Dec. 29, 1925. 1,567,869

E. H. SCOFIELD

COMBUSTION REGULATING SYSTEM FOR BOILERS

Filed Feb. 15, 1922 5 Sheets-Sheet 1

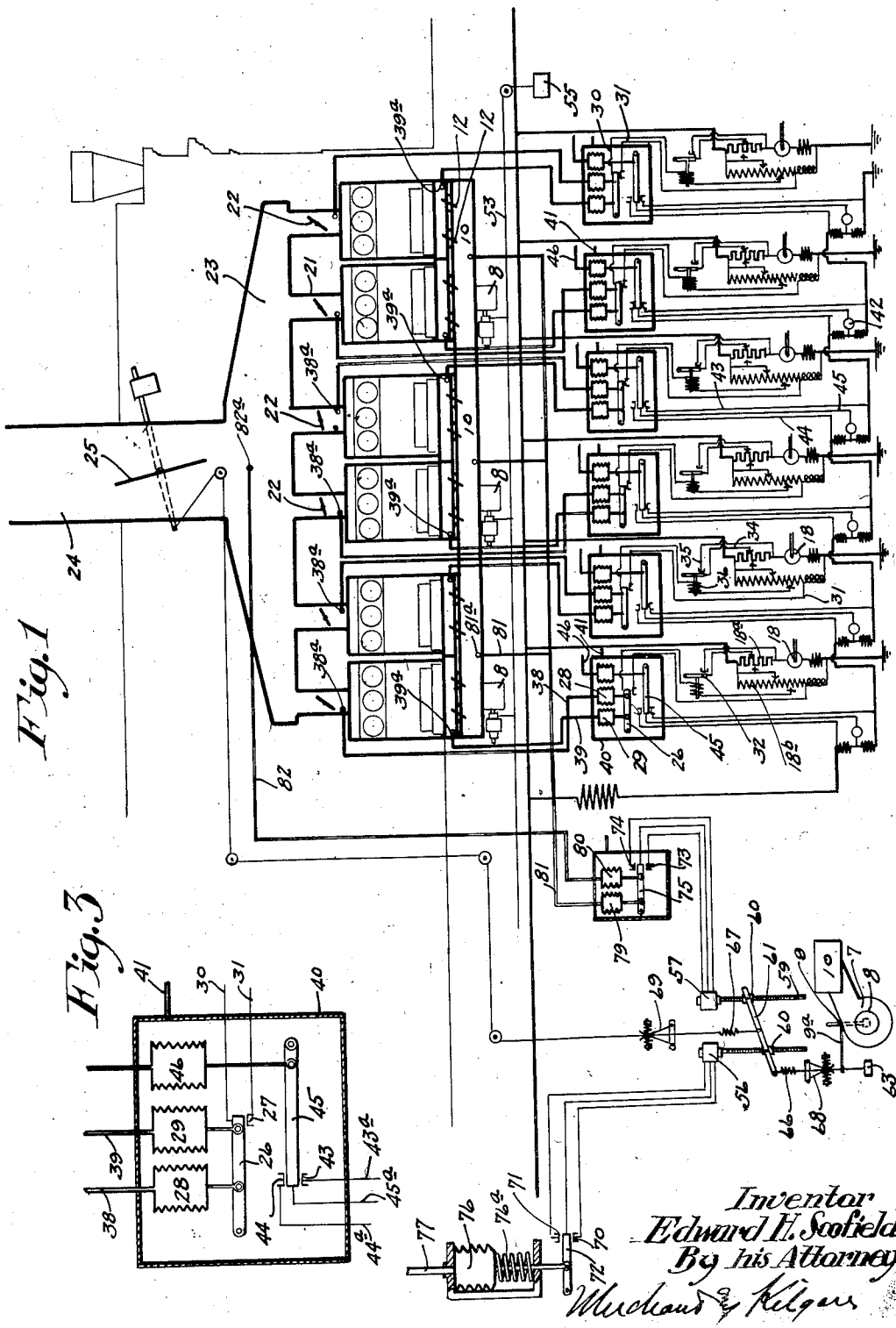


Fig. 1

Fig. 3

Inventor
Edward H. Scofield
By his Attorneys
Merchant & Kilgore

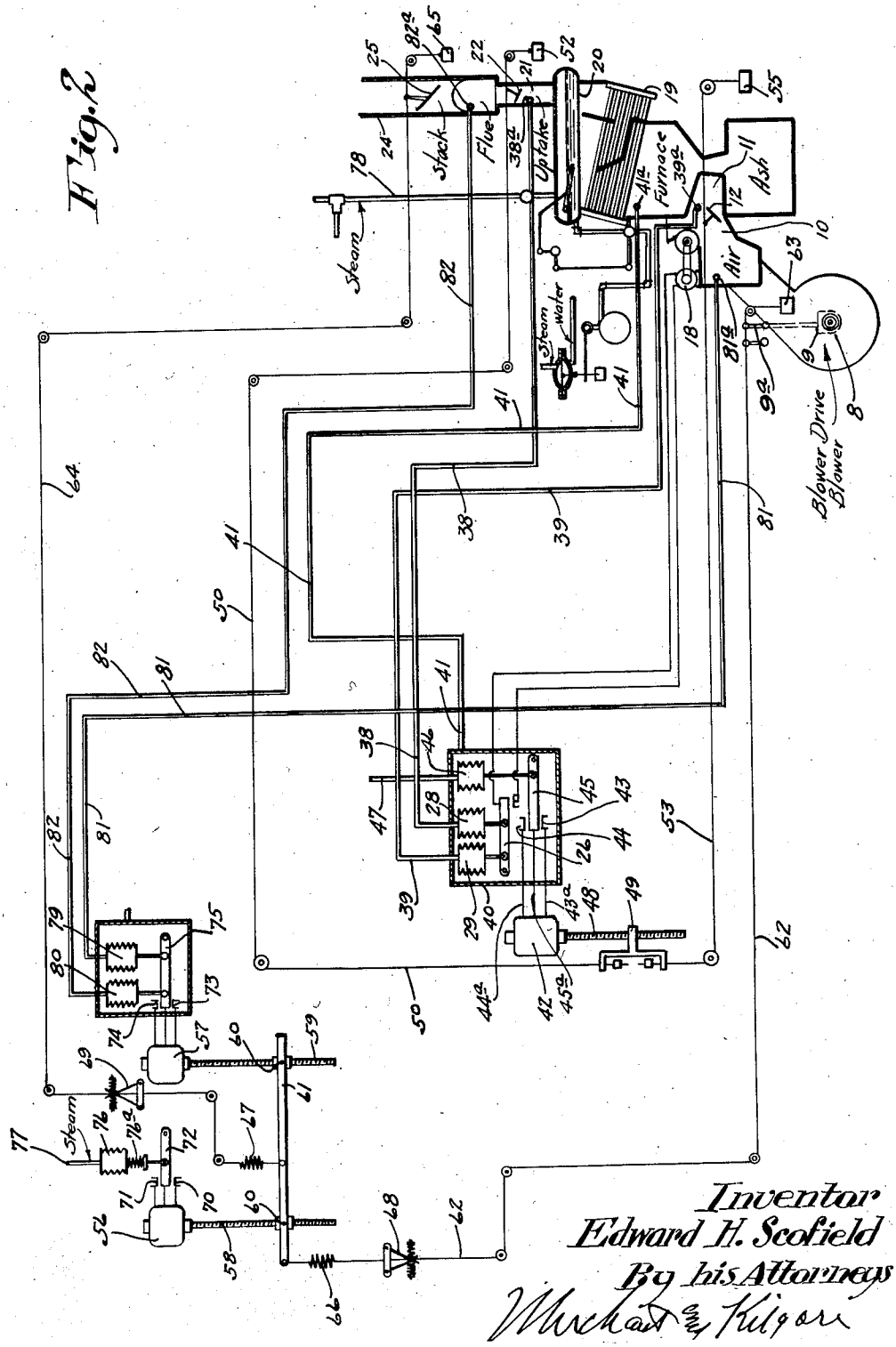
Dec. 29, 1925. 1,567,869

E. H. SCOFIELD

COMBUSTION REGULATING SYSTEM FOR BOILERS

Filed Feb. 15, 1922 5 Sheets-Sheet 2

Fig. 2



Inventor
Edward H. Scofield
By his Attorneys
Murchant & Kilgore

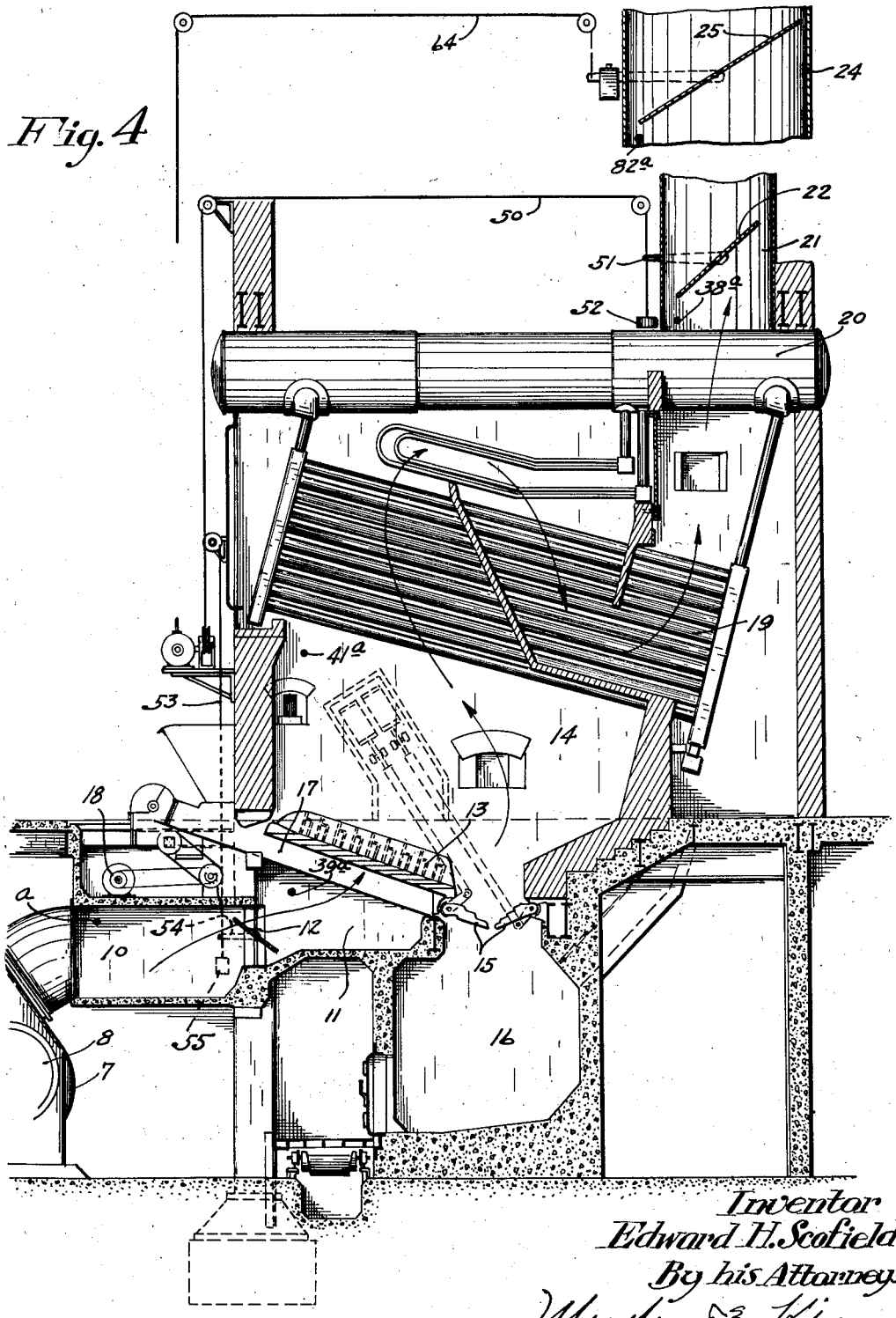
Dec. 29, 1925. 1,567,869

E. H. SCOFIELD

COMBUSTION REGULATING SYSTEM FOR BOILERS

Filed Feb. 15, 1922 5 Sheets-Sheet 3

Fig. 4



Inventor
Edward H. Scofield
By his Attorneys
Merchant & Gilmore

Dec. 29, 1925. 1,567,869

E. H. SCOFIELD

COMBUSTION REGULATING SYSTEM FOR BOILERS

Filed Feb. 15, 1922 5 Sheets-Sheet 4

Fig. 5

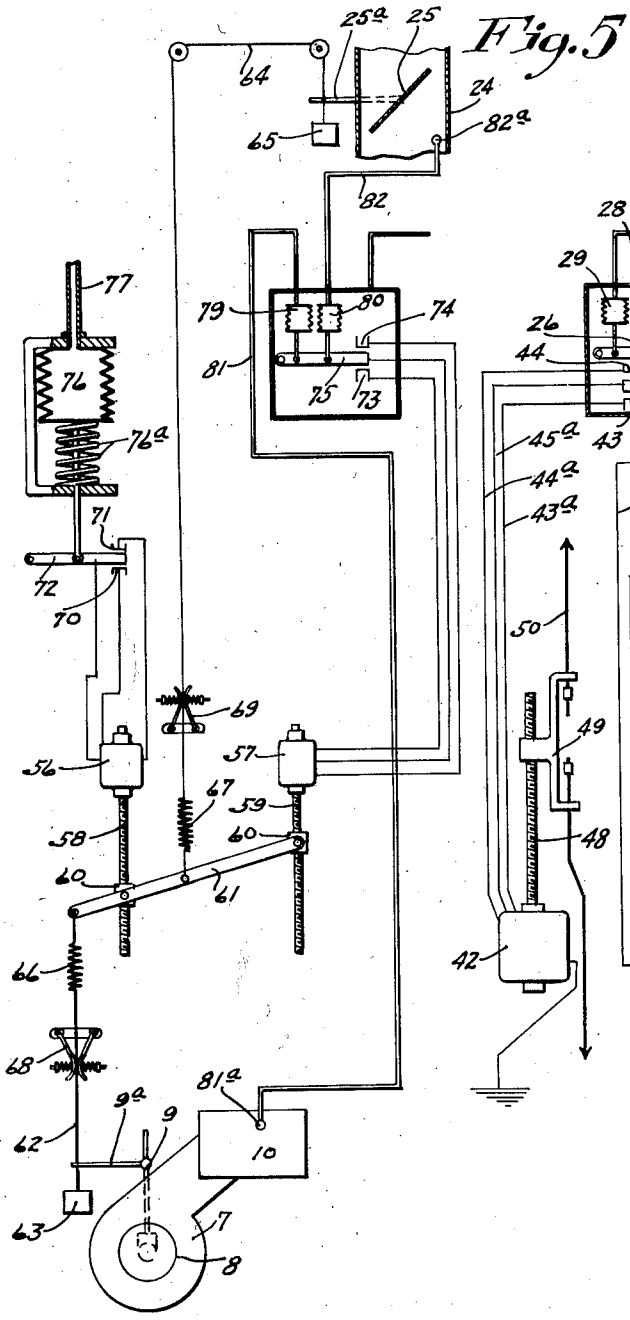
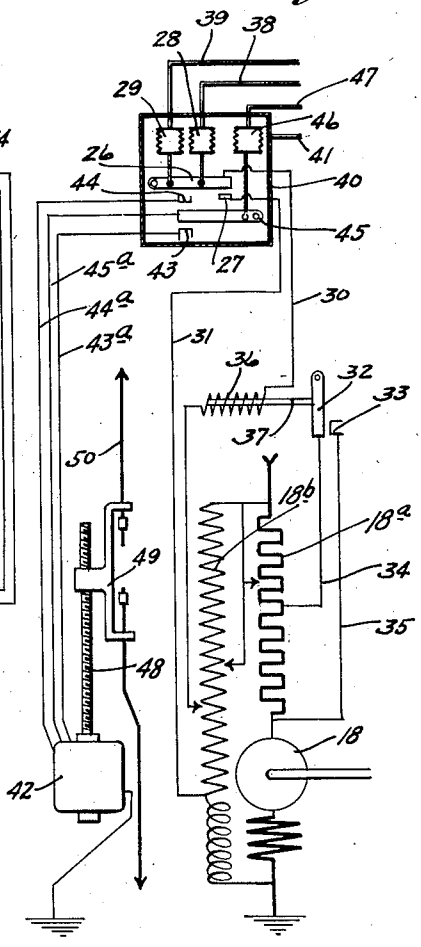


Fig. 6



Inventor
Edward H. Scofield
By his Attorneys
Merchant & Kilgore

Dec. 29, 1925. 1,567,869

E. H. SCOFIELD

COMBUSTION REGULATING SYSTEM FOR BOILERS

Filed Feb. 15, 1922 5 Sheets-Sheet 5

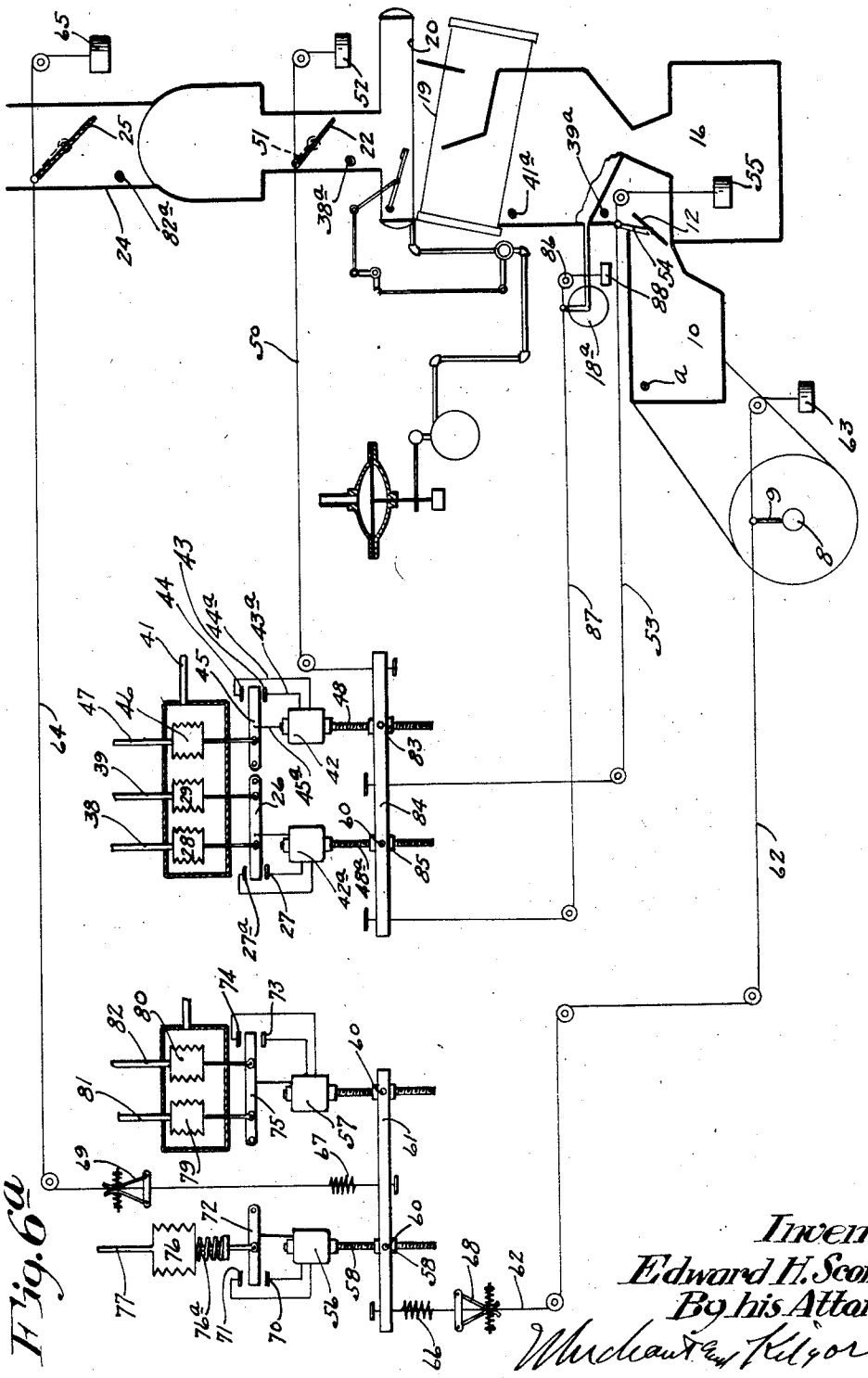


Fig. 6a

Inventor
Edward H. Scofield
By his Attorneys
Murchant & Kilgore

Patented Dec. 29, 1925. 1,567,869

UNITED STATES PATENT OFFICE.

EDWARD H. SCOFIELD, OF MINNEAPOLIS, MINNESOTA.

COMBUSTION-REGULATING SYSTEM FOR BOILERS.

Application filed February 15, 1922. Serial No. 536,697.

To all whom it may concern:

Be it known that I, EDWARD H. SCOFIELD, a citizen of the United States, residing at Minneapolis, in the county of Hennepin and State of Minnesota, have invented certain new and useful Improvements in Combustion-Regulating Systems for Boilers; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention provides a highly efficient combustion regulating system for boilers, adapted not only to regulate the combustion in any particular boiler unit, but also to maintain approximately the same or a predetermined relative combustion or regulation in all of the units of a group of boilers that receive an air supply from a common source and are connected to a common stack.

Ideal conditions demand a fuel bed of approximately constant effective thickness or depth on the grates of the boiler units, and to maintain such condition under varying load demands, it is necessary that the fuel supply be varied with the variations in such load demand. Otherwise stated, these conditions necessitate an automatic regulation of the fuel feeding devices or stokers in such manner that, regardless of variations in the load demands put upon the boiler units, the fuel beds in the several units will be maintained at approximately constant effective thickness or depth. The device that automatically takes care of such fuel bed conditions is herein designated as the fuel feed regulator, and is actuated by a disturbance of the normal or desired relative pressures above and below the fuel bed and grate and in the uptake. The fuel bed affords what is herein broadly designated as the point or place of initial combustion, because there the combustion is started.

It is also highly desirable to maintain, within the combustion chambers of the several boiler units, a pressure below, but very slightly below, the room or exterior atmospheric pressure, so as to thereby reduce to a minimum and substantially eliminate all infiltration of air and cooling of gases and, at the same time, prevent gases from escaping into the room. This also increases the efficiency of the heat absorption, by the boiler, of the heat-containing gases. The devices that automatically take care of this condition manipulate dampers of the individual boiler units and are herein designated as individual damper regulators.

The proportional amount of heat generated by each boiler unit of the group may be regulated by manual or other adjustments of the controlling dampers, but the total heat production of the several boiler units of the group must be proportioned to the load demands, so as to maintain the generated steam pressure at some constant pressure, or at least within certain limits of variation. For controlling these conditions, I provide a so-called "boiler group regulator," which comprises so-called "primary and secondary" controllers.

The primary controller is actuated by the steam pressure generated by the group of boilers and it operates to properly regulate the total air supply and draft to the several boiler units of the group.

The secondary controller is actuated by disturbances of the relative pressure in the common air supply source or main air duct and in the common draft connection or manifold flue, and it operates to automatically produce certain damper adjustments, which correct or more accurately accomplish the purpose roughly attained by the primary controller, to wit: substantially the exact amount of air supply and draft for varying load demands.

The features above generally noted and other important features, as applied in a group of commercial boilers, are illustrated in the accompanying drawings, wherein like characters indicate like parts throughout the several views.

Referring to the drawings:

Fig. 1 is a diagrammatic elevation illustrating the system as applied to a group of boiler units;

Fig. 2 is also a diagrammatic view but shows only one of the boiler units;

Fig. 3 is a sectional diagram showing one of the individual boiler unit-regulating instruments;

Fig. 4 is a vertical section taken from front to rear through a boiler unit of a well known commercial water tube type;

Fig. 5 is a diagrammatic view illustrating particularly the connections between the operating motors and certain of the regulating instruments for the group of boiler units;

Fig. 6 is a diagrammatic view illustrating particularly one method of connecting the

operating motors and regulating instruments for the individual or boiler unit control; and

Fig. 6ª is a diagrammatic view illustrating a slightly modified arrangement of certain parts of the regulating mechanism.

Directing attention now particularly to Fig. 4, and considering the construction of the boiler unit there illustrated, in so far as deemed desirable for the purposes of this case, the parts thereof may be noted as follows:

The air blast is produced by a blower or fan 7 driven by a suitable motor 8, which may be assumed to be a steam turbine controlled by a vertically movable throttle valve 9 shown only in Fig. 2. This blower discharges into a main air duct 10, which delivers into the individual wind boxes 11 of the several boiler units through passages controlled by pivoted dampers 12. The wind boxes 11 supply air through the main grate 13 and through the fuel bed carried on said grate, into the combustion chamber 14. The numeral 15 indicates the customary dumping grates, which discharge into the ash pit 16.

Fuel is supplied in a well known manner onto the main grate 13, by means of a stoker of suitable construction but which may be assumed to be of the type known as the "under feed" type. Such "under feed" stokers are commercially known as the Westinghouse or the Taylor furnaces. For the purposes of this case, it is only desirable to note the fuel retort 17 through which the coal or fuel is forced by the customary reciprocatory plungers driven through well known connections, from an electric motor 18 or the like.

The hot gases from the combustion chamber 14 pass upward between the boiler water tubes 19 and past the boiler drum 20 into the individual "uptakes" 21, in which are pivoted dampers 22. The air of the uptakes 21 is discharged into the manifold flue or breeching 23 (see Fig. 1), and thence to the common or main stack 24, in which is a pivoted controlling damper 25.

The stoker-operating motor 18 is of the variable speed type, preferably having a hand control, but which will be automatically connected for higher or lower speed by a stoker regulator, which, in turn, is actuated by disturbances in the predetermined relative pressures above and below the grate and in the uptake. In Fig. 6, the wiring of the motor 18 is diagrammatically indicated, the armature circuit resistance coil being designated at 18ª and the shunt field circuit resistance coil at 18ᵇ. The stoker regulator (see Figs. 2 and 6), comprises a switch lever 26, a co-operating fixed contact 27 and two pressure-actuated devices such as sylphon bellows or diaphragms 28 and 29, both of which are connected to said lever 26. The lever 26 and contact 27 are connected to the field resistance coil 18ᵇ at different points, respectively through leads 30 and 31.

The numeral 32 indicates a relay lever and the numeral 33 a co-operating relay contact connected to different points of the armature circuit resistance coil 18ª, respectively, through shunting leads 34 and 35. Interposed in the lead 30 is a solenoid or coil 36 that acts upon a core 37 attached to the relay contact 32. The bellows 28 is connected by a small air pipe 38 to a port 38ª located in the individual uptake 21 below the damper 22, (see Figs. 2 and 4). The bellows 29 is connected by a small air pipe 39 to a port 39ª located in the individual wind box 11 and, of course, underneath the grate 13. In the diagram view, Fig. 2, the bellows 28 and 29 are shown as located in an air-tight box or casing 40. The interior of this box 40 is connected by a small air pipe 41 to an air port 41ª that opens into the combustion chamber 14 below the tubes 19, as shown in Figs. 2 and 4.

The pressures herein referred to are related to pressure in the combustion chamber, and which pressure is maintained but slightly below atmospheric pressure and would preferably be about one-tenth of an inch or less, water column pressure. The pressure in the wind box, when the conditions are ideal or normal, will be, for example, four inches positive pressure when there is a draft or negative pressure in the uptake 21 below the damper 22, of approximately one inch. Ideal conditions will also be maintained when the pressures in the wind box and in the uptake increase or decrease, in respect to the combustion chamber pressure, while maintaining, in respect to each other, the said assumed predetermined relation.

The damper-operating motor 42 is of the reversible type and is controlled through three leads 43ª, 44ª and 45ª, which, respectively, are connected to a fixed contact 43, a fixed contact 44 and a movable contact lever 45, all preferably located in the air-tight box or housing 40, as shown in Figs. 1, 3 and 6. The movable contact 45 is connected to a sylphon bellows 46 that is connected by a pipe or conduit 47 to the room, or, in other words, to the atmospheric pressure outside of the boiler, the box 40 being connected to the combustion chamber 14.

The rotor of the motor 42 has a projecting threaded stem 48, (see Figs. 2 and 6), that engages a cross-head or sliding bracket 49. The upper end of the cross-head 49 is connected by a suitable guided cable 50 to an arm 51, (see Fig. 4), connected to the shaft of the uptake damper 22. At its extended end, said cable 50 is provided with a weight 52 that serves to open the damper 22 when relieved from tension from said cable. The lower end of the cross-head 49 is connected by a suitably guided cable 53 to an arm 54

on the shaft of the wind box damper 12. At its extended end, said cable 53 is provided with a weight 55 that tends to open said damper 12 when relieved from tension from the cable 53.

So far, only the individual boiler unit regulators or controlling means have been specifically described and it will, of course, be understood that the said devices are provided for each boiler unit and operate in themselves independently of those of other boiler units. As already indicated and as hereinafter described, there is a group regulator provided for important reasons to be hereinafter more fully discussed, but for the present, attention is called directly to the action of the regulating mechanism for one boiler unit.

The constantly running stoker-actuating motor 18 will be timed normally to run fast enough to supply the fuel for maximum load conditions, or even in excess of such an amount. Hence, if this motor should remain running at normal speed, there would ultimately be an over-accumulation of fuel on the grate, that is, the bed of coal or fuel on the grate would frequently get too thick. Whenever this happens, the positive pressure in the wind box 11 will increase and the negative pressure or partial vacuum, above the grate and in the uptake 21, will be decreased. When such disturbances between the normal relative pressures below and above the grate and in the uptake take place, such pressures act through the port 39^a and pipe 39 to increase the positive pressure in the bellows 29, and act through the port 38^a and pipe 38 to decrease the negative pressure or suction within the bellows 28, and thus the two bellows co-operate to move the contact 26 into engagement with the contact 27 and thereby close the shunt circuit, including the wires 30 and 31 and a portion of the motor's field circuit resistance 18^b. Closing of said shunt circuit also energizes the magnet 36 and opens the switch 32—33, thereby opening the shunt around a portion of the armature circuit resistance 18^a. The above described connections are best shown in Fig. 6.

The effect of closing the switch 26—27, as just described, is to slow down the speed of the motor 18 so that the motor will operate the stoker at a slower speed until the fuel bed has burned down to an extent to which it gives the normal resistance and the normal or predetermined relative pressure below and above the grate and in the uptake. Of course, in practice, the above described variations in the speeds of the stoker-actuated motor 18 will take place very frequently and, in fact, may set up a very nearly continuous motor variation in speed, the result of which will be, in effect, the regulation of the motor speed almost exactly to the desired feed conditions for any load, whether constant or varying. Otherwise stated, the resultant speed of the motor and stoker will automatically follow the variations in load demand.

As long as the normal or predetermined pressure in the combustion chamber 14 is maintained, which pressure is assumed to be approximately one-tenth of an inch or less, water column pressure, below atmosperic or room pressure, the movable contact 45^a, of the three-lead circuit to the damper-operating motor 42, will remain in its neutral position and the motor 42 will remain idle and the dampers 12 and 22 will remain set in open or partly open normal positions, say substantially as shown in Fig. 4.

The action of the damper regulator for the individual unit is substantially as follows:

When, as before described, the bed of fuel in the grate gets a little too thick and thereby restrains the flow of air through said fuel and, of course, through the combustion chamber 14, the suction or partial vacuum produced by the draft in the stack and uptakes will increase, that is, the difference between the atmospheric pressure of the room and the pressure in the combustion chamber will increase. The effect of this will be as follows:

Atmosphere from the room is always active on the interior of the bellows 46 through the pipe 47, but when the suction or partial vacuum increases in the combustion chamber 14, it acts through the port 41^a and pipe 41 to increase the suction or partial vacuum in the interior of the box or casing 40, so that atmospheric pressure then expands the bellows 46, thereby moving the contact 45^a downward into engagement with the contact 43^a, closing the motor circuit through the leads 45 and 43 and operating the motor 42 in a direction to move the crosshead 49 downward, thereby moving the wind box damper 12 toward a more open position, while, at the same time, moving the uptake damper 22 more nearly toward a closed position. This will restore the normal desired relation of the room or atmospheric pressure and combustion chamber pressure by choking off the draft through the uptake and increasing the supply of air through the bed of coal and, of course, when these normal conditions are restored, the movable contact 45 will be restored to its neutral position and the motor 42 will again stop.

The reverse of the above action is as follows: If the bed of coals on the grate should get too thin, then the excessive amount of air forced upward therethrough from the wind box 11 will tend to bring the pressure in the combustion chamber 14 nearer or even up to the atmospheric pressure of the room and, unless choked, would fre-

quently produce a combustion chamber pressure much in excess of the room or atmosphere with a result that the furnace gases would be forced from the furnace into the room, sometimes with very serious results. With the automatic damper regulator, however, when the initial increase in the normal or predetermined desired combustion chamber pressure takes place, it acts through the port 41ª and pipe 41 to decrease the suction or partial vacuum in the housing 40 to a point where such pressure is but very slightly less than atmospheric pressure and, at which point, the bellows 46 will be compressed and slightly collapsed, thereby moving the contact 45ª upward into engagement with the contact 44, thus closing the motor circuit through the leads 44ª and 45ª and causing the motor 42 to run in a direction to move the cross-head 49 upward; and the movement of said cross-head 49 in an upward direction, acting through the cables 50 and 53, simultaneously moves the wind box damper 54 more nearly toward a closed position and the uptake damper 22 more nearly toward an extreme open position.

Closing or partial closing of the damper 54 cuts down the supply and reduces the excessive rush of air through the fuel bed, and opening of the damper 22 renders the smoke stack suction stronger in its pressure-producing action in the combustion chamber 14 and thus automatically restores the normal desired relation of pressure of the combustion chamber to the outside or atmospheric pressure. Of course, when the normal combustion chamber pressure is thus restored, the contact 45ª will again be restored to its neutral position shown in Fig. 6.

In further explanation of the above described action of the bellows 46, it should be stated that the plaited walls thereof are of such spring nature that they have a slight tendency to contract, so that said bellows will be shortened in respect to the condition shown in Fig. 6, before the partial vacuum in the box 40 has been entirely destroyed or before such pressure reaches atmospheric pressure.

I have now fully described the individual regulation of any one of the several boiler units, a group of which receives their air supply from the common main or manifold air duct 10, and all of which are subject to draft from a common stack 24 through the manifold flue 23, and will now particularly describe the automatic boiler group regulator, which regulates the air blast or supply by control of the blower motor 8 and of the stack damper 25. This boiler group regulator comprises what may be designated as primary and secondary controllers, each of which preferably involves an electric motor.

The primary controller is actuated by varying steam pressure in the boiler, while the secondary controller is actuated by disturbances in the relative pressures in the air duct manifold and in the manifold flue, or, in other words, by disturbances between the relative air supply pressure and the stack draft pressure as predetermined.

The electric motor of said primary controller is indicated by the numeral 56 and the electric motor of said secondary controller is indicated by the numeral 57. The rotors of these two motors are provided, respectively, with threaded shafts 58 and 59 that have threaded engagement with sleeves 60 shown as pivoted at points on an equalizing lever 61. The lever 61 is connected to an arm 9ª, of the throttle valve 9 of the blower motor 8, by a suitably guided cable 62 equipped with a weight 63 that tends to close said throttle valve. Said lever 61 is also connected to an arm 25ª of the stack damper 25 by a suitably guided cable 64 equipped with a weight 65 that tends to open said stack damper. Preferably, coiled springs 66 and 67 are interposed, respectively, in the cables 62 and 64, and also, for a purpose which will presently appear, said cables are subject, respectively, to frictional retarding devices or anchored spring clamps 68 and 69 that operate under considerable friction in one direction but under very slight friction in the opposite direction. The motors 56 and 57 are reversible motors. Said motor 56 is controlled by a three-lead circuit that includes fixed contacts 70 and 71 and a movable contact 72. The motor 57, in a similar manner, is controlled by a three-lead circuit that includes fixed contacts 73 and 74 and a movable contact 75.

The movable contact 72 is connected to the stem of a sylphon bellows 76 that is connected by a small steam pipe 77 to a suitable point in the main steam pipe system 78.

The movable contact 75 is connected to the stems of two sylphon bellows 79 and 80. The bellows 79 is connected by an air pipe 81 to a port 81ª in the main or manifold air duct 10. The bellows 80 is connected by an air pipe 82 to a port 82ª located in the manifold flue 23 at the base of the stack 24 and, of course, below the stack damper 25. A coiled spring 76ª, (see particularly Fig. 5), tends to compress or collapse the bellows 76, but under normal operative conditions, this spring will be balanced by the steam pressure within said bellows and the movable contact 72 will be held in its neutral position.

When, under normal running conditions, the steam pressure in the boilers and the resulting steam pressure in the main steam piping system from the several boiler units is at the predetermined desired pressure, the steam pressure in the bellows 76 will counterbalance the spring 76ª and will maintain

the contact 72 in its neutral position, leaving the motor 56 idle; and when the predetermined desired relations between the air pressure in the main air duct 10 and in the manifold flue 23 are maintained, there will be a certain positive pressure in the bellows 79 and a certain negative pressure in the bellows 80, and the movable contact 75 will then stand in a neutral position and the motor 57 will remain idle.

If the above noted steam pressure is increased above the predetermined desired pressure, then the spring 76ª will be compressed, the contact 72 will be moved into engagement with the contact 70, thereby closing the motor circuit and causing the primary controller motor 56 to be rotated in a direction to lower the left-hand sleeve 60, the left-hand end of the equalizing lever 61 and the cables 62 and 64. This movement of said lever simultaneously accomplishes two things, to wit: acting through the cable 62, it causes or permits the motor throttle valve 9 to be more nearly closed, thus slowing down the blower motor and reducing the supply of air through the main air duct; and acting through the cable 64, it causes or permits the stack damper 25 to be moved more nearly to a closed position. This reduced supply of air from the blower and draft from the stack decreases the intensity of the fire and will be maintained until the boiler pressure is reduced to the predetermined desired or normal pressure, whereupon the contact 72 will be again restored to neutral position.

On the other hand, if the boiler pressure should become reduced below predetermined desired or normal pressure, the resulting reduced pressure in the bellows 76 will permit the spring 76ª to move the contact 72 into engagement with the contact 71, thereby closing the motor circuit so as to cause the motor 56 to run in an opposite direction from that above described and with the reverse result, to wit: that the throttle valve 9 will be opened wider, thereby increasing the speed of the motor 8 and the supply of air and, simultaneously therewith, moving the stack damper 25 more nearly toward a completely open position. This will increase the combustion in the boiler units until the steam pressure has again been brought up to the normal or predetermined desired pressure, and thereupon the contact 72 will be again moved to neutral position. This further action should be noted, that the cable 62 moves freely through the retarding frictional device 68 in a downward direction and, hence, quickly causes closing of the throttle valve 9, but said cable in its upward movement will be delayed or retarded by said friction device 68, so that the opening movement of the throttle valve will be delayed. On the other hand, the cable 64 moves freely upward through the retarding device 69 so that the stack damper 25 is quickly opened, but in the downward movement, the cable 64 is retarded and the stack damper 25 will be delayed in its movement toward its closed position. The object of this is to give the draft in the stack a lead over the throttle valve 9 under increasing load conditions and to give said throttle valve a lead over said damper under decreasing load conditions, thereby preventing momentary or temporary blowing of gases from the furnace into the room.

When there is a proper balance or relation of pressures in the main air pressure manifold 10 and in the manifold flue 23, the two bellows 79 and 80 will hold the contact 72 in its neutral position.

The primary steam pressure actuated controller of the so-called boiler group regulator operates to make corrections in the draft in a sort of a rough way, that is, only to approximately desired conditions. This is necessarily so because it is impossible to always determine in advance just the proper position of the throttle valve 9 in respect to any particular position of the stack damper 25. The secondary controller, however, automatically makes the required corrections substantially as follows: Assume that, after an adjustment has been made by the primary controller, the pressure in the main air duct 10 is too great in respect to the negative pressures in the draft in the manifold flue 23. When this condition arises, the positive pressure in the bellows 79 becomes too great as compared with the negative pressure or suction in the bellows 80, with a result that the contact 75 is moved into engagement with the contact 73, thereby closing the circuit through the motor 57 and causing the same to rotate in a direction to raise the right-hand sleeve 60 and right-hand end of the lever 61; this moves the lever 61 pivotally on the left-hand sleeve 60, thereby simultaneously lowering the cable 62 and raising the cable 64. Lowering of the cable 62, of course, closes the throttle valve 9, reducing the air pressure in the main air duct, and raising of the cable 64 causes or permits the stack damper 25 to move slightly further toward an extreme open position.

On the other hand, if the pressure in the main air duct 10 is too low in respect to the draft in the manifold 23, then an action just reverse from that described will take place, to wit: positive pressure in the bellows 79 will be too low in respect to the partial vacuum or suction in the bellows 80 and the contact 75 will be moved into engagement with the contact 74, thereby reversing the motor 57 and simultaneously moving the stack damper 25 toward a closed position and moving the throttle valve 9 to a more open position, and this, of course, causes an increase in the air pressure in the main

air duct 10 and checks the draft in the stack.

Hence, it is evident that the primary and secondary controllers work independently, but produce a resultant action which gives the best possible kind of regulation of air supply and draft to the entire group of boiler units. Obviously, as soon as the normal conditions are restored, both of the movable contacts or levers 72 and 75 will be restored to neutral positions and both motors 56 and 57 will be stopped.

Assume a group of any number of boiler units with furnace and stoker equipment, served by a common smoke flue with one or more chimneys connected; also by a common air duct supplied by one or more blowers.

A master control governed by variation of pressure in the main steam header is utilized for responding to load demand on the group of boilers. A device of similar pattern to the Mason regulator is suitable. Also, if desired, steam flow may be utilized for actuating the master control.

The master control may regulate the damper in the chimney or chimneys and thereby control the draft pressure in the main flue; or preferably, may regulate the throttle or motor speed of the blower drives, thereby controlling the available supply of air and air pressure.

As the air pressure in the main duct governs the capacity output of the individual boiler units connected thereto, it is essential that as this air pressure changes, corresponding change be made in the draft pressure of the main flue which takes away the products of combustion.

The group load-controlling instrument, by proper calibration and adjustment, so regulates automatically the draft pressure in the main flue as to at all times properly coordinate the pressure in this flue to the pressure in the main air duct, so that gases do not blow out into the room; neither does the draft pressure in the furnace build up to a pressure to cause undue infiltration of air through the setting walls and openings. The instrument is actuated by the net effect of pressures in main flue and main air duct and controls the operation of the main chimney damper so that at all times the above proper coordination is maintained, although the master regulator may regulate the air supply blowers throughout the full range of their load capacity, limited only by the ultimate draft capacity of the chimneys.

In addition to the group control, a differentiated control is provided for the individual boiler to compensate for a varying characteristic of the boiler, a temporary fault in the condition of the fuel bed, for arbitrarily varying the distribution of the aggregate load amongst the various units or for partially or completely limiting for a period the amount of load demand on the individual unit.

Such arbitrary limitation may preferably be accomplished manually by setting the uptake damper in a more or less closed position, thereby reducing the effect of the available draft pressure of the main flue. The direct effect of such manipulation of the draft available at the uptake is to lower the draft pressure in the furnace chamber and if not counteracted may result in a pressure in the chamber and gas blow out.

Varying condition of the fuel bed, such as blow holes, coarse or fine coal, unequal distribution of fuel, excessive moisture or packing of fuel, may accelerate or restrain the normal flow of air through the fuel bed, thereby effecting the desired draft pressure in the furnace chamber.

The damper-controlling instrument, by proper calibration and adjustment, automatically regulates the draft pressure in the furnace chamber at all times, compensating for all such abnormal conditions affecting the individual unit. This instrument is actuated by the pressure in the furnace chamber and controls the operation of the wind box damper, regulating the pressure in the wind box as required for the load demand and in case of improper fuel bed, when there is a deficiency of fuel on the grate, the load demand is temporarily reduced, and with an excess of fuel on the grate, the load demand is increased from normal. This regulation accelerates the correction of the fuel bed conditions.

Fuel supply to the individual units is governed by the momentary condition of the fuel bed as related to the load demand on such unit. The rate of fuel supply is not directly proportioned to the load demand at any time but is accelerated or retarded as necessary to, with the least delay within the limits of variable speed of the driving motor, correct such fuel bed condition to the normal required for the load demand then in effect.

The fuel-controlling instrument, by proper calibration and adjustment for the particular grade of coal used, automatically regulates the acceleration or retardation of fuel supply as required. This instrument is actuated by the net effect of pressures in wind box, furnace and uptake of the individual unit and controls the speed and power developed by the driving motor operating the stoker mechanism and fuel feed.

In Fig. 6a, I have illustrated a regulator which, in its main characteristics and in many of its detail features, corresponds to the structure already described, but it differs therefrom in many particulars herein-

after to be described and which are added to the broad principles of the invention here disclosed and claimed.

The parts that correspond to parts in the regulating system above described in detail are all indicated by the same numerals, and the additional or modified parts are as follows:

In this arrangement, the screw shaft 48 of the motor 42, of the damper regulator, engages a sleeve-like nut 83 pivoted to a floating lever 84. In this arrangement, for co-operating with the stoker motor regulator, I provide a reversible motor 42^a that is similar to the motor 42 and is provided with a screw shaft 48^a that engages another nut-acting sleeve 85 pivoted to the lever 84 at a point quite distant from the sleeve 83. In this arrangement, movements of a contact 45 control the motor 42, as above described, but for co-operating with the movable contact 26 of the stoker motor regulator, in addition to the contact 27, there is provided a second fixed contact 27^a.

Again in this arrangement, the damper-operating cables 50 and 53, instead of being connected to the cross-head 49, as before described, are connected to the lever 84, at points on opposite sides of the sleeve 83.

The stoker-operating motor herein employed may be the same motor that is illustrated in Fig. 6, but for the purposes of this case, it may be assumed to have an upstanding oscillatory motor speed control arm 86, which, when moved toward the left, will increase the speed of said motor and which, when moved toward the right, will decrease the speed of said motor. Arrangements for accomplishing variable speeds of a like motor, by the oscillating of an arm or the like, are well known to all persons familiar with the art.

For oscillating the motor speed control arm 86 mechanically, I provide a cable 87 passed over suitable guides attached at one end to the left-hand end of the floating lever 84 and at its other end to said arm 86 and having a weight 88 which, when said cable is given slack, will move the arm 86 toward the right or in the direction to decrease the speed of the motor.

In a general way, the operation of this modified form of the regulator is like that of the regulator above more fully described in detail, but there are some important specific features of difference. In the first place, the connection between the speed regulator of the motor 18^a and the motor-actuated element sections of the stoker motor regulator and of the damper regulator are, in a way, independent, but, nevertheless, the two are comparatively arranged for resultant actions due to the combined effect of both, operated either simultaneously or at different times.

What I claim is:

1. The combination with a boiler installation or unit having an automatic fuel feed mechanism, of a fuel feed regulator operative by disturbances of relative pressures above and below the point of initial combustion, and automatic means for maintaining in said combustion chamber a pressure closely approaching but below that of the external pressure.

2. The combination with a boiler installation or unit having a grate and an automatic stoker including a driving motor, of dampers in the draft passages above and below said grate, means for operating said motor by disturbances of relative pressures in the draft passages above and below the grate, and means for operating said dampers by variations in the combustion chamber pressure above the grate, in respect to atmospheric pressure.

3. The combination with a boiler installation or unit having a combustion chamber a wind box below and a draft uptake above the combustion chamber proper, an automatic stoker delivering to said combustion chamber and having a motor for operating the same, means for operating said motor by disturbances in the relative static pressure in said wind box, combustion chamber and uptake, dampers in said wind box and uptake, and means for operating said dampers by a pressure in said combustion chamber that closely approximates atmospheric pressure.

4. The combination with a group of boiler units each having an automatic fuel feed mechanism, of a fuel feed regulator for each fuel feed mechanism operated by disturbances of relative pressures in the respective units above and below the points of initial combustion, a main air duct connected to the several boiler units, a stack having a manifold flue connecting the same to the several boiler units, draft-controlling dampers co-operating with said main air duct and stack, and a boiler group regulator for operating said dampers, and itself subject to and actuated by the pressure of the steam generated by the group of boiler units.

5. The combination with a group of boiler units each having an automatic fuel feed mechanism, of a fuel feed regulator for each fuel feed mechanism operated by disturbances of predetermined relative pressures in the respective units above and below the points of initial combustion, a main air duct connected to the several boiler units, a stack having a manifold flue connecting the same to the several boiler units, draft-controlling dampers co-operating with said main air duct, and a boiler group regulator comprising primary and secondary controllers, the former being actuated by the pressure of steam generated by the group of boiler units and the latter being actuated by disturbances

of the relative pressures in said main air duct and manifold flue, said primary and secondary controllers having connections to and differentially operating said dampers.

6. The structure defined in claim 1 in which said fuel feed mechanism includes an electric motor, and said fuel feed regulator includes a pressure-expansible switch-actuating element, a switch actuated thereby and a controlling circuit including said switch and said electric motor.

7. The combination with a boiler installation having a grate and an automatic stoker including a stoker-driving motor, of dampers, one in the draft passage below the grate and the other in the flue connection, three pressure-expansible switch-actuating elements, the first subject to pressure in the combustion chamber above the grate, the second subject to pressure in the flue connection, and the third subject to the pressure below the grate, an electric circuit including a damper-actuating motor and a controlling switch therefor, said latter switch being actuated by the first noted pressure-expansible element, said last noted motor having connections for operating said dampers, and a second electric circuit including said stoker-driving motor and a switch for said second noted circuit, which latter noted switch is subject to the combined action of said second and third noted pressure expansible elements.

8. The structure defined in claim 3 in which the stoker motor actuating means includes a switch, a pressure-expansible switch-actuating device and connections from said pressure-expansible device leading one to the wind box and the other to the draft uptake of the boiler installation.

9. The structure defined in claim 4 in which the stoker motor actuating means includes a switch, a pressure-expansible switch-actuating device and connections from said pressure-expansible device leading one to the wind box and the other to the draft uptake of the boiler installation.

10. The structure defined in claim 4 in which the stoker motor actuating means includes a switch, a pressure-expansible switch-actuating device and connections from said pressure-expansible device leading one to the wind box and the other to the draft uptake of the boiler installation, and in which said boiler group regulator comprises as follows: reversible primary and secondary electric motors with controlling circuits including reversing switches, a pressure-expansible switch-actuating element for the primary switch connected by a steam pipe to a steam conduit subject to the steam pressure generated by the boiler group, pressure-expansible switch-actuating elements for the secondary switch connected to two pipes one leading from the main air duct and the other leading from the manifold flue, and a co-ordinatedly and differentially acting lever subject to said primary and secondary motors and having connections for operating the blower or blowers of said main air duct and the damper for said stack.

11. The structure defined in claim 4 in which the stoker motor actuating means includes a switch, a pressure-expansible switch-actuating device and connections from said pressure-expansible device leading one to the wind box and the other to the draft uptake of the boiler installation, and in which said boiler group regulator comprises as follows: reversible primary and secondary electric motors with controlling circuits including reversing switches, a pressure-expansible switch-actuating element for the primary switch connected by a steam pipe to a steam conduit subject to the steam pressure generated by the boiler group, pressure-expansible switch-actuating elements for the secondary switch connected to two pipes one leading from the main air duct and the other leading from the manifold flue, and a co-ordinatedly and differentially acting lever subject to said primary and secondary motors and having connections for operating the blower or blowers of said main air duct and the damper for said stack, and in which there are also one-way retarding devices operating on the connections for operating said main air duct and stack dampers.

12. The combination with a group of boilers, each unit having an automatic fuel feed mechanism, of a fuel feed regulator for each fuel feed mechanism operated by disturbances of relative pressures in the air and gas passages of the respective units above and below the points of initial combustion, a main air duct connected to the several boiler units, a stack having a manifold flue connecting the same to the several boiler units, draft-controlling blower and damper co-operating with said main air duct manifold and stack, and a boiler group regulator including a motor for operating said blower and damper, and itself subject to and actuated by disturbances in the pressure of the steam generated by the group of boiler units.

13. The combination with a group of boilers, each unit having an automatic fuel feed mechanism, of a fuel feed regulator for each fuel feed mechanism operated by disturbances of relative pressures in the air and gas passages of the respective units above and below the points of initial combustion, a main air duct connected to the several boiler units, a stack having a manifold flue connecting the same to the several boiler units, draft-controlling blower and damper co-operating with said main air duct and manifold flue and a boiler group regulator comprising primary and secondary controllers

the former being actuated by disturbance in the pressure of steam generated by the group of boiler units and the latter being actuated by disturbances of the relative pressure in said main air duct and manifold flue, said primary and secondary controllers having connection to provide co-ordinated and differential control for said blower and damper.

14. The structure defined in claim 12 in which the stoker motor actuating means includes a switch, pressure-expansible switch-actuating devices and connections from said pressure-expansible devices leading one to the wind box and the other to the draft uptake of the boiler installation, and in which said boiler group regulator comprises as follows: reversible primary and secondary electric motors with controlling circuits including reversing switches, pressure-expansible switch-actuating elements for the primary switch connected by a steam pipe to a steam conduit subject to the steam pressure generated by the boiler group, pressure-expansible switch-actuating elements for the secondary switch connected to two pipes one leading from the main air duct and the other leading from the manifold flue, and a co-ordinatedly and differentially acting lever subject to said primary and secondary motors and having connections for operating the blower or blowers of said main air duct and the damper for said stack.

15. The structure defined in claim 12 in which the stoker motor actuating means includes a switch, pressure-expansible switch-actuating devices and connections from said pressure-expansible devices leading one to the wind box and the other to the draft uptake of the boiler installation, in which said boiler group regulator comprises as follows: reversible primary and secondary electric motors with controlling circuits including reversing switches, pressure-expansible switch-actuating elements for the primary switch connected by a steam pipe to a steam conduit subject to the steam pressure generated by the boiler group, pressure-expansible switch-actuating elements for the secondary switch connected to two pipes one leading from the main air duct and the other leading from the manifold flue, and a co-ordinatedly and differentially acting lever subject to said primary and secondary motors and having connections for operating the blower or blowers of said main air duct and the damper for said stack, and in which there are also one-way retarding devices operating on the connections for operating said main air duct and stack dampers.

16. In a boiler installation, a fuel feed mechanism comprising a plurality of feed units, each having its own feed regulator controlled by variations in pressure above and below the point of initial combustion, and a common controller, operated by disturbances in the pressure of the steam generated by said boiler installation and having connections for controlling the air supply and the stack draft.

17. The structure defined in claim 16 in which the several feed devices are stokers and each stoker has its own driving motor, which latter is subject to the control herein indicated.

In testimony whereof I affix my signature.

EDWARD H. SCOFIELD.