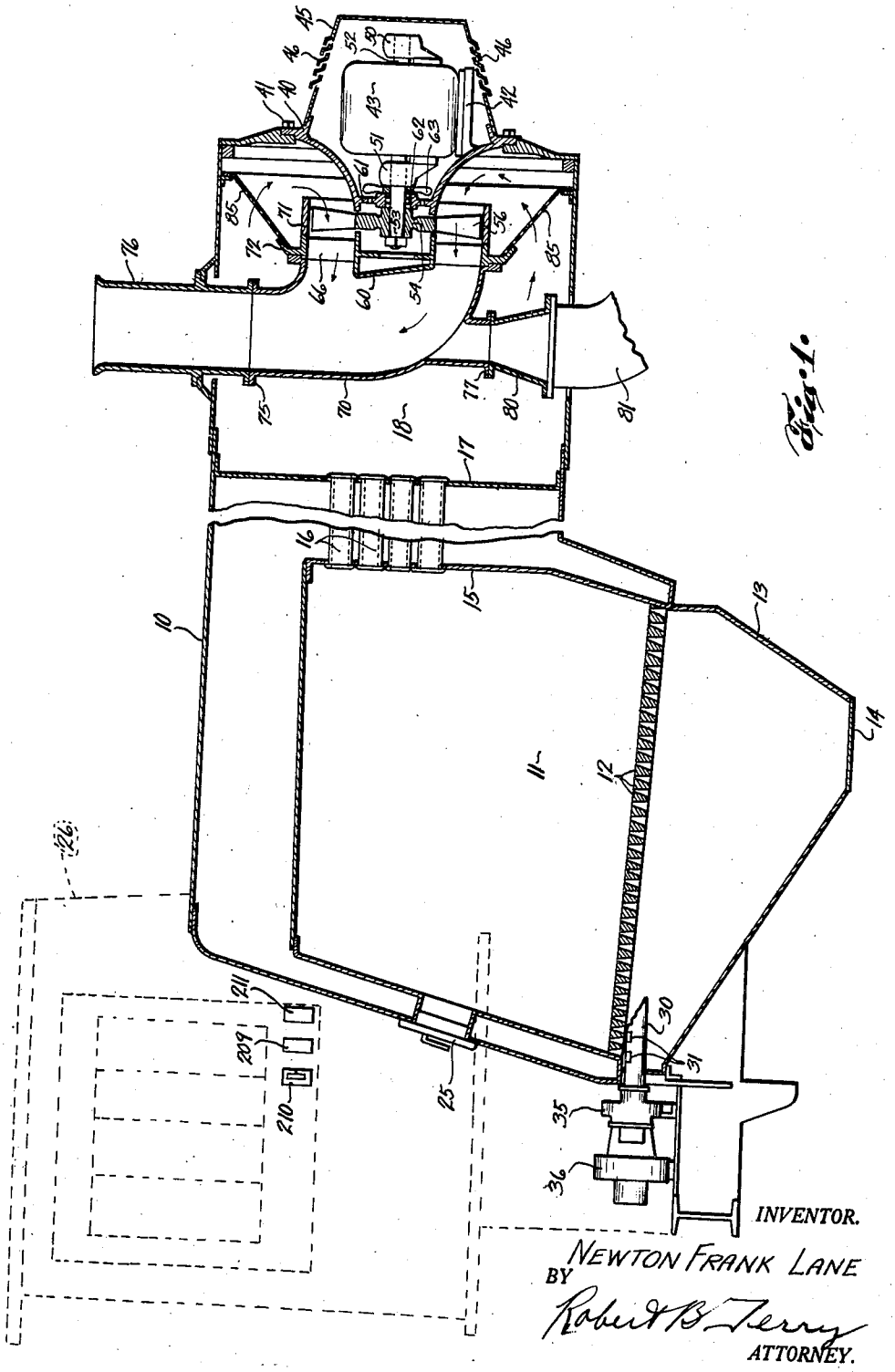
Dec. 26, 1939. N. F. LANE 2,184,647

DRAFTING OF LOCOMOTIVES

Filed May 19, 1937 2 Sheets-Sheet 1



Dec. 26, 1939. N. F. LANE 2,184,647

DRAFTING OF LOCOMOTIVES

Filed May 19, 1937 2 Sheets-Sheet 2

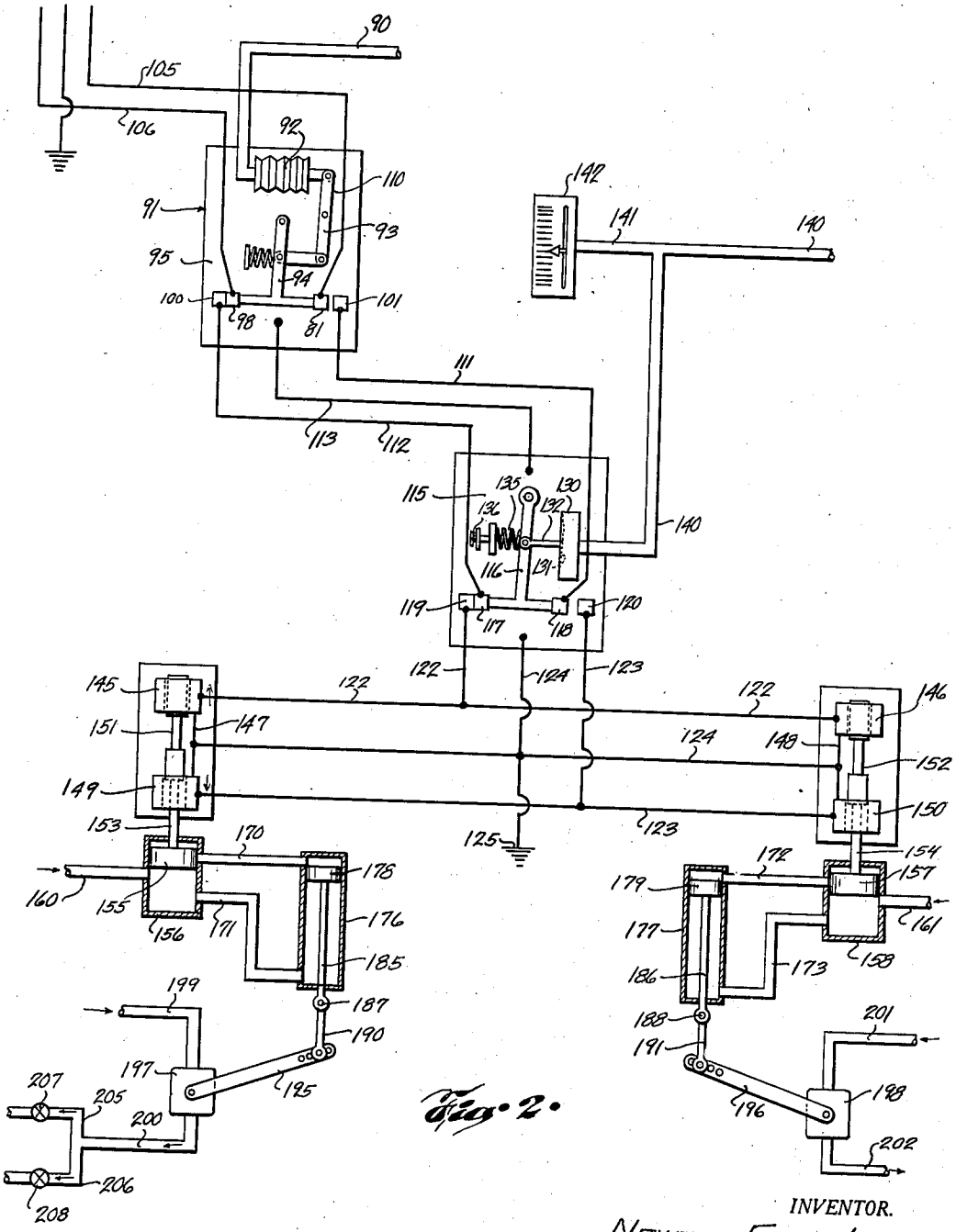


Fig. 2.

INVENTOR.
NEWTON FRANK LANE
BY
Robert B. Terry
ATTORNEY

Patented Dec. 26, 1939 2,184,647

UNITED STATES PATENT OFFICE

2,184,647

DRAFTING OF LOCOMOTIVES

Newton Frank Lane, Decatur, Ill.

Application May 19, 1937, Serial No. 143,463

6 Claims. (Cl. 236—15)

This invention relates to improvements in drafting of locomotives, and more particularly to improved means for effecting a balanced drafting of locomotive type boilers, together with automatic control facilities for the drafting means.

With the advent of high speed train operation, and consequently greater requirements of steaming rate, it has become increasingly important to improve the efficiency of draft-producing equipment, among other reasons, in order to enhance the steaming rate of existing types of locomotives and locomotive type boilers.

Numerous attempts have been made over a period of years, to the end of perfecting a mechanical system of drafting of boilers of the types mentioned; however, such attempts have met with only indifferent success, due in large part to the lack of provisions for effecting an automatic control of the draft-inducing and -producing agencies, these shortcomings being due at least in part to the lack of equipment for controlling the air displacement by such agency, as a function of or in response to variations in steaming requirements of the engine or boiler. So far as is known, no automatic control of mechanical drafting equipment has appeared in the art, but for the few devices which to date have been definitely proven unsatisfactory for their intended purpose. It is accordingly a major object of the present invention to provide a fully automatic control system, responsive to boiler steam pressure or boiler steaming requirements, to influence the mechanical drafting means utilized in connection with boilers of the types noted.

A number of attempts have been made in the past, but with no degree of success, to draft locomotive type boilers mechanically through the use of an induced draft fan or blower, generally located in or adjacent to the smoke box. It has also been attempted to augment the volume of air utilized for combustion, by the installation of forced draft fans or blowers of various types, serving to introduce the combustion air under a positive pressure, through or beneath the grate bars. Neither of these devices or methods is, considered alone, fully satisfactory for the purpose of drafting locomotive type boilers, largely because of the widely varying pressure conditions existing between the zones in and adjacent to the fire box, and those zones in which the air, charged with solid particles resulting from combustion, exists at a high temperature, as in the smoke box. With the use of a forced draft system alone, the zones of combustion are put under a substantial positive pressure, creating a tendency at times for the gases and flames to be driven out through the fire door. On the other hand, utilizing only an induced draft blower, there results a partial vacuum in the zone of combustion. Thus at the numerous times of opening the fire door, there results a detrimental inrush of cold air which reduces the temperature of the gases of combustion and reduces the heat otherwise available to generate steam. It is accordingly an additional object of the present invention so to regulate the speeds, and hence the displacements of the fore and aft blowers, that there is maintained a pressure approximating atmospheric in the combustion chamber. This arrangement results in what may, for convenience, be termed a balanced draft system.

It is a still further important object of the invention to provide, as a part of or adjunctively to a balanced draft system of the type described, a full automatic control arrangement therefor, whereby the speeds and displacements of the forced draft and induced draft blowers may be not only proportioned correctly, but may be varied directly and automatically in keeping with steaming requirements.

Still further objects of the invention may be noted as attained in an improved design and structure of blowers or fans for the purposes noted, including features of design which greatly enhance the efficiency of the blowers; the provision of expedients for materially prolonging the life of the blower parts subjected to the gases and particles resulting from combustion; improved cooling means for certain elements of the induced draft blower, and numerous other objects which will hereinafter appear from the following detailed description, considered in connection with the accompanying drawings of a presently preferred exemplary embodiment of the invention, and in which:

Fig. 1 is a vertical longitudinal section of a locomotive boiler equipped in accordance with the present invention, certain parts being shown in elevation, and Fig. 2 is a schematic or diagrammatic representation of the control system, certain parts thereof being shown in forms approximating their preferred physical embodiments.

Referring now by characters of reference to the drawings, the boiler shell is indicated at 10, the fire box at 11 and the grate, which may be of any suitable or conventional construction, is characterized by the grate bars 12. Below the grate bars is a substantially air-tight ash pan 13 provided with a clean-out door 14. The rear

flue sheet is indicated at 15 and the flues at 16, the latter terminating in the usual manner, in a front flue sheet 17 forming the rear wall of the smoke box 18. The fire door, which may be of usual type in case the boiler is hand-fired, is shown at 25, and to show the relation of parts in a locomotive of usual type, the cab structure is indicated in dotted lines and designated generally at 26. As thus far described, with the exception of the special air-tight ash pan 13, the parts are or may be of conventional construction.

In keeping with the present developments, air is supplied to the ash pan, beneath the grate bars, through a supply pipe 30. This may be made of any suitable or desired length and preferably extends over a substantial part of the total length of the grate. For better distribution of air, the pipe 30 may be provided with tuyères or the like 31. Air is supplied under pressure to the pipe 30 as by a pressure-type fan or blower, which is preferably of centrifugal type, and indicated at 35. This blower is conveniently powered by direct connection to a steam turbine 36, supplied from the boiler and controlled by means hereinafter described.

It is a preference to utilize, for better control and for better distribution of air of combustion, two of the units 30—35—36, each located somewhat laterally of the center line of the grate. Dependent however upon the arrangement of air distribution piping, a single, or any desired number of such units may be utilized, although only one is shown for convenience of illustration.

Proceeding now to a description of the parts internally of the smoke box, in the front end structure of the locomotive boiler, it is my preference to substitute for the usual front clean-out door, a mounting frame 40 which is conveniently secured in place of the clean-out door as by studs 41. The mounting frame 40 is of hollow construction and serves to carry, partially internally thereof, a turbine base 42 carrying a high speed fan-driving turbine 43. The enclosure of the turbine is completed by a hollow sheet metal cap or nose structure 45, provided with cooling louvres 46 which are so arranged and directioned as to induce a circulation of air within the frame 40 and cap 45, such circulation resulting in part from the motion of the locomotive.

The bearings of the turbine and fan assembly are indicated at 50 in the front, and at 51 in the rear of the turbine, the latter bearing serving also as a journal for the fan, hereinafter described, the turbine shaft 52 being extended rearwardly of the turbine and provided with a tapered portion 53 for receiving the hub portion 54 of the blower or fan. The latter is characterized by a plurality of curved centrifugal-type blades of reasonable number, preferably seven. It is a further important provision, greatly augmenting the life of the blades which are normally subjected to very high temperatures and the abrasive effects of cinders and the like, that the blades 56, each be completely coated to a depth of between ¼ and ½ inch with stellite, which retains its hardness almost indefinitely even under protracted periods of subjection to the high temperature gases and solids. It will appear that the hub portion of the fan, as well as the shafting and bearings therefore are more or less completely housed and isolated from the zones utilized for conducting the gases of combustion. This housing is completed through a structure 60, complemental to the framing or support structure 40, this support structure being provided with an apertured partition 61, a central aperture of which is provided with packing elements 62 tending to prevent the travel of lubricant along the shaft and into the zone of the fan proper. For the purpose of promoting air circulation through the chamber about the turbine and shaft bearings, it is my preference to utilize a cooling fan 63, the blades of which are pitched in a manner to coact with the air currents normally created by the motion of the locomotive and to impart a definite direction to the cooling air entering and leaving through the louvres 46 of the nose portion 45.

The induced draft fan 56 preferably operates at a substantial speed, in order to obtain the requisite displacement, and to realize this displacement through use of a fan which is not of excessive diameter and power requirements, and yet may be disposed within the space usually available therefor in the smoke box. This high speed of operation would ordinarily result in a substantial turbulence and eddy effects which, but for the provision of air-deflecting and -directing devices to be described, would materially impair the best efficiency of the induced draft fan, in its cooperation with the exhaust from the engine cylinders. To the end of assuring a definite direction of output of air from the fan, there are provided a plurality of vertical, parallel directing vanes, one of which is shown in elevation at 66. These have a definite function in damping turbulence, and in tending to reduce the discharge flow from the induced draft fan, to a substantially rectilinear path.

The substantially elbow-shaped fitting 70 is employed to connect an annular structure 71 and a supporting ring 72 for the directing vanes. The member 70 is also provided with an upper outlet flange connection 75 providing a connection to the stack 76, and with a lower flange connection 77 assembled to the exhaust fitting 80, from which connection is made through a pair of conduits, one shown at 81, to the engine cylinders. The latter elements are or may be of conventional construction.

From the foregoing it will appear that as the air discharged from the induced draft fan 56 is directed upwardly by the fitting 70, this discharge air stream will pick up and merge with the steam from the exhaust, and is so directed as to provide a definite ejector effect in a manner tending to reduce exhaust back-pressure on the cylinders. Otherwise expressed, the design of the induced draft fan and associated parts is such that at no time will it oppose in any way the free egress of exhaust steam from the fitting 80, but on the contrary, is definitely designed to aid the evacuation of this and connected conduits, after the manner of an ejector. It will be noted as unnecessary to employ any of the usual types of exhaust nozzle in connection with the system proposed.

It is preferred, in order to avoid subjecting the fan blades and associated structure to needless abrasive effects, to provide a cinder screen through which the flue gases are caused to pass. A convenient location and structure of such an element is indicated at 85, showing a frusto-conical screen member of smaller diameter at its rear end and of larger diameter at its forward end. The slope and mounting of this screen 85 is such that, as it is subjected to the impact of cinders and solid particles in the flue gases, such particles will fall away from the screen by gravity, to a zone in the lower portion of the smoke box, whence they may be periodically re-

moved through a clean-out door, (not shown) provided for this purpose.

My preference in installations in locomotive boilers of usual and standard types, is to employ a blower and turbine assembly of materially greater displacement capacity in the front end assembly, than in the forced draft assembly. By way of providing an example, it has been found that, in many cases, a pair of turbine blowers, each of 30 H. P. may be utilized for the forced draft introduced under the grates, while a turbine-blower assembly of 100–105 H. P. bears about the correct proportion in the case of the front end assembly.

To be sure, both sets of blower assemblies are required to handle all of the air required for combustion of the fuel. However, it is noted that the volume of air to be displaced by the forced draft blower or blowers, is only about one-half of the volume of the gases to be displaced by the induced draft blower assembly. This is due to the substantial difference in volume because of the increased temperature of the gases in the smoke box. The function of the forced draft blower is primarily to create a sufficient initial pressure to impel the air through the bed of fuel and the grates; thus the induced draft blower is required only to draw the gases through the boiler tubes and smoke box. It is obvious from the foregoing that it is more efficient to employ a balanced draft system than merely an induced draft system alone, or a pressure draft system, of itself.

Proceeding now to a description of the means by which is effected an automatic control of the blowers in keeping with the steam pressure or steaming requirements of the boiler, there is seen (Fig. 2) that this type of control involves, at least in part, an influence of the main steam supply, a conduit for this purpose being indicated at 90, which serves directly to affect a control unit designated generally as 91. This unit is conveniently of a type involving a metal bellows indicated at 92, connected to the boiler as through the pipe 90, and through a lever connection 93, serves to actuate a pendulum-type control lever 94, pivotally mounted on a control panel 95. The lever 94 includes a pair of horizontal arms provided at their extremities with contacts 98 and 99. The length of the aligned horizontal arms of this lever is so selected, relative to the distance between a pair of fixed contacts 100 and 101, that when the lever is in its mid-position, neither of the switches 98—100 or 99—101 is closed. When, however, the lever is moved to the right or the left, the contact 98 or 99 as it approaches the adjacent stationary contact, serves to close the circuit. Each of the switches is illustrated only diagrammatically, any one of a number of suitable types of switches now available being suitable for this purpose.

The electrical circuit may be considered as having its origin in either of a pair of supply leads 105 and 106 taken with a ground leg of the circuit. The leads are conveniently connected to the usual 32 volt supply system of the locomotive, and accordingly may be energized through the generator or storage batteries, or both.

The circuits originating in the control leads 105 and 106, are continued beyond the control panel designated generally at 110, through a pair of conductors 111 and 112, a ground wire 113 being provided in the circuit relation indicated, and electrically connected to the lever 94 in the example disclosed.

The leads 111 and 112 are continued into a control panel 115, the latter being provided with a pivotally mounted, pendulum-type switch lever 116, provided similarly to the lever 94, with horizontal arms, the extremities of which carry contacts 117 and 118, serving after the manner of the elements 98, 99 to control the circuits through a pair of switch contacts indicated at 119 and 120, respectively arranged in the lines 112 and 111. The switches 117—119 and 118—120 may be similar in design and capacity to the switches associated with the panel 95. Beyond the switches on the panel 115, the circuits are continued through leads 122 and 123, a ground wire 124 being provided for return purposes, and a ground connection effected as at 125. It will have appeared that the control circuit is of the type known as a single wire system, in which one side of each circuit is completed through a grounded leg which may conveniently consist, in part, of the metal portions of the locomotive structure and associated parts.

There is by preference mounted on the control panel 115, and operatively connected to the pendulum lever 116, a variable volume control chamber indicated at 130, and provided, for example, with a movable diaphragm 131, or in lieu thereof a piston (not shown), or some equivalent of the diaphragm or piston. To the diaphragm, for example, is connected a control rod 132 pivotally connected to the lever 116, the movement of this lever under the influence of the diaphragm, being opposed by a variably-loaded compression spring 135, the loading of which is subject to adjustment as through threaded elements and lock nuts, the assembly of which is indicated at 136. The variable volume control chamber 130 is supplied internally with air under pressure through a conduit 140, which has its origin or entrance end, in the boiler structure at such location as to maintain the conduit under a pressure which varies directly with the variation in overfire draft supply. For convenience of providing a visual indication of the pressure in the zones over or beyond the fire, the conduit 140 may be branched and continued as at 141, to a pressure gauge 142, preferably located in the cab or at some point for convenient visual indication to the engineer or fireman.

The control circuits are each completed beyond the panel 115, through the control wires 122 and 123, the former being connected to a pair of similarly disposed solenoid windings 145 and 146, for the energization thereof, the return circuit from each such winding being completed through the leads 147 and 148 connected to the ground lead 124, grounded at 125. In similar manner, the leads 123 are connected to a pair of similarly disposed electromagnets or solenoids 149 and 150, the return connections from which are completed through the conductors 147 and 148 to the ground at 125. It will have appeared that the solenoids or electromagnets are related in pairs, one pair comprising the magnets 145 and 149, and the other comprised of solenoids 146 and 150. Each of the pairs of magnets is provided with a common, double-end armature structure indicated generally at 151 and 152, and the armatures of each such structure connected through plungers 153 and 154 to an adjacent air control valve of piston and cylinder type. These air control valves include a piston 155 operating in a cylinder 156 on the one side, and a piston 157 operating in a cylinder 158, on the other side. The cylinders 156 and 158 are of double-end type,

the cylinders being provided with air under pressure, as from the brake system of the locomotive, through air inlet pipes 160 supplying the cylinder 156, and 161 supplying cylinder 158. Each cylinder is provided with a pair of outlets respectively near the upper and lower ends of the valve, these outlets being indicated in the control for the forced draft turbines, at 170 and 171, and in connection with the cylinder 158 serving to control the induced draft blower turbine, at 172 and 173.

The paired air discharge tubes or conduits from each valve cylinder, are connected respectively to the upper and lower ends of a double-ended cylinder-and-piston control unit, or air servo-motor, the motor cylinders being indicated at 176, for the forced draft turbine control, and 177 for the induced draft turbine control. These cylinders are each provided with a power piston, the pistons being designated respectively at 178 and 179.

Each power piston is connected through a rod, such as 185 or 186, through a pivotal connection 187, and 188, to a steam valve. The two steam valves illustrated are preferably of so-called chronometer type, providing a plurality of steam-admission passages through the body of the valve, which are graduated and so arranged that the first position of each valve provides an idling regulation of the associated turbine or turbines, while the remainder of the positions provide, in sequence, for augmenting the steam supply to, and hence serve to enhance the air displacement by the turbines controlled therethrough. Through the provision of links such as 190 and 191, the movements of the servo-motor pistons are translated to the valve actuating arms 195 and 196, operatively associated, respectively, with the valve bodies 197 and 198. The former of these serves to control the flow of steam through a boiler-connected steam supply pipe 199 and a forced-draft turbine supply pipe 200, and the latter valve controls the flow of steam through a boiler-connected steam supply pipe 201, thence to the supply line to the induced draft turbines, indicated at 202.

In the case of stoker-fired boilers, assuming according to usual practice that the stoker is steam-powered, either through a reciprocating unit or a turbine and reduction gear assembly, it is preferred that the steam supply for the stoker drive be derived from the supply pipe such as 199. This arrangement is utilized so that the valve 197, in augmenting or decreasing the steam supply to the forced-draft fan turbine, will proportionately augment or decrease the steam supply to the stoker drive. But for this expedient, the decrease in air supplied to the grates would not necessarily result in a corresponding reduction in rate of fuel supply to the grates. It will be seen, however, that by controlling both the forced-draft turbine steam supply and the steam supply for the stoker drive through the same, or through separate correspondingly operated valves, the rates of air feed and fuel feed are automatically coordinated through the control system described. It has been found convenient in practice to provide the steam supply pipe 200 under the control of the valve 197, with at least a pair of branches, one thereof such as 205 leading to the steam supply for the stoker drive, and another shown at 206 being directed to the forced-draft turbines. If desired, hand valves 207 and 208 may be utilized for manual regulation or proportioning of the flow of steam through the respective branches 205 and 206.

The operation of the control system may be briefly reviewed by noting that, as the steam pressure increases in the boiler and hence in the conduit 90, and hence that, as the steaming requirements of the boiler decrease, the increased pressure will influence the unit 91 in a manner to swing the lever 94 to the left, thus serving to bring the contact 98 into engagement with the stationary contact 100, thus completing the circuit through the ground and through the control legs 106 and 112, thence, assuming the switch 117—119 to be closed, through the lead 122 so as to energize the upper coils 145 and 146 of the solenoid valve-operating assembly. This will cause the armature assemblies 151 and 152 to be actuated upwardly, into the positions shown by the drawing, raising the pistons 155 and 157, closing the inlets 170 and 172 to the servo-motors, but opening the inlets 171 and 173. This actuation will have the effect of putting the air pressure from the air supply system against the lower faces of pistons 178 and 179 of the servo-motors, with the effect of raising, in the positions shown, the valve-actuating levers 195 and 196. If the circuit remains closed as indicated, for an appreciable time, the valves will thus be actuated toward steam-restricting positions, and will be brought to positions in which the steam supply is only sufficient to cause the turbines and blowers to operate at idling speed.

It will have been noted that this actuation is dependent upon the closed position of switch 116—117, this switch being closed only in response to a predetermined but substantial air pressure in the overfire zone. It is accordingly seen that the controls are responsive primarily to the steam supply and boiler steaming requirements, and also secondarily subjected to the influence of the overfire draft pressure. This is true since the one of the switches carried by panel 115, which is closed, the switches being operable only one at a time or selectively, is determined by draft conditions.

Assuming now an opposite set of conditions to prevail, namely a relatively reduced steam pressure and a relatively reduced draft pressure, the influence of the bellows unit 91 will operate to close the switch 99—101 and permit the switch 98—100 to open. Assuming the switch 99—101 to be closed, and assuming a low draft condition to prevail in the overfire zone, so that switch 118—120 is closed, a different control circuit will now be completed, one side through the ground, and the other side through the leads 105, 111 and 123, so that the coils 149 and 150 become energized, at the same time coils 145 and 146 being deenergized. This will result in a movement of the armatures 151 and 152 to their lowermost positions in the figure, in a manner to move the valve pistons 155 and 157 to the opposite ends of the valve cylinders. Under this condition, air is excluded from the lower end of the motor cylinders and admitted to the upper ends thereof, assuming them to be mounted in the positions shown. Thus the valve levers 195 and 196 will be actuated to a steam-admitting position, the extent of their opening depending upon the amount and duration of air admission to the servo-motor, as influenced by the controls described. This set of conditions serves to increase the speed of the forced draft turbines as well as the speed of the induced draft turbine in a manner to increase the draft supply, and similarly the steaming rate. It is to be observed that the increase or decrease of turbine and blow-

er speeds, is always such as to keep the induced-draft and forced-draft units correctly proportioned in output.

It is preferred to provide for an adjustment of the extent of actuation of the valve-operating levers, as through the provision of a number of openings selectively utilized for the connection of a pivot pin on each of the links 190 or 191 to the associated valve lever. It is also preferred so to set the control instrument such as the steam-pressure responsive unit 91, and the draft-responsive unit carried by panel 115, so that an appreciable range of pressure occurs between opening and closing valve movements. This is preferably at least a five pound pressure differential and in many cases it is advisable to provide for a ten pound difference in setting, so as to prevent unnecessary hunting of the controls in response to minor variations in steam pressure. Similarly, the setting of the draft responsive control avoids excessive changes in the control circuits and avoids needless control actuation in response to minor variations in draft pressures.

It is desirable in most installations, to provide for a manual control of the steam supply through the turbines, in case of failure of any part of the control system, or so as to enable the operator, as in an emergency, to meet extreme conditions by manually controlling the amount of draft. Among the instruments preferably so provided, is a master steam pressure control indicated at 209, a draft control for the forced draft fans shown at 210, and a chronometer type throttle valve designated as 211. These are preferably disposed at a convenient point of access to the engineer, as in the cab 26.

It will have appeared that the system described serves to compensate for differences in fuel bed according to type of fuel being burned, and to compensate for other variations in specific operating conditions, so that the speeds of the fans are correctly proportioned, through an automatic control, at all times. Concurrently both fans as well as the stoker operation, and hence the rate of fuel feed, are subject to control under the influence of steam pressure, and hence of steaming rate. The ideal operating condition is, of course, to maintain the optimum steam pressure to meet a given set of working conditions of the locomotive, and when desired, to maintain as high a pressure as possible without loss of steam through popping of the safety valve, which obviously results in inefficiency and loss of thermal values.

From the foregoing it will have appeared that the system described fully attains each of the several objects above specifically enumerated, as well as those implied from the description.

While the invention has been described by making specific reference to a presently preferred embodiment of the invention, the description is not to be understood in a limiting sense, since obviously many changes may be made both in the draft-producing agencies as well as in the control apparatus, without departing from the spirit and full intended scope of the invention as defined by the claims hereunto appended.

I claim as my invention:

1. In combination in a steam locomotive, a balanced draft producing and control system including a turbine-driven blower of forced-draft type, having its outlet ahead of the grates and adapted to force a supply of combustion air therethrough, a turbine-driven induced-draft blower located in the smoke box of the locomotive boiler, a fitting forming a discharge passage directed from the induced draft blower and so directioned as to impart a steam eductive effect to the engine exhaust passages into the stack, and such that exhaust impulses coact in the draft-inducing action of the last said blower, the two blowers being so proportioned with respect to each other as to maintain in the drafting system between the blowers, a pressure substantially of the order of atmospheric; a control system for the blowers including a pressure-responsive apparatus having a loaded pressure-movable element subjected to draft pressure in an overfire zone, electromagnetic means in throttling relation to the steam supply of the turbines associated with the blowers, means for varying the proportionate throttling effect of said electromagnetic means, and means for varying the loading and response of said pressure movable element.

2. In combination in a steam locomotive, a balanced draft producing and control system including a turbine-driven blower of forced-draft type, having its outlet ahead of the grates and adapted to force a supply of combustion air therethrough, a turbine-driven induced-draft blower of substantially greater volume displacement capacity than the forced draft blower, and located in the smoke box of the locomotive boiler, a fitting forming a discharge passage directed from the induced draft blower and so directioned as to impart a steam eductive effect to the engine exhaust passages into the stack, and so connected to the exhaust passages that the exhaust impulses coact with the blower in its draft inducing effect, the two blowers being so proportioned with respect to each other as to displacement capacity, as to maintain at all times during blower operation, a substantially balance draft pressure condition between the grates and the induced-draft blower, and to maintain in the drafting system between the blowers, a pressure substantially of the order of atmospheric; a control system for the blowers including a pressure-responsive apparatus having a loaded pressure-movable element subjected to draft pressure in an overfire zone and above the fire arch, electromagnetic means influenced by said pressure-responsive apparatus, separate fluid pressure control devices, each in individual throttling relation to the steam supply to one of the blowers, both said devices being subject to control of said electromagnetic means, and arranged to effect concurrent throttling actuation in the same direction, means for varying the proportionate throttling effect of said devices on the two blowers, as influenced by said electromagnetic means, and means for varying the loading and response of said pressure movable element, whereby to provide for variation in range of pressure influence on the blower turbines.

3. In a draft-producing and controlling system for locomotive boilers, an air displacement device or blower of forced-draft type, arranged to supply air to the grates, a blower in the smoke box, and arranged to coact in the draft-inducing effect of the engine exhaust, a steam turbine in driving relation to each of said blowers, a throttle valve in the steam supply line of each turbine, directly controlling the admission of steam thereto, an air motor connected to each of said throttle valves, and means responsive to draft pressure in an overfire zone adjacent the fire arch, for influencing the air motors.

4. In a mechanical drafting system of balanced-draft type for locomotive boilers, a forced-

draft blower arranged to supply air under pressure to the grates, an induced draft blower located substantially beyond the zone of primary combustion, a steam prime mover for each of said blowers, separate throttle means for each of the prime movers, and combined air pressure and electromagnetic means for effecting corresponding throttling effects of the prime movers, the last said means being responsive to variations in draft pressure in an overfire zone between the blowers, and an exhaust ejector fitting adjacent the discharge side of the induced draft blower whereby the exhaust impulses coact with the induced draft blower in maintaining desired draft pressures in the zones between the blowers.

5. In combination in a steam locomotive, a mechanical drafting system of balanced-draft type including a steam turbine, a forced draft blower driven thereby and arranged to supply air under pressure to the grates, an induced draft blower located in the smoke box of the boiler, a drive turbine therefor, means for controlling the admission of steam to the blower turbines, and hence controlling blower speeds, in response to variation in draft pressure in an overfire zone, a discharge fitting connected to the outlet side of the induced draft blower and directly connected to the blower stack, a locomotive exhaust connection opening into said fitting adjacent the discharge of the induced draft blower, and a plurality of parallel air-directing vanes positioned near the inlet of said fitting, and extended across the region of discharge of the blower into said fitting.

6. In combination in a steam locomotive, a draft-producing and controlling system of balanced-draft type, including a pair of turbine driven air blowers discharging beneath the grates, each of said blowers being provided with an air discharge pipe provided with tuyères closely adjacent and beneath the grates, a turbine driven induced draft blower in the locomotive smoke box, a discharge fitting for said blower extending from the outlet side thereof to the locomotive stack, an exhaust connection from the locomotive cylinders into said fitting, so arranged that the exhaust impulses augment the drafting effect of the induced draft blower, and means for throttling the supply of steam to the blower turbines in response to variation in draft pressure in a zone adjacent the fire arch of the boiler.

NEWTON FRANK LANE.