiler casing. At the lower end of this cylinder is a valve 17 arranged to open upward and a small opening 18 through which air may pass in either direction, also a sleeve 21 fitting loosely around the rod 15 which in turn is secured to the bottom of the inner cylinder 20, which can move freely up and down inside the cylinder 16.

The rod 19 slides freely through the top of the cylinder 20, but supports the cylinder 20 by means of the nut or enlargement of the rod 19 at its lower end.

The rod 19 is firmly attached to the arm 24, which in turn is firmly attached to the piston rod 25 of the regulator 26. This rod is extended to communicate with the bell crank 27 pivoted at the point 27′ and communicating with a connecting rod 28, which at the opposite end is attached to the inner cylinder 29 of the second lag mechanism 30.

The second lag mechanism 30 is of the same construction as the first lag mechanism previously described. The rod 37 is connected to the chain 31 which passes over the sheaves 33, which is connected with a damper or other means of controlling the air supply. The counter-balance weight 34 serves to rotate the sheave 33 when the tension on the chain 31 is released. The lag mechanism is shown in the horizontal position, but may equally well be installed in any position.

The control mechanism 26 is of well known and of standard type used for the control of dampers. It consists of the cylinder 26 in which a piston (not shown in the drawings) moves back and forth under the impulse of water pressure delivered through the pipe 37 and exhausted through the pipe 38, being controlled by the pilot valve 39. The piston in the cylinder 26 is firmly attached to the rod 25, which as explained above, is attached to the arm 24 and the bell crank 27. The pilot valve 39 is controlled by a connecting rod 40 which is attached to the beam 41 of the regulator. This beam is pivoted at a point 42 and has a bearing point 43 on a diaphragm 44. The counter-balance weight 45 causes the bearing point 43 to be maintained in contact with the diaphragm 44 at all times. The steam pressure from the boiler is transmitted to the diaphragm through the pipe 46 and the counter-balance weight 45 is so adjusted that at a predetermined steam pressure the beam 41 will take a horizontal position, and the pilot valve 39 will be in a neutral position equalizing the pressure on opposite sides of the piston in the cylinder 36 and holding the rod 25 at rest. As the steam pressure rises, however, the beam 41 will be forced upward, moving the pilot valve and admitting water pressure to the lower side of the piston in the cylinder 26 and forcing up the rod 25. As this rod moves up, it carries with it the rod 66 which is attached at its lower end to a chain 47 passing over a sheave 48. This chain then passes to the carrier 49 which is free to move along the beam 41. The chain is kept taut by the action of the balance-weight 50 which serves to move the carrier outward towards the end of the beam when the tension on chain 47 is released. The carrier 49 carries in suspension a counter-balance weight 51.

It will be observed that as the beam rises under the influence of increased steam pressure, and the piston rod 25 moves up, the rod 66 will move up with it and release the tension on chain 47, so that the counter-balance weight 51 will move outward along the beam and immediately bring it into a horizontal position. This places the pilot valve in a neutral position and immediately stops the movement of the rod 25. If the steam pressure should be lowered, the action of the couner-balance 45 will cause the beam 41 to drop. This will reverse the operation by means of the pilot valve 49 and water pressure will be admitted in the top end of cylinder 26, forcing the rod 25 with the attached connection 66 downward. This in turn places a tension on chain 47 and draws the counter-balance weight 51 inward along the beam towards the fulcrum so that it again assumes a horizontal position notwithstanding the lower steam pressure. As this action is well known in the art it requires no further description.

It will be observed that changes in steam pressure through the action of this mechanism cause the rod 25 with its attachments to move upward and downward by small increments. Thus, slight adjustments are possible for slight changes in steam pressure, and a regulation is obtained much more closely in agreement with the changes in steam requirements than in those forms of control which change from one extreme to the other at each change in load.

It now remains to explain the action of this control mechanism on valve 11 and the damper 62 through the lag mechanism, (shown in Figure 2). As the steam pressure falls and the rod 25 moves downward, it forces the arm 24 and the rod 19 downward. This disengages the lower end of the rod 19 from the cylinder 20, which cylinder is then supported in the position shown by the air between the two cylinders 16 and 20. The weight 14 acting on the rod 15, which is secured to the cylinder 20, tends to pull this cylinder downward, but its movement will be slow as valve 17 is then closed and the air can escape only through the small aperture 18. The downward movement of rod 15 and cylinder 20 then continues until the part 22 on rod 19 and the upper part of cylinder 20 again come in contact, when all movement ceases. It is obvious therefore, that the weight 14, carrying with it the arm 12 will move downward very slowly as the air slowly escapes, so that the

valve 11 will be closed very slowly, there being a very decided lag in the closing of this valve after the initial movement of the regulator.

Now to consider the action of the damper for air control. As the regulator under the influence of a falling steam pressure forces down the rod 25, the bell crank 27 immediately comes into action, moving the rod 28 to the left. In this case, the damper will be opened immediately by the sheave 33, for the rod 28, by means of the part 60 draws along the inner cylinder 29 and the rod 37 attached to it, the valve 32 opening inward and allowing a free flow of air to the inside of the cylinder 30. Thus, in this case, there is no lag and no delay in opening the damper, and we have the effect that immediately upon the lowering of the steam pressure and the movement downward of the regulator rod 25, the damper is immediately opened, increasing the air supply while there is a lag in the closing of the valve 11 and an increase in the oil supply. This is the desired effect.

It will be obvious from the above explanation that the reverse action takes place when the steam pressure rises. In this case the rod 25 moves upward. There is no lag in the mechanism 16 which immediately opens the valve 11 and reduces the oil supply. In the case of the lag mechanism 30 however, the cylinder 29 moves within the cylinder 30 and the damper closes slowly under the action of the air compressed between the heads of the two cylinders. In this case, therefore, as the steam pressure rises, the oil is immediately shut off, while there is a lag in the action of the damper. This again is the desired result, being just the reverse of the action which takes place when the steam pressure falls.

In order to secure the proper delicacy in the operation of the oil control valve 11, I have devised a special form of valve shown in Figure 4. This is provided with a seat 52, which is attached to a hollow cylinder-like extension 53 and in the wall of this cylinder a suitable opening 54 can be so made as to give any desired opening of the valve 11 for a given movement of the control rod 55, which is connected to the beam 12. Should it be necessary to provide for special regulation of the damper mechanism, it is obvious that the sheave 33 can be made of any desired shape, such as ellipse, or of some cam-like formation as shown in Figure 5. By the design and adjustment, therefore, of the shape of the sheave 33 and the opening 54 in the valve 11, positive movements of the damper regulator will produce any desired control of the air and oil supply.

Referring to Figure 5, 61 represents a portion of the flue through which the waste gases pass to the chimney, which latter creates the suction which in turn draws the air into the furnace, the amount of this suction in the furnace being regulated by the position of the damper 62, shown in dotted lines for the reason that it is contained inside the flue. Various positions of this damper are indicated by the letters: *a*—*b*—*c*—*d* and *e*, *a* being the closed position, *b* slightly open, *c* not quite half open, *d* more than half open and *e* fully open.

It will be noted that the distance between *a* and *b* is less than between *b* and *c*, etc. In other words, the angular movement of the damper varies by increasing increments from *a* to *e*. On the other hand, the rod 37′ of the damper controlling mechanism moves by even increments from *a*′ to *b*′, *b*′ to *c*′, etc. The position of this rod when the damper is closed is at *a*′, and *e*′ is the position when the damper is fully open. Thus, while the controlling mechanism moves from *a*′ to *b*′, the damper itself moves from *a* to *b*, and while the control mechanism moves a similar increment from *b*′ to *c*′, the damper moves from *b* to *c* through a greater angle than before; and so on to the wide-open position.

This special movement of the damper is brought about by the fact that the chain 31′ which causes the damper shaft to rotate, passes over a surface of the cam so constructed as to present, as the shaft rotates, a different radius or leverage on which the pull of the chain acts to operate the damper. This radius or leverage is greatest in the closed position *a*, and as the damper rotates to the open position a gradually diminishing radius is presented to its action so that when in the opening position, the radius is less than at any other. The intermittent positions vary accordingly.

It will be obvious that this cam 31′ can be constructed in any desired way so as to control the movement of the damper through any desired cycle. Inasmuch as the amount of air drawn into the furnace is controlled directly by the position of the damper, it will be seen that merely by varying the shape of the cam 33′ any desired quantity of air can be provided for any desired rate of combustion of the fuel.

As described in connection with Fig. 5, the construction shows the operation of the device under "natural draft" conditions, as the use of a chimney for providing the draft presents the simplest illustration of the invention. If the air for combustion is forced into the furnace by means of a fan or fans, (usually referred to as "forced draft") or if in place of a chimney a fan is used for creating the suction, (usually referred to as "induced draft") the amount of air delivered to the furnace may be controlled by means of dampers in the air duct leading to the furnace (forced draft) or in the duct leading to the suction of the fan (induced

draft); or the air supply may be varied by the speed of the fan itself. In any case, the same cam-like construction illustrated in Fig. 5 may be employed for regulating the position of the dampers or the speed of the fan. The invention is, therefore, applicable to any method by which air is admitted to the furnace.

Pressure variation in a boiler is caused by two distinct and different factors: first, the amount of steam generated; and second, the amount of steam consumed; and upon these two variables depend the uniformity of pressure. It will be readily understood therefore that my method and apparatus can be operated by either a variation in pressure in the boiler or a variation in pressure due to steam flow. I do not wish to limit myself to air control in natural draft for either forced or natural draft may be controlled in the same way.

I wish it distinctly understood that my method and apparatus for the control of burning liquid fuel herein described and illustrated is in the form in which I desire to construct it and that changes or variations may be made as may be convenient or desirable without departing from the salient features of my invention and I therefore intend the following claims to cover such modifications as naturally fall within the lines of invention.

I claim:—

1. An oil burning apparatus comprising a burner for a boiler, a valve controlling fuel supplied to the burner, a valve controlling the air supply, a regulator operated by the steam pressure in the boiler, means interposed between the regulator and the valves for controlling the air and fuel in sequence, and means for varying the proportion of air to fuel at different combustion rates.

2. An oil burning apparatus comprising a burner for a boiler, a valve controlling fuel supplied to the burner, a valve controlling the air supply, a regulator operated by the steam pressure in the boiler, means interposed between the regulator and the valves which causes the fuel change to lag behind the air change on a falling steam pressure and the air change to lag behind the fuel change on a rising steam pressure, and means for varying the proportion of air to fuel at different combustion rates.

3. An oil burning apparatus comprising a burner for a boiler, means for supplying fuel thereto, a damper, cam means for operating the damper to vary the proportion of fuel to air at different rates of fuel supply, a regulator operated by the steam pressure in the boiler, and means governed by said regulator for controlling the fuel supply means and the damper operating means to cause the increase in fuel to lag behind the air on a falling steam pressure and the decrease in air to lag behind the fuel supply on a rising steam pressure.

4. An oil burning apparatus comprising a burner for a boiler, fuel supply means therefor, a damper for regulating the air, a regulator operated by the steam pressure in the boiler, means operated by said regulator for controlling the fuel supply, and cam means operated by said regulator for controlling the air damper, said means being arranged so that the fuel and air are operated in sequence, the order depending upon whether the steam pressure is rising or falling.

5. An oil burning apparatus comprising a burner for a boiler, fuel supply means therefor, air regulating means, a regulator operated by the steam pressure in the boiler, a member operated by said regulator, and separate trains of connections from the member to the fuel supply means and the air regulating means to control the same in sequence, said means being constructed and arranged to cause the supply of fuel and air to the apparatus in a given proportion at one combustion rate and a different proportion at another combustion rate.

6. An oil burning apparatus comprising an atomizer for a boiler, means for returning oil therefrom, air regulating means, a regulator operated by the steam pressure in the boiler, and separate mechanical means for controlling the oil returning means and the air regulating means from the regulator and to vary the proportion of fuel to air at different combustion rates.

7. An apparatus for burning liquid fuel in the combustion chamber of a boiler provided with a damper comprising eccentric means for regulating the damper, means for regulating the fuel supplied to the combustion chamber, a regulator operated by the pressure in the boiler, and means for directly operating both of said first named means from the regulator.

8. An apparatus for controlling the burning of liquid fuel in the combustion chamber of a boiler, comprising a valve controlling the fuel supply, a valve controlling the air supply, an eccentric for operating said air valve, a regulator operated by steam pressure in the boiler, a member operated by said regulator, mechanical means directly connecting said member to the fuel valve, mechanical means directly connecting said member to the eccentric, and a lag mechanism interposed in each of said means but effecting a lag in reverse directions.

9. An apparatus for controlling the burning of liquid fuel in the combustion chamber of a boiler comprising a control valve, a regulator operated by steam pressure in the boiler, a member operated by said regulator and a dash pot lag mechanism interposed between the member and the valve to effect coincident movements of the member and valve in one

direction and a delayed movement of the valve corresponding to movement of the member in the other direction.

10. Combustion apparatus including fuel and air supply means, means for operating the same to cause the supply of fuel and air to the apparatus in a given proportion at one combustion rate and a different proportion at another combustion rate, said means being so effective over a major portion of the range of operation, and means for providing an excess of air as the combustion rate is changed.

11. An oil burning apparatus comprising an atomizer, means for returning oil therefrom, air supplying means, a regulator operated by the steam pressure in the boiler, a valve in the oil returning means, a connection between said regulator and valve to control the supply of oil to the atomizer, a damper in the air supplying means, and a connection between said regulator and damper to control the supply of air.

12. Apparatus for controlling the burning of fuel in the combustion chamber of a boiler comprising fuel supplying means, air supplying means, a regulator operable by steam pressure in the boiler, a member operable by said regulator, controllers for the air and fuel supplying means respectively, a dash pot lag mechanism connected between said member and the air controller, and a dash pot lag mechanism connected between said member and the fuel controller, said lag mechanism having retarded and free movements in opposite directions and reversely to each other.

Signed at 501 5th Avenue, New York in the county of New York and State of New York this 30 day of August A. D. 1923.

ERNEST H. PEABODY.