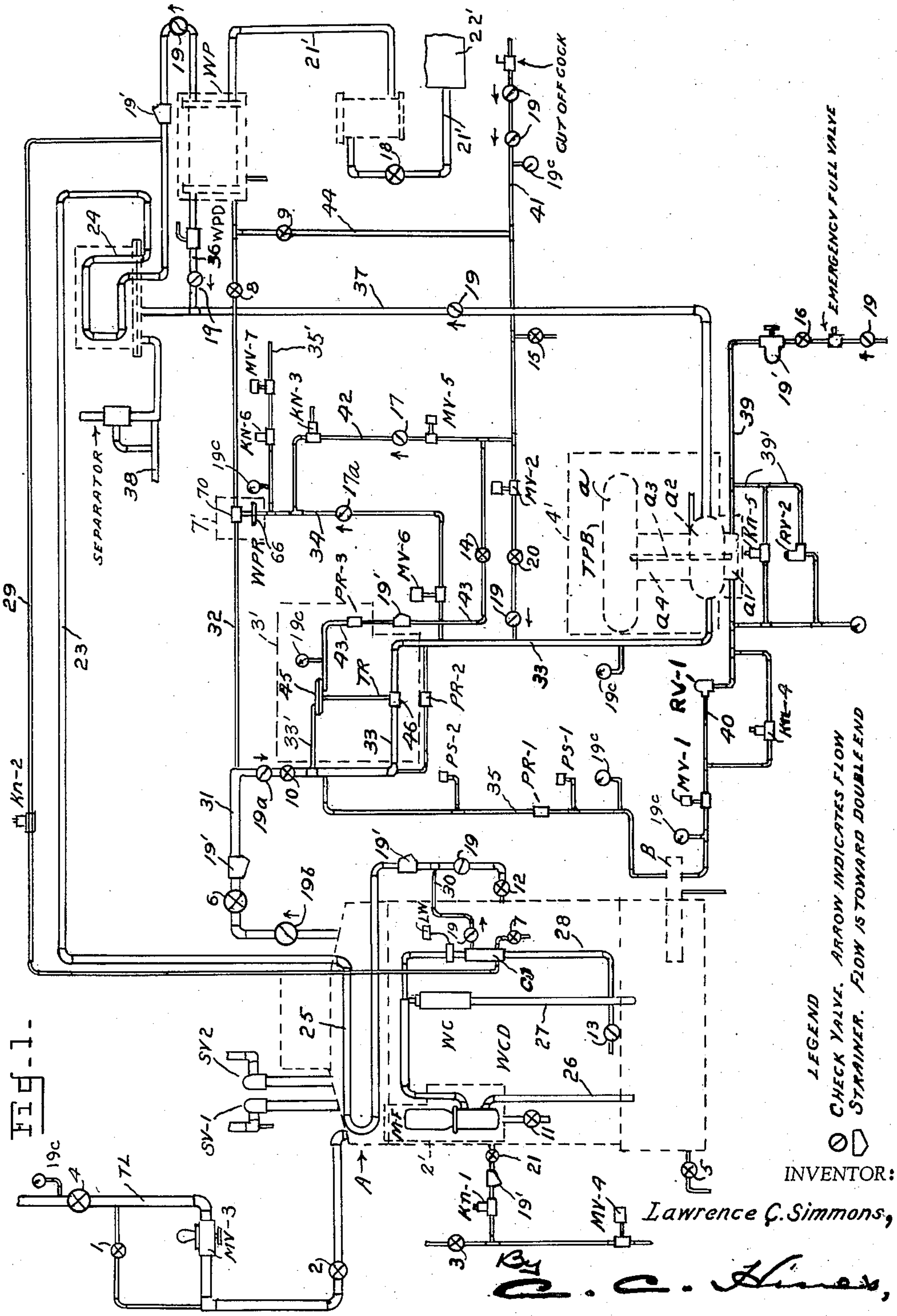
Sept. 16, 1958 L. C. SIMMONS 2,852,003

STEAM HEATING BOILER CONTROL SYSTEMS

Filed June 20, 1952 5 Sheets-Sheet 1



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STEAM HEATING BOILER CONTROL SYSTEMS

Filed June 20, 1952 5 Sheets-Sheet 2

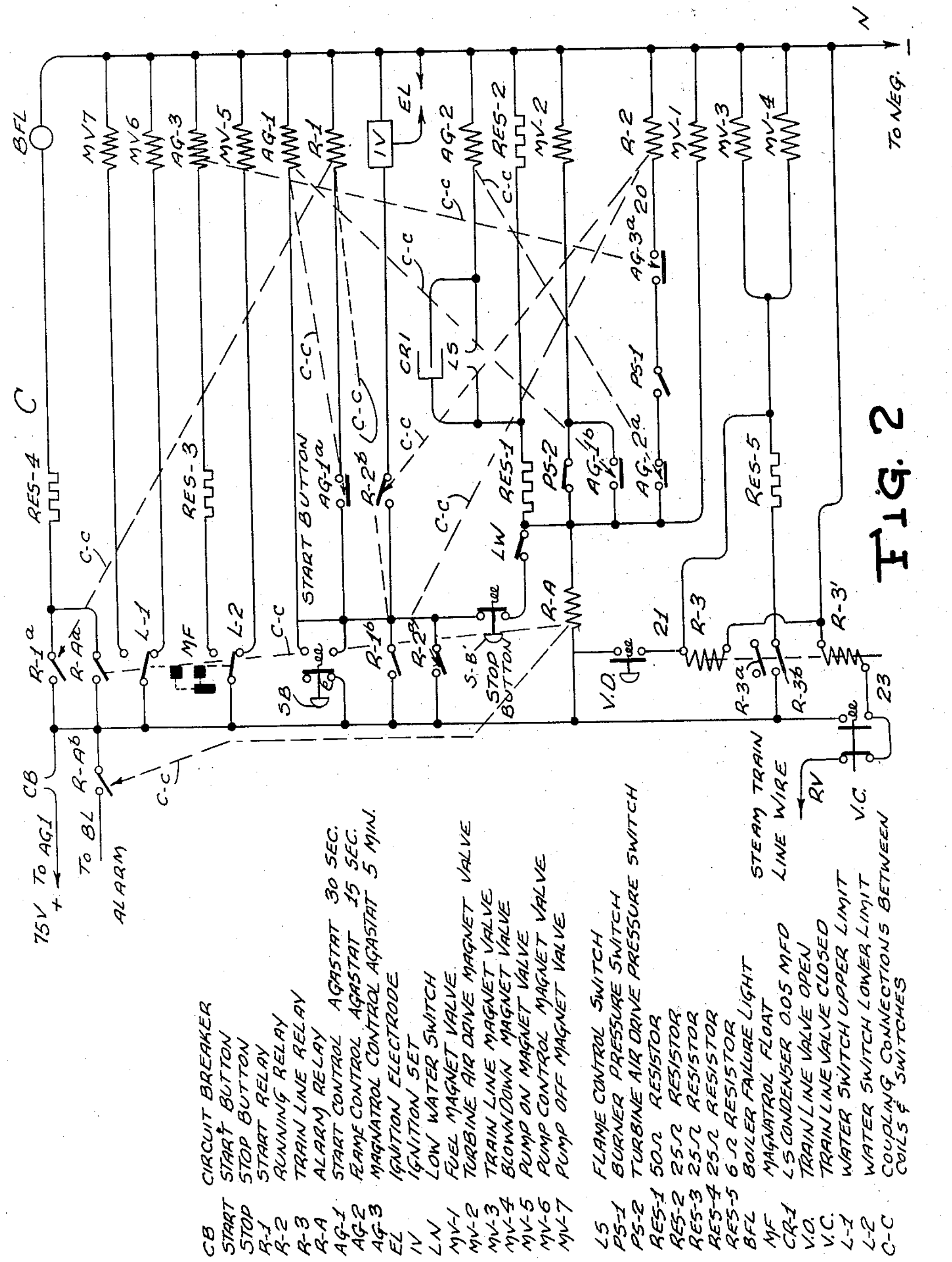

FIG. 2

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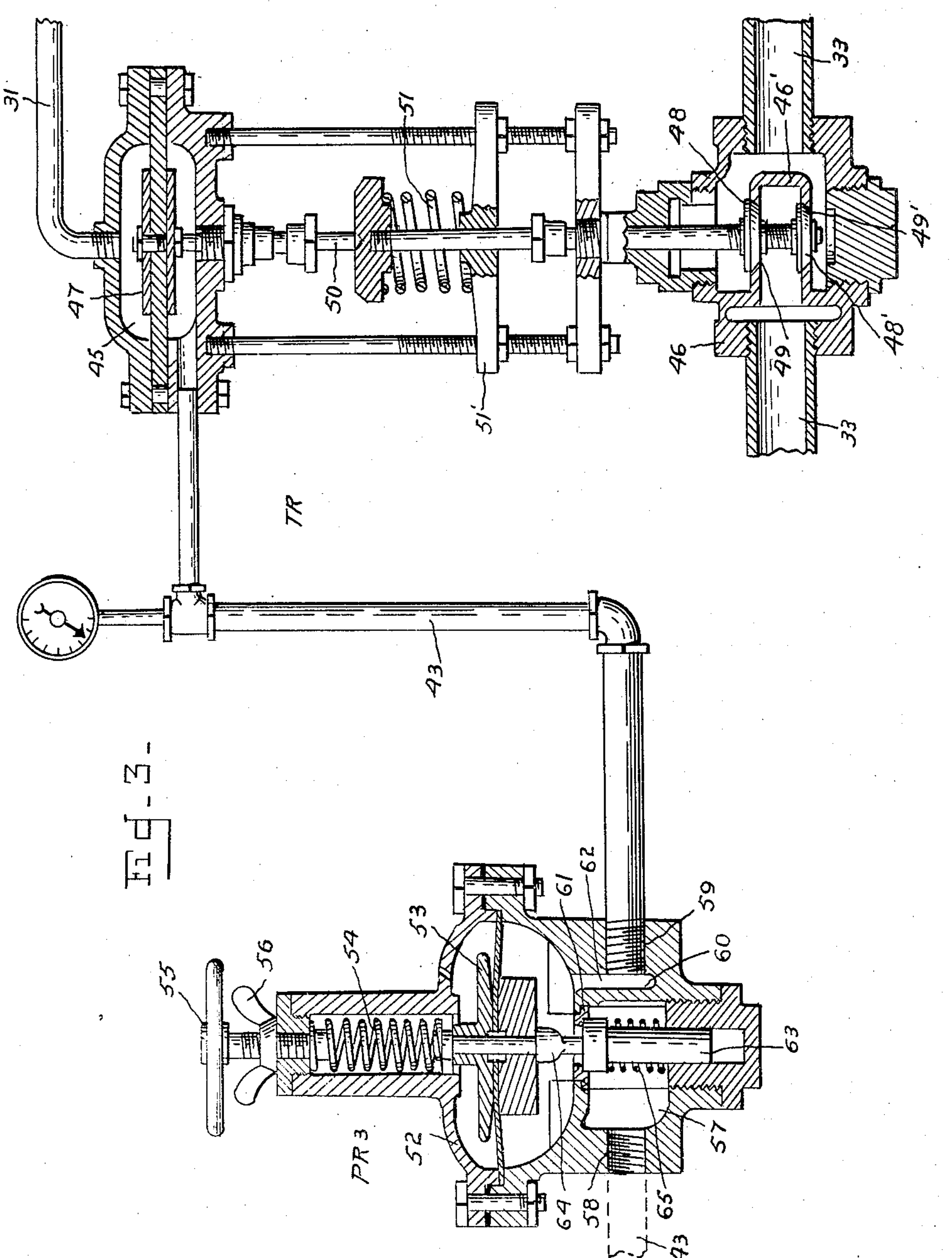
STEAM HEATING BOILER CONTROL SYSTEMS



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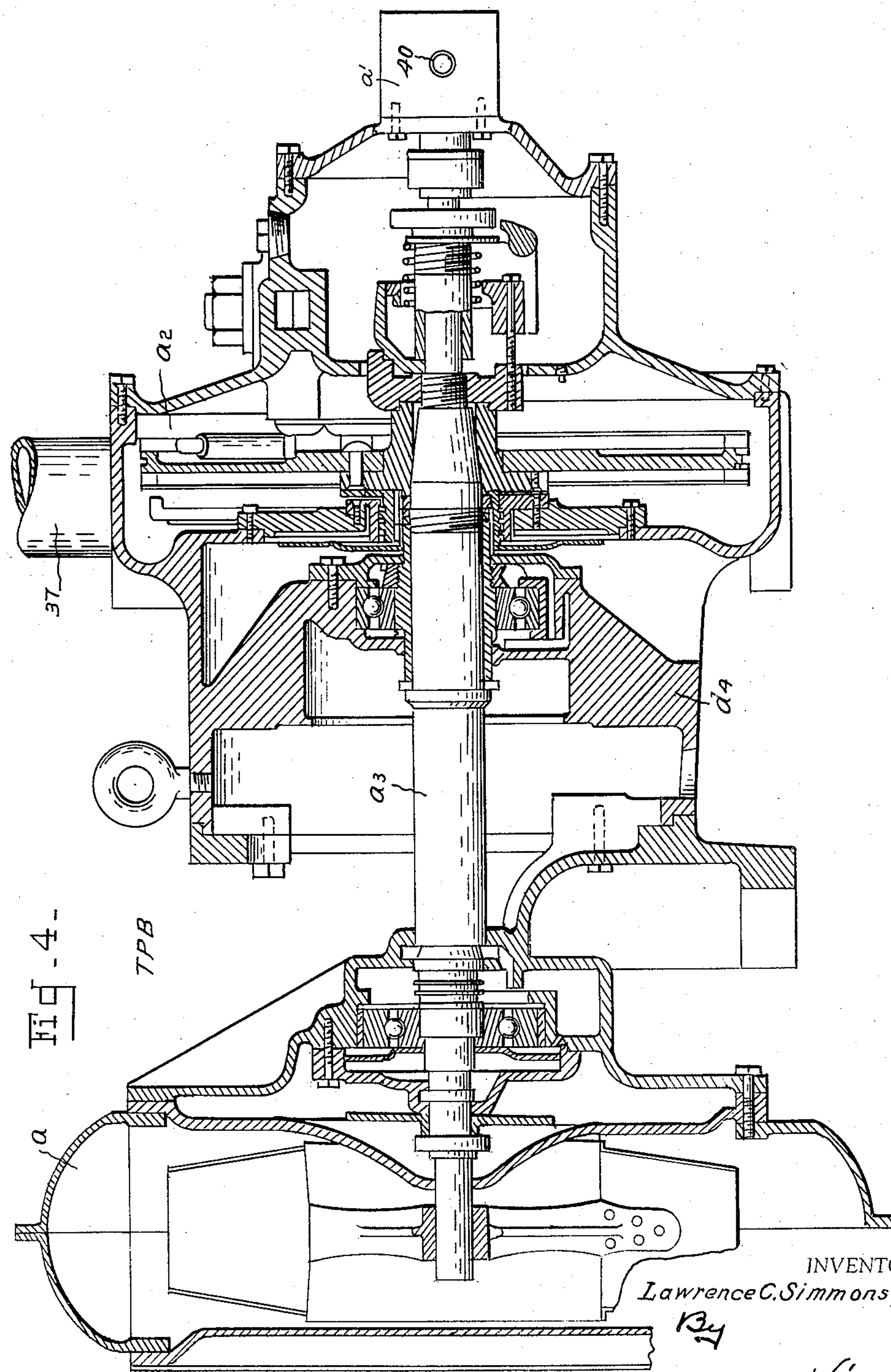

Fig-4-

TPB

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Sept. 16, 1958 L. C. SIMMONS 2,852,003

STEAM HEATING BOILER CONTROL SYSTEMS

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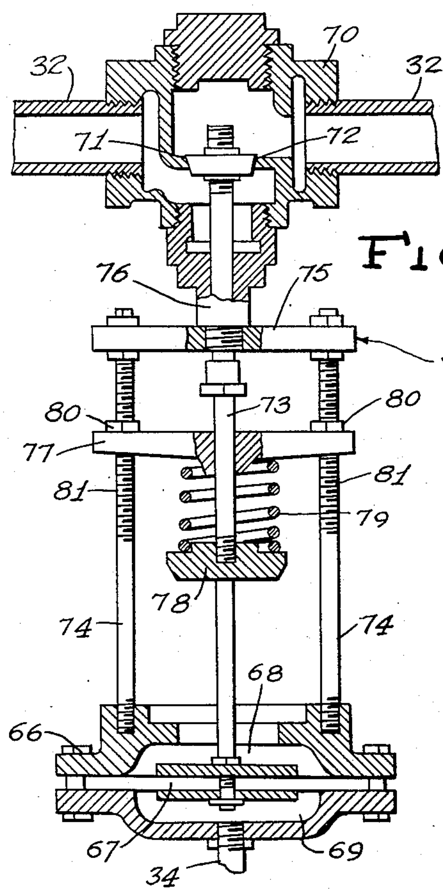

FIG. 7

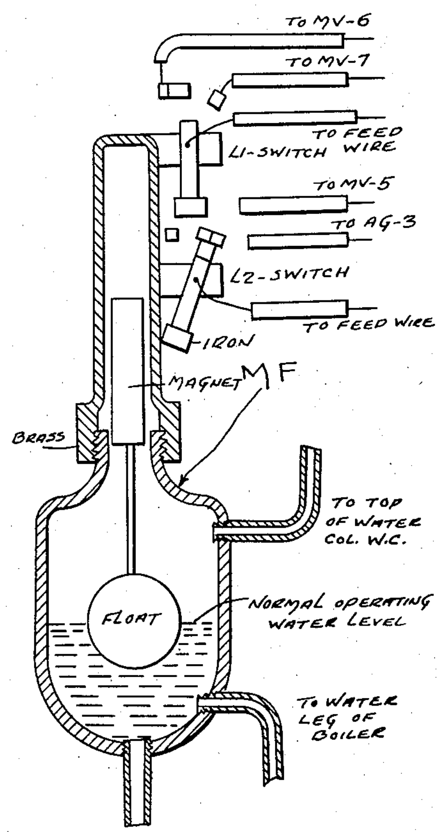

FIG. 5

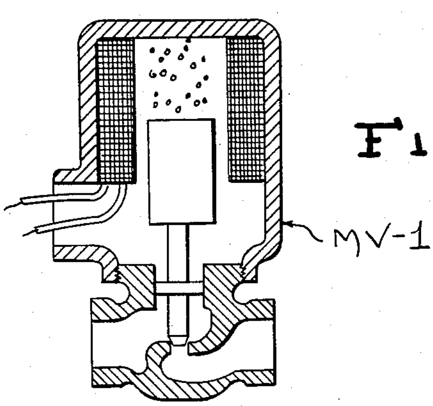

FIG. 6

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United States Patent Office

2,852,003

Patented Sept. 16, 1958

2,852,003

STEAM HEATING BOILER CONTROL SYSTEMS

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Continuation of application Serial No. 184,669, September 13, 1950. This application June 20, 1952, Serial No. 294,679

17 Claims. (Cl. 122—448)

This invention relates to improvements in steam heating boiler control systems, and particularly to systems of the type shown in Hamilton and Rowell Patent No. 2,116,943, of May 10, 1938, and my Patent No. 2,566,041, of August 28, 1951, for starting a boiler heater or steam generator of a steam heating or supply system into action and controlling and regulating the operation of fuel and water supply pumps for automatically supplying fuel and, if desired, a fuel condition medium, to a burner for heating the boiler and supplying water to the boiler as required according to conditions in the operation of the system. The systems disclosed in these patents are especially designed and adapted for use on an electric or diesel locomotive or on a baggage or other railway car for cooperation with steam standard cars or coaches to supply steam for heating the same, but are also capable of use on other vehicles or in stationary plants where the steam is utilized for either heating or power purposes.

In the systems covered by the aforesaid patents a blower-motor-turbine-oil-pump set is employed to supply fuel and atomizing air or steam, or both at times, to an atomizing burner, and also to supply combustion air to the combustion chamber or fire-box of the boiler. This blower-motor-turbine-oil-pump set comprises as employed in said patents a gear-type fuel pump, a steam turbine, a paddle-type blower and an electric motor mounted on a common shaft to operate in unison for calibrated fuel and combustion air supplying actions, the set being initially driven by the electric motor to supply fuel and combustion air to start the burner into operation, then operated by the motor and turbine jointly to increase the power and speed of the set when the boiler begins to generate and steam at low pressure is supplied to the turbine to supplement the driving action of the electric motor, and finally operated by the turbine alone under steam supplied thereto at relatively high pressure when the boiler is fully generating. These operations of the blower-motor-turbine-oil-pump set are governed by electrical and pressure-regulated controlling means whereby the electric current to the motor is cut off when the boiler pressure reaches a predetermined degree, after which the supply of steam to the turbine to drive the set is regulated and controlled as a function of boiler pressure. In the system shown in Patent No. 2,116,943, combustion air only is supplied to the fire-box by the blower of the blower-motor-turbine-oil-pump set while in the system shown in Patent No. 2,566,041 compressed air from a suitable source, such as the main air reservoir of the locomotive, is also supplied directly to the burner for use as an atomizing agent to preliminarily atomize the fuel until steam generation begins, and thereafter, when the boiler begins to generate steam at low pressure, steam is also supplied for admixture with the compressed air passing to the burner to serve as the atomizing agent. As soon, however, as the boiler begins to generate steam at a high pressure, the central means operates to automatically cut off the supply of atomizing air to the burner, and thereafter, as long as the boiler continues in normal operation, steam alone is supplied to the burner as the fuel atomizing agent.

The systems disclosed in the aforesaid patents differ mainly in the use of atomizing burners of different types for heating the boiler, that of Patent No. 2,566,041 employing an atomizing burner of whirl type and means for controlling the supply of steam and air thereto in starting and running actions and the supply of steam to the turbine in accordance with boiler pressure to govern the boiler firing rate. The boiler control systems of the Hamilton and Rowell patent and my Patent No. 2,566,041 are essentially constant pressure control systems and employ turbine and water pump regulators under control of the firing rate, which are satisfactory under general conditions and for general service use in controlling boilers operating alone, but have certain disadvantages when the systems are used on Diesel locomotives where the train line pressure is the result of two or three boilers operating in multiple, and it is necessary that each boiler have a ready controllable boiler pressure.

In my prior application, Serial No. 184,669, filed September 13, 1950, now Patent No. 2,767,690 dated October 23, 1956. I have disclosed a boiler control system employing an air-start type of blower-turbine-oil-pump set which dispenses with the use of an electric motor as a component part thereof, and which includes novel means for controlling the operation of the turbine and water pump regulators, whereby the disadvantages of the patented systems above referred to are overcome. In said Patent No. 2,767,690, I have claimed the air-start feature and controlling means associated therewith as a subject-matter of invention. The present application is a continuation-in-part of said Patent No. 2,767,690, and the claims thereof cover as a subject-matter of invention the novel means above referred to for controlling the operation of the turbine and water feed regulations to govern the boiler firing rate and the level of the water in the boiler. In this connection it is to be understood that such means for controlling the operation of the turbine and water feed regulators may be used in a system employing blower-turbine-oil-pump sets with or without an electric motor and burners of the types disclosed in the aforesaid patents and application, or of any other suitable types.

The invention will be readily understood from the following description, taken in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of a heating system embodying the novel features of the invention.

Fig. 2 is a diagrammatic view of the wiring of the control circuits thereof.

Fig. 3 is a vertical section on an enlarged scale through the turbine regulator and associated control valve.

Fig. 4 is a longitudinal section on an enlarged scale through the turbo-fuel pump-blower unit.

Fig. 5 is a vertical section through the Magnatrol float control device.

Fig. 6 is a vertical section through one of the magnet valves.

Fig. 7 is a vertical section through the water pump regulator.

The following legends applying to the general organization shown in Fig. 1 will be of aid in obtaining an understanding of the construction and operation of the parts thereof:

LEGENDS

X—Manual valves, even no's. normally open in operation, odd no's. normally closed

2 Train line
4 Train line
6 Auxiliary steam
8 Pump steam
10 Turbine steam
12 Boiler feed
14 Air to turbine reg. valve
16 Fuel
18 Water
20 Turbine air, **22** Cont. blowdown
1 Train line emergency
3 Continuous blowdown, test
5 Boiler blowdown
7 Drain and water sample
9 Pump air
11 M F blowoff
13 W C blowoff
15 Stack blower

MV—Magnet valves

MV–**1** Fuel
MV–**2** Turbine air drive
MV–**3** Train line, may be operated manually
MV–**4** Continuous blowdown
MV–**5** Pump on, governed by M F
MV–**6** Pump, load control governed by M F
MV–**7** Pump off, governed by M F

KN—Key needle valves

KN–**1** Continuous blowdown, set for 100 lbs. per hour.
KN–**2** Set to keep C J cool
KN–**3** Set for 40 lbs., when valve **10** is closed and MV–5 open
KN–**4** Low fire, set for minimum fire
KN–**5** High fire, set maximum fire
KN–**6** Open 1 turn

SV or RV—Relief or safety valves

SV–**1** Set for 250 lbs.
SV–**2** Set for 252 lbs.
RV–**1** Fuel control, set for 40 lbs.
RV–**2** Pump protection 250 lbs.

PS—Pressure switches

PS–**1** Set to close at 10 lbs. and reopen at 5 lbs.
PS–**2** Set to open at 60 lbs. and reclose at 42 lbs.

Pressure regulating valves

1 Atomizer, set for 15 lbs.
2 Turbine standby, set for 15 lbs.
3 Turbine reg. control, set for desired train L. press.
MF Magnatrol float, boiler water control
CJ Cooling jacket, for LW switch
LW Low water thermostat
WC Water column

Referring first more particularly to the general organization shown in Fig. 1, the steam heating supply system comprises a boiler or steam generator A of the type described, an atomizing burner B, herein shown as one of whirl type, a steam driven water pump WP for supplying water to the boiler, and a fuel-pump-blower unit TPB indicated at **4′** in Fig. 1 and shown in detail in Fig. 4, said unit consisting of a blower *a* for supplying combustion air to the boiler fire-box, a gear-type pump a' for supplying a liquid fuel, such as oil, to the burner, and a turbine a^2 for driving the blower and fuel pump, said blower, fuel pump and turbine being mounted on a common shaft a^3 within a common casing a^4; together with a superheated steam service pipe TL for supplying

steam to the car heaters, a system of piping connecting the burner, water pump, turbine and fuel pump with the boiler and a source of compressed air supply, a set of devices, generally indicated at WCD, for regulating the water level in the boiler, and an electric circuit C containing control devices associated with automatic control elements in the piping of the system and governing or governed by the automatic control elements in the circuit to regulate the supply of water to the boiler, fuel to the burner, driving air and steam to the turbo-fuel-pump-blower unit, and atomizing air and steam to the burner.

The boiler is provided with two safety valves, one, SV–**1**, set for 250 lbs. pressure, and the other, SV–**2**, set for 252 lbs. pressure, while in the various pipe connections of the system, which are hereinafter more fully described, are arranged a turbine regulator TR indicated at **3′** in Fig. 1 and shown in detail in Fig. 3, and sets of valves and pressure switches for governing the flow of the fluids to the working parts. These sets of valves and switches consist of a set of manual valves **1** to **16**, inclusive, and **18**, **20**, **21**, **22**, the even-numbered valves being normally open and the odd-numbered valves normally closed in operation, a set of magnet valves MV–**1** to MV–**7**, inclusive, one of which is indicated at **2′** in Fig. 1 and shown in detail in Fig. 6, a set of key needle valves, KN–**1** to KN–**6**, inclusive, a pair of relief valves, RV–**1**, RV–**2**, a set of pressure regulating valves PR′, PR–**2**, PR–**3**, and a pair of pressure switches PS–**1**, PS–**2**. In addition to these valves and switches, there are arranged at proper points in the piping check valves **17**, $\mathbf{17^a}$, **19**, $\mathbf{19^a}$, $\mathbf{19^b}$, gauges $\mathbf{19^c}$ and strainers **19′**, the direction of flow through the check valves being indicated by the associated arrows and the direction of flow through the strainers being toward their wider ends. Of these valves of set **1** to **16**, **18**, **20**, **21**, **22**, whose functions are not indicated by legends on or applying to Fig. 1 of the drawings or hereinafter described, valve **1** is an emergency valve which may be opened to allow steam to by-pass magnet valve MV–**3** when occasion requires, valve **3** is a continuous-blow-down test valve, valve **5** is a boiler blow-down valve, and KN–**1** is a continuous blow-down key-needle valve set for 100 lbs. per hour. Valve MV–**3** is a magnet valve which may be operated by hand when required. Pressure switch PS–**1** is set to close at 10 lbs. and reopen at 5 lbs. Pressure switch PS–**2** is set to open at 60 lbs. and reclose at 42 lbs. Pressure regulating valve PR–**1** is set for 15 lbs., while pressure regulating valve PR–**2** is set for a turbine stand-by action at 15 lbs., and pressure regulating control valve PR–**3** is set for a desired train line pressure.

Of the set of valves **17**, $\mathbf{17^a}$, **19**, $\mathbf{19^a}$, $\mathbf{19^b}$, valves **19** may be check valves of conventional type, but valves **17**, $\mathbf{17^a}$, $\mathbf{19^a}$, $\mathbf{19^b}$ are arranged and designed to perform special functions, as hereinafter described.

Referring now to the circuit C shown in Fig. 2, which is supplied with current from a battery or other source on the vehicle, this circuit includes the circuit breaker CB, the start button SB, the stop button SB′, the start relay coil R–**1** and its switches R–$\mathbf{1^a}$, R–$\mathbf{1^b}$, the running relay coil R–**2** and its switches R–$\mathbf{2^a}$, R–$\mathbf{2^b}$, the train line relay coil R–**3** and its switches R–$\mathbf{3^a}$, R–$\mathbf{3^b}$, the alarm relay R–A, the start control Agastat coil AG–**1** (30 sec.) and switches AG–$\mathbf{1^a}$, AB–$\mathbf{1^b}$, the flame control Agastat coil AG–**2** (15 sec.) and its switch AG–$\mathbf{2^a}$, the Magnatrol control Agastat coil AG–**3** (5 min.) and switch AG–$\mathbf{3^a}$, the ignition electrode EL, the ignition set IV, the low water switch LW, the fuel magnet valve MV–**1**, the turbine air drive magnet valve MV–**2**, the train line magnet valve MV–**3**, the blow-down magnet valve MV–**4**, the pump-on magnet valve MV–**5**, the pump control magnet valve MV–**6**, the pump-off magnet valve MV–**7**, the flame control switch LS, the burner pressure switch PS–**1**, the turbine air drive pressure switch PS–**2**, the boiler failure light BFL, the Magnatrol float MF, the train line valve VO (open), the train line valve VC (closed), the upper limit water level switch L–1, the lower limit water level switch L–2, and the resistors RES–1 to RES–5, inclusive, of suitable values, which parts are connected to operate in the manner hereinafter described to govern the actions of the water pump, turbo-pump unit and other working parts of the system.

The water supplying connections to the pump WP and boiler consist of a supply pipe **21** leading to the pump from a tank **22** or other source of supply and a feed pipe **23** leading therefrom to a condenser **24** and an economizer **25** and thence to the water containing space of the boiler. The supply of water to the boiler is controlled in this system by regulating the supply of steam to the pump WP and the water level in the boiler is limited within certain levels by the action of the set of control devices WCD which govern the supply of steam to the pump and also operate to cut off the supply of steam to the pump and given an alarm in the event that the water in the boiler falls below a predetermined low level.

The set of control devices WCD consists of pipes **26**, **27**, **28** connected at their upper ends to each other and to the steam space of the boiler and connected at their lower ends to the water containing space of the boiler. In the pipe **26** is arranged the Magnatrol-float boiler water regulator M–F, indicated at **2′** in Fig. 1 and (shown in detail in Fig. 5) controlling the electric switches L–1, L–2, arranged in the control circuit C, while in the pipe **27** is disposed a water column WC and in the pipe **28** is a cooling jacket CJ and a thermostatic low water level switch LW. A pipe **29** containing the key needle valve KN–2 and leading from the intake end of pipe **23**, supplies cooling water to the lower end of the jacket, and a pipe **30** allows flow of the hotter water from the top of the jacket to the delivery end of pipe **23**, whereby a circulation of cooling water through the jacket is provided for to keep the thermostat inactive as long as the water in the boiler is above the predetermined low level. When, however, the water in the boiler falls below such level, heat from the steam in pipe **28** will energize the thermostatic element to cause it to open switch LW and shut down the boiler.

Leading from the boiler is a main steam supply pipe **31** having a feed branch **32** leading to the water pump drive WPD, a feed branch **33** leading to the turbine a^2, a pressure supply branch **34** connecting the branch **33** and the diaphragm chamber of WPR and a feed branch **35** leading to the atomizing burner B for supplying steam as an atomizing agent thereto. A water pump regulator valve WPR of suitable type and indicated at **7′** in Fig. 1 and shown in detail in Fig. 7, is arranged in pipe **34** between pipes **32**, **33**. Spent steam or exhaust pipes **36**, **37**, leading from the pump WP and turbine a^2, are provided for the flow of the exhaust steam therefrom to the jacket of the condenser **24**, from which the water of condensation may be conducted through a pipe **38** back to the water supply tank for re-use. The valve **6** in the pipe **31** and the valve **10** in the inlet end of pipe **33** are manually operable control valves. Valve **10**, however, which controls the flow of steam to the turbine and is arranged ahead of the turbine regulator TR and pressure regulating valve PR–2 in pipe **33**, may be automatically controlled to open when the running relay R–2 is energized. A drain pipe **35′** governed by the key needle valve KN–6 and magnet valve MV–7, is included in the steam pipe connections, and drain connections are provided at other points where needed.

The fuel supply connections to the fuel pump and burner consist of a fuel supply pipe **39** leading to the pump a' from a source of fuel supply, an atomizing fuel feed pipe **40** leading from the outlet of the pump to the burner B, a pair of by-pass connections **39′** between said pipes across the pump, one of which by-passes contains the high fire key-needle valve KN–5 set for supply of fuel to the burner for maximum fire, and the other pump protecting relief valve RV–2, set for 250 lbs., the fuel magnet valve MV–1 in the pipe **40**, the relief valve RV–1 in the fuel feed pipe **40**, and the key-needle low-fire valve KN–4 in the pipe **40** which by-passes the valve RV–1 and is set to control and allow passage of fuel to the burner for minimum fire. The intake end of pipe **39** is provided with a filter and valves of the character indicated.

The air supplying pipe connections of the system consist of a main air supply pipe **41** leading to the pipe **33** from a suitable source of compressed air supply, such as the main air reservoir of the locomotive, a branch pipe **42** leading therefrom to the pipe **34** below the water pump regulator valve WPR, a branch pipe **43** leading therefrom to the turbine regulator TR, and a branch pipe **44** leading therefrom to the pipe **32**, said pipes **41**, **42** and **43** containing the magnetic, the manually operable, the check and key-needle valves indicated. The pipe **44**, in which the control valve **9** is arranged, connects with pipe **32** between the control valve **8** and the pump WP and may be employed in case of an emergency to supply compressed air to operate said pump when the boiler is not generating and the water therein is too low and must be replenished before the system can be started into action. As stated, the pump regulating valve "WPR" may be of any suitable construction and is arranged so as to be governed by pressures in the pipes **34** and **35′** or **42**, to regulate the supply of steam to the water pump.

The turbine regulator TR indicated generally at **3′** in Fig. 1 and shown in detail in Fig. 3 with pressure regulator PR–3, includes a diaphragm chamber **45**, arranged between pipes **33′** and **43** and a valve chamber **46** arranged in the pipe **33**, a diaphragm **47** arranged in the chamber **45** and exposed to the opposing steam and air pressures in the pipes **33** and **43**, a valve comprising spaced valve members **48**, **48′** in the chamber **46** and controlling the flow of steam to the turbine through upper and lower ports **49**, **49′** formed in a partition **46′** in the chamber **46**, a stem **50** connecting the diaphragm and valve, and a spring **51** acting on the stem to oppose movement of the diaphragm and valve in the downward direction. Spring **51** is adjustable to regulate its pressure on the diaphragm by means of a supporting and adjusting member **51′**. The turbine regulator is adapted for cooperation with the pressure regulating valve PR–2 in the by-pass across the valve chamber **46** and the pressure regulating valve PR–3 in the pipe **43**. These valves PR–2 and PR–3 may be of any suitable construction, but, as shown, the valve PR–3 comprises a casing having a diaphragm chamber **52**, a diaphragm **53** in said chamber, a spring **54** in the upper part of the casing exerting downward pressure on the diaphragm, adjusting means **55** for regulating the pressure of the spring, locking means **56** for locking the adjusting means in adjusted position, a valve chamber **57** beneath the diaphragm having inlet and outlet ports **58** and **59**, a partition **60** separating said ports from each other, a port **61** connecting the inlet port with the bottom of the diaphragm chamber, a port **62** connecting the outlet port with the bottom of the diaphragm chamber, a valve **63** in the valve chamber, a stem **64** connecting said valve with the diaphragm, and a spring **65** pressing upward on the valve to hold it closed or more or less open against the pressure of the spring **54**. Valve PR–2 may be generally similar in construction to valve PR–3. The function of valve PR–3 acting in conjunction with the turbine regulator valve TR is to control the turbine action for a desired normal train line pressure, while the function of valve PR–2, which is set for 18 lbs., is to control the stand-by action of the turbine. The atomizer pressure regulating valve PR–1 is normally set for 15 lbs. pressure.

It will be understood that when the system is in running operation the diaphragm **47** is subjected on its upper side to the pressure of the steam at a desired boiler pressure and on its lower side to the counteracting pressure of the compressed air passed by valve member **63** of valve

PR–3 plus the pressure of the spring **51**. Normally the air in pipe **43** at the inlet side of the valve PR–3 is at main reservoir pressure, e. g., 130 lbs. per sq. inch, from which it may be varied by regulation of the spring **54** and position of valve member **63** to deliver the air at any desired pressure below or up to **130** lbs. to the diaphragm chamber **45** to control the movements of the diaphragm **47**, and consequently the normal positions and movements of valve members **48, 48'**, to regulate the flow of steam to the turbine as a function of boiler pressure to drive the turbine at a desired substantially uniform speed, whereby the amount of fuel supplied to the burner is automatically controlled to cause the boiler to generate steam at the desired maximum pressure. Through the adjustment of valve PR–3 the boiler pressure may be changed to any pressure within the limits of the main reservoir air pressure, in this instance, for example, from 250 to 120 lbs. Valve PR–2 operates to pass sufficient steam to the turbine to keep the turbine running for stand-by firing when the turbine regulator valve is closed.

In the air starting operation of the system, assuming that the boiler is cold and in starting condition, and with all even numbered valves, except Nos. 4 and 10 open and all odd numbered valves closed, the starting button is pressed with the result that valves MV–1 and MV–2 are opened for the flow of air to the turbine to drive unit TPB and for the flow of oil to the burner. Valve **20**, which is a reducing valve located on the turbine side of valve MV–2, is preadjusted to allow about 25 lbs. pressure on the turbine when valve MV–2 is open to about 130 lbs. main reservoir pressure. The check valve **15** following valve **20** is to protect the air line from condensation flow from the steam line as a safety precaution, although the normal pressures existing in the system could only cause a flow to exist from the air line towards the turbine. The turbine regulator valve TR is normally wide open until the steam pressure in the pipe line **33'** is approximately 100 lbs. or more. As this valve and the regulating valve PR–2 are not concerned in the air start, except as above described, their working functions at this stage need not be considered. When the fuel supplied to the burner ignites, however, turbine valve **10** is opened. The turbine and burner atomizer will run on air only until the boiler pressure is sufficient to lift the check valves in the steam supply pipes, at about **25** lbs. Thereafter, both steam and air will be fed to the turbine and burner until at about 50 lbs. boiler pressure switch PS–2 will be opened and cause magnet valve MV–2 to close. This cuts off the air supply to the turbine and burner and the steam supply pipes will be supplied with steam to drive the turbine, furnish atomizing steam to the burner and operate the other parts of the apparatus. If the boiler is to be started when the steam pressure is up, the same operation as above described is followed, but in this case when valve **10** is opened the air start magnet valve MV–2 will close almost immediately. In the normal air starting operation valve MV–2 is energized and opens whenever pressure switch PS–2 is closed or start control Agastat AG–1 is energized. The interlock on AG–1 in MV–2 circuit will keep MV–2 open for 30 seconds after the start button is pushed, regardless of the boiler pressure and switch PS–2 will keep MV–2 open until the gas pressure in the pipe line to the burner atomizer reaches a predetermined amount sufficient to keep the turbine running at the desired maximum speed. Whenever switch PS–2 is open and AG–1 has been deenergized for over 30 seconds MV–2 is closed. As soon as the system begins to run entirely on steam generated by the boiler, the turbine regulator is governed by boiler pressure to regulate the speed of the unit TPB and the amount of fuel supplied thereby to the burner and the amount of combustion air supplied to the boiler firebox per unit of time to keep the boiler generating at the desired rate.

As before stated, check valve **19**^{a} in pipe **33** between

valve **10** and pipe **32**, and check valve **19**^{b} in pipe **31** adjacent the boiler, have special functions. Valve **17** is a check valve and acts only to protect against any back flow of steam into the locomotive air brake system air. The arrow beside valve **17** in Fig. 1 shows direction of flow through the valve.

Valve **17**^{a} is mechanically similar to **17** except that a small hole is drilled through the valve seat and its function is thereby materially changed. When magnet valve MV–5 is opened, air flows through valve **17** through throttling valve KN–3 to chamber of WPR. Now, if valve **17**^{a} had no hole in its seat, the air pressure in chamber WPR would build up to the maximum pressure of the locomotive air system and WPR would be forced to the full open position regardless of steam pressure through MV–6. If valve **17**^{a} had a large hole in its seat, as compared to orifice in KN–3, the air flow from MV–5 through KN–3 would not be able to add to the pressure in chamber of WPR and WPR would still be entirely controlled by steam pressure through MV–6. As designed, however, valve **17**^{a} has a small hole in its seat and thereby allows the air pressure to add to the steam pressure in chamber of WPR.

Now the benefits of such an arrangement can be shown by the following examples. Assume the boiler is idling on the line and little or no steam is flowing through valve **2**. The steam pressure in line **33'** is only sufficient to supply fuel and air for this purpose and perhaps is at 20 lbs. pressure. WPR is set nominally to supply steam to the boiler water feed pump at an equivalent rate but say it is slowly falling behind in its supply. When MV–5 opens an account of this lowering of water in the boiler, the air passing through KN–3 will bleed off through valve **17**^{a} and the chamber pressure in WPR will only build up to say 36 lbs. under this dynamic condition. With 35 lbs. of pressure in chamber, the boiler feed steam will be increased but not to a maximum rate which would be the case except for valves **17**^{a} and KN–3.

A maximum feed water rate is not good for the boiler for reasons well known and also may cause a drop in boiler pressure which would cause the controls to increase the fuel-air rates and tend toward a cycling condition. It will be noted that in each case of increase in boiler load the air pressure will add to the steam pressure from line **33** until line **33** is at the same pressure as the locomotive air system. WPR is fully opened at pressures somewhat under the pressure of the locomotive air system.

The chamber of valve WPR is under atmospheric air pressure only when the water in the boiler is higher than desired; at this time valve MV–6 is closed and MV–7 is opened. When boiler water level is at nominal desired range, then the chamber of WPR is under the steam pressure obtained from line **33** through valve MV–6; MV–7 and MV–5 being now closed. When the boiler water level is below the desired level, then valve MV–5 opens and loads in unison with the steam pressure from line **33**, the chamber of WPR. The amount of pressure added by the air to chamber of WPR at this time will be in an inverse proportion to the firing rate, being zero lbs. when the pressure in line **33** is at a maximum firing rate amount of say 125 lbs., and say 15 lbs. when the pressure in line **33** is at a minimum firing rate of perhaps 20 lbs. Valve PR–3 is provided to regulate the air pressure supplied to the turbine regulating valve **46**. Valve **19**^{a}, provided with a 1/16 hole in its seat, operates to keep pipe **32** leading to the water pump from being immediately charged with air when valve **10** is opened, which would decrease the pressure in the burner atomizing line and shut down the boiler by opening switch PS–1 in the running relay circuit. It also limits the air flow to the water pump in the event that the pump regulator valve WPR is open. This valve automatically closes during the start period, although it may remain open for a few minutes. The check valve 19^b operates to keep the air from charging the boiler. It is also very necessary to keep low pressure, low temperature steam from entering the steam line and condensing in the atomizing line to the burner. The air pressure on top of this check valve holds it closed until the boiler pressure is approximately 25 lbs. Thereafter, there is a steady and increasing flow of steam to the turbine and atomizer. As stated, the water pump regulator WPR may be of any suitable construction, but I prefer to use one of the type indicated at **7′** in Fig. 1 and shown in detail in Fig. 7. This regulator, which is somewhat similar in construction to the turbine regulator TR, is interposed between pipes **32** and **34** and comprises in its construction a diaphragm casing **66** having arranged therein a flexible diaphragm **67** dividing the casing into upper and lower chambers **68** and **69**, chamber **68** being open to the atmosphere while chamber **69** is in communication with pipe **34** above the level of pipes **35′** and **42**. Above the diaphragm casing is a valve casing **70** communicating with portions of the steam supply pipe **32** and having a partition provided with a port **71** controlled by a valve **72** carried by a sliding stem **73** which couples the valve to the diaphragm. The stem is slidably mounted in a frame structure connecting the diaphragm and valve casings and consisting of a pair of rods **74** connected at their lower ends to the diaphragm casing and at their upper ends to each other by a head **75** connected by a tubular guide coupling **76** to the valve casing. The stem **73** is slidable through the head **75** and coupling **76** and also through an adjusting member **77** which is slidably mounted on the rods toward and from an abutment **78** on the stem, between which abutment and the member **77** is arranged a supporting and pressure controlling spring **79**. The spring normally holds the member **77** pressed upward against adjusting nuts **80** engaging threaded portions **81** of the rods, by which the member **77** may be adjusted to regulate the pressure of the spring and its resistance to the upward movement of the stem and valve under the pressure on the diaphragm of fluid in the diaphragm chamber **69**. With this arrangement the regulator WPR controls the supply of steam to the feed water pump WP to govern its action. Normally the valve **72** is held closed when the pressure in the diaphragm chamber **69** is zero and opens according to the steam pressure in the diaphragm chamber **69** supplied thereto from pipe **34** connected to the turbine inlet pipe **33**. By connecting the diaphragm chamber **69** to the turbine inlet pipe **33** through pipe **34** the diaphragm pressure will be automatically varied according to turbine speed, since the regulator WPR allows more steam to pass to the feed water pump proportionately as the firing rate increases. This method of operation requires the use of controls to definitely limit the water in the boiler within certain levels. This is done through the use of the float MF controlling upper and lower water limits electric switches L–1 and L–2. With the boiler level normal, between one-half and three-quarters of a glass, switch L–1 energizes pump control magnet valve MV–6 which opens and connects the pump regulator diaphragm to the turbine inlet pipe. Switch L–2 energizes time delay relay Magnatrol control Agastat AG–3 which immediately closes the interlock in the running relay R–2 circuit. If the pump regulator adjustment allows the boiler water level to rise, switch L–1 opens the circuit to pump control magnet valve MV–6, thereby cutting off the supply of steam to the pump regulator diaphragm chamber. It also energizes magnet valve MV–7 which opens and bleeds off all the pressure from the pump regulator diaphragm chamber. The boiler water level will then start to lower and at about three-quarters of a glass switch L–1 returns to its former position and the feed pump again operates.

If the pump regulator adjustment is such that the boiler water level was lowering from the normal position then switch L–2 would energize magnet valve M–5 and open the circuit to Magnatrol control Agastat AG–3. Time delay switch L–2 will hold its interlock in the closed position for five minutes after the coil is deenergized. At the end of this five minute period the interlock on AG–3 will open the circuit to the running relay R–2 and shut down the boiler. However, in the five minute interval MV–5 again opens and, through a presetting of KN–3 against the 1/16 inch hole in check valve after MV–6, about 60 lbs. of additional pressure from the air supply pipe **41** will be placed in the pump regulator diaphragm chamber. This opens the pump regulator valve **72** and speeds up the pump. The water level then returns to normal in about two minutes and switch L–2 will return to its normal position.

In this system, as stated, the feed of water to the boiler is controlled by controlling the supply of steam to the water pump driver WPD. By connecting the diaphragm chamber of the pump regulator to the turbine inlet pipe the diaphragm pressure regulates the pump speed with the firing rate and as the firing rate increases the water pump regulator allows more steam to feed to the water feed pump. The Magnatrol float switch M–F is a float mounted in such a manner on the boiler as to maintain a position in direct relation to the height of water in the boiler through that section of the boiler corresponding to the section covered by the boiler water glass. The Magnatrol float operates by magnetic action the two single pole double throw switches L–1 and L–2 which are displaced from each other by about one inch in a vertical direction and operates as follows: With no water in the boiler or water below the middle of the water glass the switch positions are as shown in Fig. 2. The feed pump may be operated on air or steam until the water level in the boiler is at the normal operating level. At this stage switch L–1 is as shown in Fig. 2, but switch L–2 completes the circuit to AG–3. This is a time delay relay having immediate action when coil AG–3 is energized but having a five minute delay when the coil AG–3 is deenergized. In this normal operating position MV–6 and AG–3 are both energized AG–3 interlock in the R–2 or running relay circuit is closed and MV–6, a magnet valve, is open. As previously described the turbine regulator controls the steam to the turbine in accordance with boiler pressure, varying the pressure to the turbine in approximately the inverse ratio to boiler pressure, and thus controlling the boiler firing rate. With MV–6 open the pump regulator WPR is under the influence of the firing rate, opening as the rate is increased and closing as the rate is decreased.

With an ideal condition, this arrangement could keep the boiler water level constant, but such a condition is not obtainable in practice, and the boiler level will either rise or fall. If the boiler water level rises switch L–1 will be opened to break the circuit to MV–6 and energize magnet valve MV–7. When this occurs the pump regulator diaphragm pressure is discharged to atmosphere and the steam to the feed pump is shut off. As the water level decreases the normal operating condition is again obtained, as above described, wherein the pump regulator WPR is opened as a function of the firing rate. If the water level falls too far switch L–2 will operate to open the circuit to AG–3 and complete the circuit to magnet valve MV–5 located in the pipe **42** between the locomotive main air reservoir (not shown) and the diaphragm of the pump regulator WPR. This pipe contains the key metering needle valve KN–3 which is set to obtain 40 lbs. pressure on the regulator diaphragm when the turbine pressure is zero. The small hole, 1/16″ diameter, in the seat of check valve 17^a allows some leak-off and under this condition the key needle valve KN–3 can be set to control the air pressure on the pump regulator diaphragm at any pressure between 0 lbs. and a few pounds below main air reservoir pressure. Now with the pressure set at 40 lbs. against 0 lbs. in the turbine, the two pressures will rise approximately together; in other words, if the turbine has 20 lbs. pressure, the diaphragm will be under 60 lbs. pressure during periods of low water. The full pressure from the air line is not desired, but only enough pressure to speed the pump up a fair amount over its speed at the normal water level setting. A wide open feed pump valve MV–5 would accelerate the pump too fast, at low firing rates, and cause erratic boiler operation on account of dumping a lot of cold water in the boiler in a short time. It would also affect the efficiency of the turbine steam condenser, as there would be periods when the amount of feed water would not be sufficient to condense the steam.

The action of the time delay relay AG–3 is as follows: When its circuit is opened it will hold the interlock in series with the running relay R–2 in closed position for five minutes. If in that time the boiler water level has not returned to the normal operating level the interlock will open the circuit to R–2 and shut down the boiler. Thus AG–3 will prevent operation of the boiler if the water level continues below about one half water glass for more than five minutes, and will prevent starting the boiler if there is insufficient water in the boiler. It thus works in conjunction with LW, the temperature controlled water switch, giving an additional safety factor for normal operation and adding the feature of preventing damage being done to the boiler on account of being fired without sufficient water.

As before stated, the boiler pressure control in the patents referred to is essentially a constant pressure control. This type of control is satisfactory for boilers operating alone, but on diesel locomotives, the steam train line pressure is the result of two or three boilers operating in multiple, and hence it is necessary that each boiler have a readily controllable boiler pressure which is obtained by the action of the turbine regulator operating in conjunction with the pressure controlled means and the pump regulator to control the firing, water feed and generating ratios. The lower diaphragm chamber of the turbine regulator is preloaded with air pressure varying from 0–125 lbs. p. s. i. The spring in the turbine regulator valve is set to close when the steam pressure is 125 lbs. in the top diaphragm chamber and there is 0 lbs. air pressure in the bottom chamber. The air pressure in the turbine regulator regulating valve is adjusted by regulating valve PR–**3** to give the desired boiler pressure according to the pressure gauge connected to the bottom diaphragm chamber. This gauge is calibrated to show 125 lbs. pressure at the normal zero position of the gauge hand. Thus when air pressure at 70 lbs. is added to the 125 lbs. spring pressure 195 lbs. pressure in the boiler will be required to close the turbine regulating valve and reduce the firing rate to a point where it will just maintain standby losses. By adjusting the air pressure supplied through control valve PR–3, the steam pressure in the boiler can be controlled from 125 lbs. to approximately 265 lbs., assuming a main air reservoir pressure of 140 lbs., and thus the steam pressure can be raised and lowered as desired by the operation of control valve PR–**3**.

From the foregoing description, taken in connection with the drawings, the construction and operation of the system will be understood without a further and extended description, and it will be seen that the invention provides novel means for regulating the action of the water feed pump and controlling the level of the water in the boiler, and pressure controlled electrical means for governing the action of the working parts of the system in a simple, reliable and efficient manner to control the firing and water feed rates to govern the steam generating action of the boiler so that boilers operating in multiple will supply the desired steam train line pressure. While the construction disclosed is preferred, it will, of course, be understood that changes in the form, arrangement and the details of construction of the parts may be made within the scope of the appended claims without departing from the spirit or sacrificing any of the advantages of the invention.

Having thus described my invention, I claim:

1. A steam generation plant, comprising a boiler, a burner for heating said boiler, a source of compressed air, an air or steam driven pump for supplying fuel to said burner, steam and air lines leading respectively from said boiler and from said source of compressed air to the pump, a regulator responsive to boiler pressure for governing the supply of steam to said fuel pump, and thus the firing rate of said burner, an air or steam driven pump for supplying water to said boiler, a regulator responsive to the pressure of steam supplied said fuel pump for controlling the supply of steam to said water pump, a compressed air conduit connected with said fuel pump regulator for varying the action of said fuel pump regulator to render said fuel pump regulator responsive to a boiler pressure of a desired degree and thus to regulate the firing rate in accordance with the desired boiler pressure, and valve means in the air and steam supply lines for controlling the feed of air and steam to said pumps to adapt the pumps to be driven by air in a starting action and to be driven by steam when the boiler generates steam at a predetermined pressure.

2. In a steam generator, a boiler, a burner for heating the boiler, a pump for supplying fuel to said burner, a steam drive means for driving said fuel pump, a regulator for governing the supply of steam to said fuel pump drive means, a source of water, a pump for supplying water to said boiler from said source, a water pump motor, and a regulator governing the supply of steam to said water pump, said first regulator being inversely responsive to variations in the boiler pressure to control the rate of fuel supply to said burner, and, thus, the firing rate of said burner inversely to the boiler pressure variations, and said second regulator being responsive to variations in the pressure of the steam supplied said fuel pump drive means whereby the rate of water supply to said boiler is varied directly in accordance with the firing rate of said burner.

3. A steam generator according to claim 2, and in which a float is located in said boiler, additional water supply regulating means under the control of said float to further regulate the supply of water to said boiler inversely in dependance on the height of the water level therein.

4. A steam generator according to claim 3, and in which said additional water supply regulating means comprises a valve and electrical switch means influenced by the position of said float in said boiler for controlling said valve.

5. In a steam generator, a boiler, a burner for heating said boiler, a pump for supplying fuel to said burner, steam driven means driving said fuel pump, a regulator directly responsive to boiler pressure for governing the supply of steam to said fuel pump driving means, and, thus, the fuel supplying action of said pump, thus, to regulate the firing rate of said burner, said fuel supply regulator including variable resistance means acting inversely to the boiler pressure, a source of water, a water pump for supplying water to said boiler from said source, a pump driving said water pump, a regulator responsive to the pressure of the steam supplied said fuel pump drive means for governing the rate of supply of water to said boiler directly in accordance with the burner firing rate.

6. In a steam generator, a boiler, a burner for heating said boiler, a pump for supplying fuel to said burner, steam driven means driving said fuel pump, a regulator governing the supply of steam to said burner, a regulator governing the supply of steam to said fuel pump drive means to control its speed and the rate of supply of fuel

to said burner, a source of water, a water pump for supplying water to said boiler from said source, a steam driven motor driving said water pump, a regulator for governing the supply of steam to said water pump motor, thus, to control its speed, a source of constant pressure compressed air, a connection between said compressed air source and said fuel pump drive means regulator, said last-mentioned regulator being responsive to boiler steam pressure and said compressed air pressure acting oppositely to the steam pressure to increase the supply of steam for driving said fuel pump faster when the steam pressure is relatively low, thus, to increase the firing rate of the burner, said water supply regulator having a connection with the steam supply to said fuel pump drive means for acting to increase the supply of steam to the water pump, and, thus, the supply of water to the boiler in accordance with the firing rate of the burner.

7. In a steam generator, a boiler, a burner for heating the boiler, a pump for supplying fuel to said burner, steam driven means driving said fuel pump, a regulator for governing the supply of steam to the fuel pump drive means, a source of water, a pump for supplying water to the boiler from said source, a steam driven motor driving said water pump, a regulator governing the supply of steam to the water pump drive motor, said first regulator being responsive to variations in the boiler pressure to control the rate of fuel supply to said burner, and, thus, the firing rate of said burner inversely to the boiler pressure variations, and said second regulator being responsive to variations in the pressure of the steam supplied said fuel pump drive means, whereby the rate of water supply to said boiler is varied directly as the firing rate of said burner, and means controlled by the level of water in said boiler for altering the effect on said water pump regulator of the pressure of steam supplied said fuel pump drive means, to cause the speed of said water pump to vary inversely to the height of level of said boiler water.

8. A steam generation system comprising a boiler, a burner for heating said boiler, a pump for supplying fuel to said burner, steam drive means for said pump, a conduit connecting said pump drive means with said boiler to supply steam to said pump drive means, a fuel pump regulator having steam control means connected in said fuel pump drive means steam supplying conduit, said fuel pump regulator being connected to said boiler and being responsive to the boiler steam pressure to reduce the supply of steam to said fuel pump drive means as the steam pressure increases, and, thus, to reduce the firing rate of said burner, a source of water, a pump connected to supply water to said boiler from said source, a steam driven motor driving said water pump, said water pump drive motor having a steam supply conduit from said boiler, a water pump drive motor regulator having a connection to said fuel pump drive means steam supply conduit, and having steam control means in said water pump drive motor steam supply conduit, said regulator operating said water pump steam control means to increase the supply of steam to said pump, and, thus, increase the supply of water to the boiler directly in accordance with the pressure of the steam supplied said fuel pump drive means, so that the water is supplied directly in accordance with the firing rate of said burner, a steam control valve connected in said connection between said water pump drive motor regulator and said fuel pump drive means steam supply conduit, means including an electric circuit for controlling said valve, and means for altering said electric circuit in dependence on the height of the level of the water in said boiler.

9. A steam generation system comprising a boiler, a burner for heating said boiler, a pump for supplying fuel to said burner, a motor drivingly connected with said fuel pump, a conduit supplying steam from said boiler to said pump motor driving said fuel pump motor, a fuel pump regulator having steam control means connected in said fuel pump motor steam supplying conduit, said fuel pump regulator being connected to said boiler and being responsive to the steam pressure therein to reduce the supply of steam to said fuel pump motor as the boiler steam pressure increases, and, thus, to reduce the firing rate of said burner, said regulator means being responsive to a pressure condition which varies directly as the boiler pressure for closing said conduit when a predetermined maximum boiler pressure is reached, a second conduit means by-passing said regulator and supplying a small amount of steam to said fuel pump motor when said regulator closes said first-mentioned conduit, a source of water, a water pump connected to supply water to said boiler from said source, a steam driven motor connected for driving said water pump, said water pump motor having a steam supply conduit from said boiler, a water pump motor regulator having steam control means in said water pump steam supply conduit, said water pump motor regulator having a connection to said fuel pump steam control means, said water pump motor regulator operating said water pump steam control means to increase the supply of steam to said pump, and, thus, the supply of water to the boiler directly in accordance with the pressure of the steam supplied said fuel pump motor, so that the water is supplied in accordance with the firing rate of said burner, a steam control valve connected in said connection between said water pump regulator and said fuel pump motor steam supply conduit, and means responsive to the level of water in the boiler for exercising further control of the supply of steam to said water pump to cut off the supply of water when the boiler water level rises above a predetermined maximum.

10. A steam generation plant, comprising a boiler, a burner for heating said boiler, a pump for supplying fuel to said burner, a motor for driving said pump, a regulator responsive to boiler pressure for governing the supply of steam to said fuel pump motor, and, thus, the fuel supplying action of said fuel pump, thus, to regulate the firing rate inversely to the boiler pressure, said regulator being responsive to a predetermined maximum boiler pressure to cut off the supply of steam to said fuel pump motor, a water pump having a steam driven driving motor, a regulator responsive to the pressure of the steam supplied said fuel pump motor for normally controlling the supply of steam to said water pump motor to maintain a given normal level of water in said boiler, and means controlled by the level of water in the boiler and connected to said water pump motor regulator to adjust the supply of steam to said water pump motor and, thus, selectively to adjust the speed of said pump to decrease said speed when the water in the boiler rises above the normal water level limits and to increase said speed when said level falls below the normal level limits.

11. A steam generating plant, comprising a boiler, a burner for heating said boiler, a pump for supplying fuel to said burner, a steam driven motor driving said fuel pump, a regulator inversely responsive to boiler pressure for governing the supply of steam to said fuel pump motor, means varying the action of said fuel pump regulator to render it responsive to a boiler pressure of a desired degree to stop said supply of steam to said pump, and, thus, to regulate the firing rate of said burner inversely to the boiler pressure to maintain the desired boiler pressure, a pump for supplying water to said boiler, a steam driven motor driving said water pump, a regulator responsive to boiler pressure for normally controlling the supply of steam to said water pump, thus, to maintain a predetermined normal level of water in the boiler, an electric circuit, including an electromagnet, a valve in said water pump regulator steam supply controlled by said electromagnet for selectively controlling the action of said water pump regulator, and, thus, the speed of the water pump to decrease said pump speed when the water in the boiler rises above the normal level, and to increase said pump speed when said water level in said

boiler falls below the normal level, and a float controlled switching means controlling the action of said valve.

12. A steam generator plant, comprising a boiler, a burner for heating said boiler, a fuel pump for supplying fuel to said burner, a motor for driving said pump, a regulator inversely responsive to boiler pressure governing the supply of steam to said fuel pump motor, and thus, the fuel supplying action of said pump, and, thus, regulating the firing rate, means varying the action of said regulator to render it responsive to a predetermined maximum boiler pressure to shut off said supply of steam to said motor, a water pump having a steam driven motor, a regulator responsive to the pressure of steam supplied said fuel pump motor for controlling the supply of steam to the water pump motor to maintain a predetermined normal level of water in said boiler, an electric circuit, a magnet valve connected in said circuit and controlling the supply of steam, and, thus, the action of said water pump regulator, to reduce respectively, the supply of steam to the water pump motor when the level rises above the normal water level and increase the supply of steam to the water pump motor when the water level falls below the normal level, a float in said boiler, switching means controlled by said float governing the action of said valve.

13. A steam generation plant, comprising a boiler, a burner for heating said boiler, a pump for supplying fuel to said burner, a motor for driving said fuel pump, a regulator inversely responsive to boiler pressure governing the supply of steam to said fuel pump motor, and, thus, the fuel supplying action of the pump, thus, to regulate the firing rate of said burner, means for varying the action of said regulator to render it responsive to the desired maximum boiler pressure, to cut off said supply of steam to said motor, a water pump, a steam driven motor driving said water pump, a regulator responsive to the pressure of the steam supplied said fuel pump for controlling the supply of steam to said water pump motor, thus, to maintain a given normal level of water in said boiler, an electric circuit, a valve connected in said electric circuit to be controlled thereby for controlling the action of the water pump motor regulator to reduce respectively, the supply of steam to the water pump motor when the water level rises above the normal water level and increase the supply of steam to said water pump motor when the water level falls below the normal level, a valve for cutting off the supply of fuel to the burner in the event that the normal level of the water is not restored within a given period after its fall to a low level, a float in said boiler, and switches in said circuit controlled by said float governing the operations of said valve.

14. A steam generation system comprising a boiler, a burner for heating said boiler, a fuel pump supplying fuel to said burner, a fuel pump motor drivingly connected with said pump, a conduit connecting said pump motor with said boiler to supply steam to said pump motor, a fuel pump motor regulator having steam control means connected in said fuel pump motor steam supplying conduit, conduit means connecting said fuel pump regulator to said boiler, said regulator being responsive to the pressure of the boiler steam to reduce the supply of steam to said fuel pump motor as the boiler steam pressure increases, and, thus, to reduce the firing rate of said burner, a source of water, a water pump connected to supply water to said boiler from said source, a steam driven water pump motor connected to drive said water pump, said water pump motor having a steam supply conduit from said boiler, a water pump motor regulator having a connection to said fuel pump motor steam supply conduit and having steam control means in said water pump motor steam supply conduit, said water pump regulator operating said water pump motor steams control means to increase the supply of steam to said water pump motor, and, thus, the supply of water to the boiler directly in accordance with the pressure of the steam supplied said fuel pump motor so that the water is supplied in accordance with the firing rate of said burner, and means governing the action of said water pump motor regulator and operative at subnormal level of the water in said boiler to speed up said water pump for a given period of time and to shut down the burner if the normal water level is not restored during such time period.

15. A steam generator system comprising a boiler, a burner for heating said boiler, a fuel pump for supplying fuel to said burner, a steam driven fuel pump drive means, steam conduction means for supplying steam from said boiler to said fuel pump drive means, a regulator comprising a diaphragm operated valve connected in said steam conduction means for governing the supply of steam to said fuel pump drive means, a steam driven pump for supplying water to the boiler, a steam conduit for supplying driving steam from said boiler to said water pump, a regulator comprising a diaphragm operated valve connected in said water pump steam supply conduit for governing the supply of steam to said water pump, conduit means connecting the diaphragm of said fuel pump drive means regulator with the boiler steam, said fuel pump regulator diaphragm being operatively connected to said fuel pump regulator valve to tend to close said fuel pump regulator valve as the steam pressure increases, thus, to reduce the burner firing rate oppositely to the steam pressure, and conduit means connected with said water pump regulator diaphragm and with the steam supply conduction means of said fuel pump drive means at a point toward said fuel pump drive means from its regulating valve, to control the operation of said water pump directly in accordance with the supply of steam to said fuel pump drive means, thus, to regulate the supply of water to said boiler directly in accordance with the firing rate of said boiler.

16. A steam generation system according to claim 15, and a source of constant pressure compressed air, conduit means connecting said compressed air with the side of said diaphragm of said fuel pump regulator opposite from the stem connected side, thus, to set said regulator to close the supply of steam to said fuel pump at a predetermined boiler steam pressure sufficient to overcome all forces, including said compressed air acting on said diaphragm, in opposition to said steam pressure on said diaphragm, and means for regulating the pressure of the air supplied said fuel pump regulator.

17. A steam generation system according to claim 15, and in which supplemental control means is provided for governing the action of said diaphragm of the water pump regulator at normal water levels in the boiler to increase or decrease the speed of said water pump at low and high water levels, respectively.

References Cited in the file of this patent

UNITED STATES PATENTS

2,116,943	Hamilton et al.	May 10, 1936
2,204,138	Knowlton	June 11, 1940
2,235,541	Warren	Mar. 18, 1941
2,566,041	Simmons	Aug. 28, 1951