

July 10, 1945.

R. R. McINTOSH

2,379,916

METHOD AND APPARATUS FOR DRAFT CONTROL

Filed March 1, 1941

4 Sheets-Sheet 1

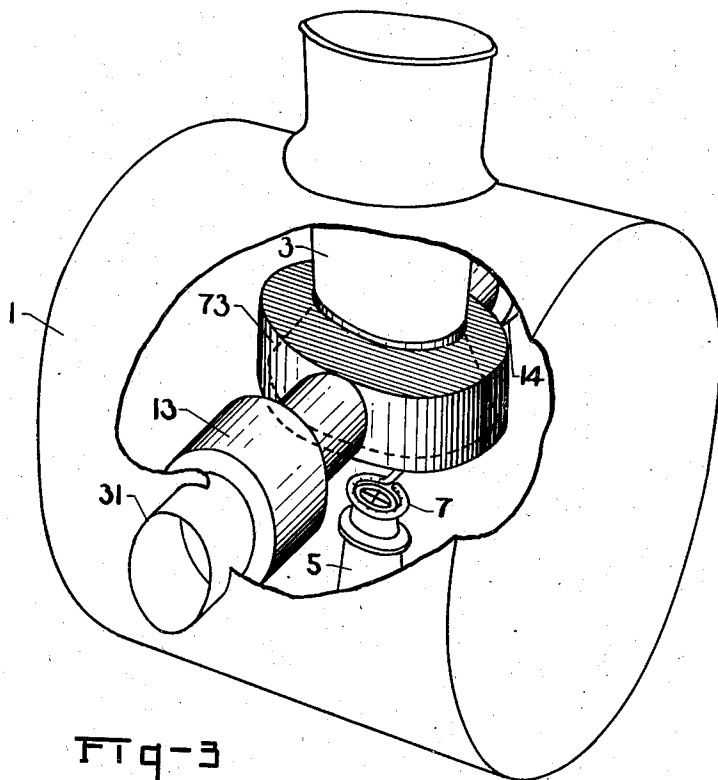


FIG-3

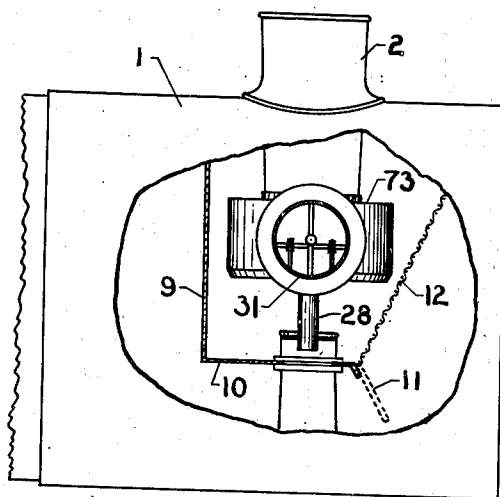


FIG-2

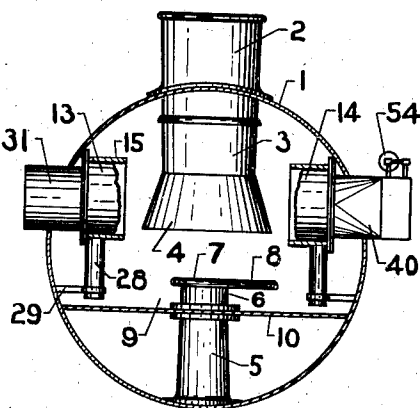


FIG-1

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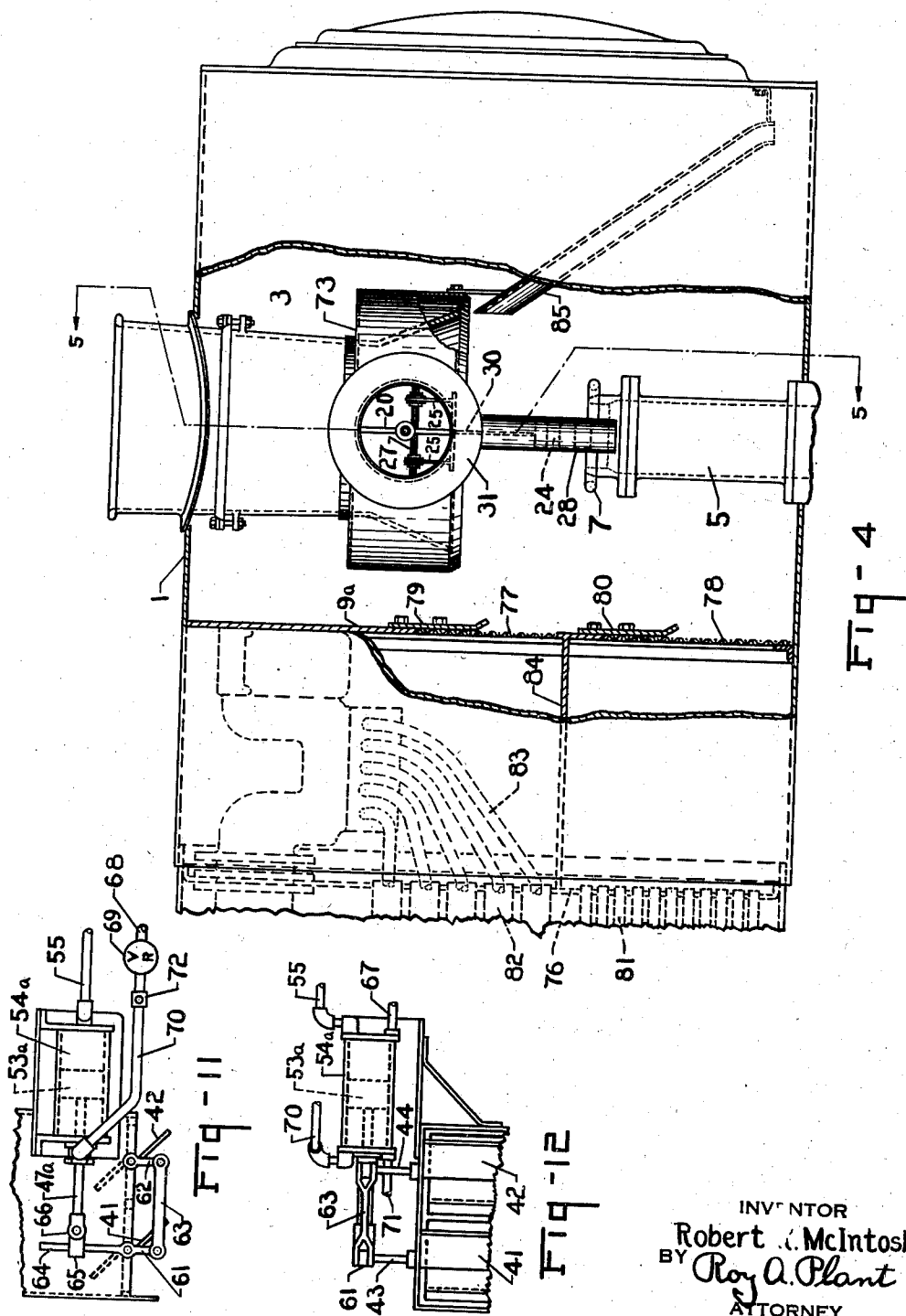
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METHOD AND APPARATUS FOR DRAFT CONTROL

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4 Sheets-Sheet 2



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4 Sheets-Sheet 3

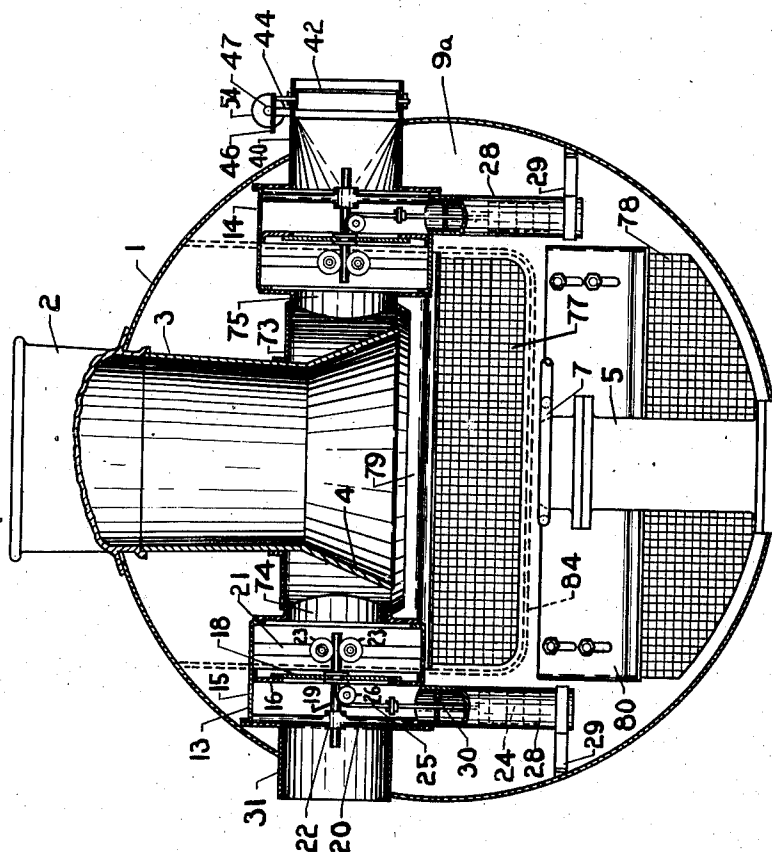


Fig. 5

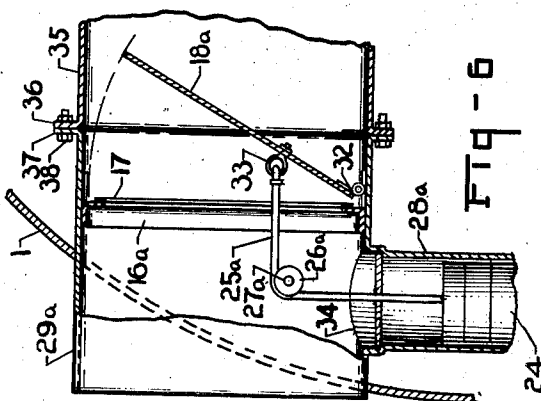


Fig. 6

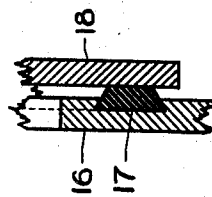


Fig. 7

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METHOD AND APPARATUS FOR DRAFT CONTROL

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4 Sheets-Sheet 4

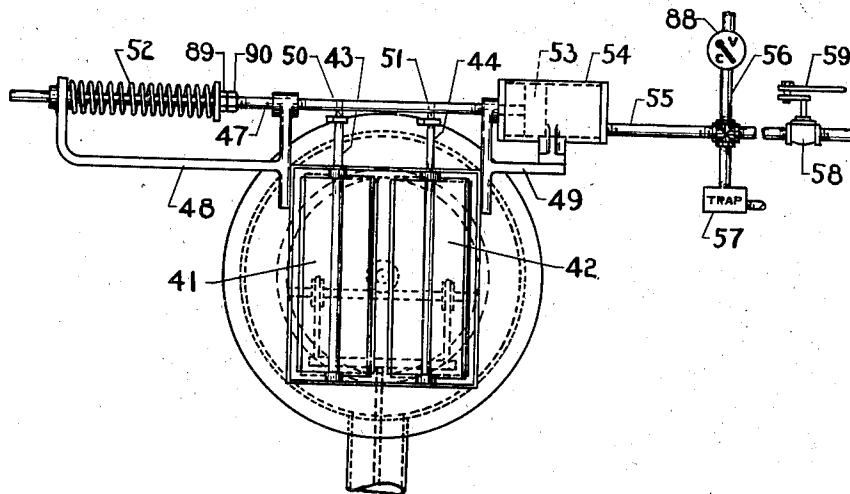


Fig - 9

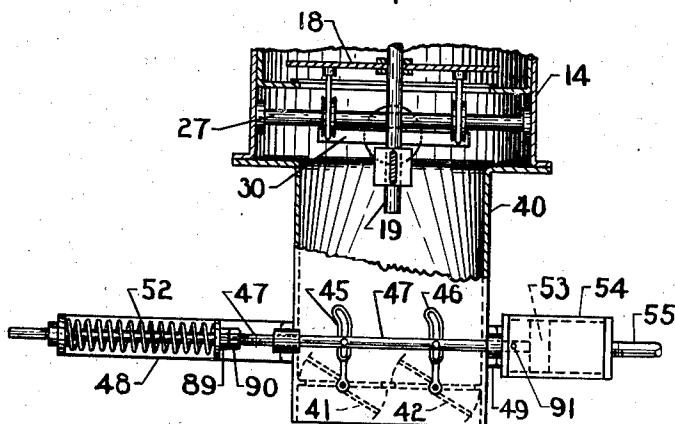


Fig - 10

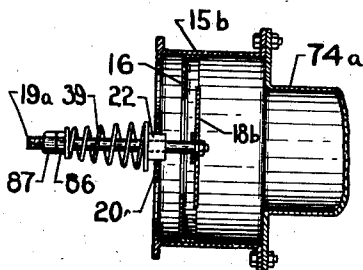


Fig - 7

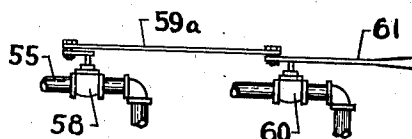


Fig - 13

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR DRAFT CONTROL

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Application March 1, 1941, Serial No. 381,290

13 Claims. (Cl. 110—150)

The present invention relates broadly to the automatic regulation of draft for the hot products of combustion used in generating steam and the like, and in its specific phases it relates to methods and apparatus for use in automatically controlling the induced draft created in railway locomotive smoke boxes.

The standard practice for creating draft in railway locomotives is to use the exhaust from the driving cylinders to create a partial vacuum in the smoke box at the front end of the locomotive, and to supplement this with a live steam blower for use during standing and drifting operation of the locomotive. Draft produced in this manner varies with the per cent cut off at which the locomotive is operated, as well as with the frequency of exhaust from the cylinders. Such operation results in extreme variations in suction pressures which, at the higher suction pressures, carries small cylinders and burning coal particles from the fire box and blows them out of the smoke stack, a thing which not only creates a dirt nuisance, fuel loss, and a fire hazard, but abrasively wears out the tubes, superheater units, and front end surfaces exposed to the flow of gases containing these particles. This practice also results in dilution of the products of combustion with excess air, and wastes heat due to too rapid flow of the diluted products of combustion from the fire box to the front end of the locomotive.

In an effort to partially reduce the detrimental effect of excessive and fluctuating suction in the smoke box the practice has grown up of installing baffle plates to restrict the flow areas in an attempt to control the flow of products of combustion through the smoke box, and such baffles are further supplemental with a netting to hold back and break up the larger cinders and burning pieces of fuel drawn out of the fire box due to such suction. The practice of baffling is of some beneficial aid in holding the suction pressures within closer limits but this still leaves undesirable fluctuations of same, and requires higher suction pressures in front of the baffles to overcome the effect of the restrictions. The production of these higher suction pressures in turn requires the employment of higher steam exhaust back pressures from the cylinders, a thing which reduces the output of the locomotive. Higher suction also automatically requires a higher firing rate to utilize the excess air and reduce its cooling effect upon the heating surfaces, thus increasing fuel consumption. Restricting the area of the openings through the

grates is often resorted to as a supplemental means of draft fluctuation control, and this again requires further increase of the back pressures on the cylinders with the detrimental effect noted. Attempted solutions of this nature take into consideration the fundamental need of artificial draft, but fail to do more than lower and partially control the suction pressure range of same as a whole at the front tube sheet. This leaves the original inherent drafting problem unsolved, and requires the use of higher back pressure exhaust from the cylinders to boost the draft sufficiently to overcome the restrictions imposed by the baffles or reduced grate opening area and yet maintain sufficient draft for combustion in the fire box. It was with a view to the solution of these problems that a study of the locomotive drafting situation was made which resulted in the present discovery that fluctuations in suction pressures could be held much closer within predetermined limits without restricting the free flow of the gases in the locomotive front end or reducing the grate opening areas. This permits the air drawn through the fire box, tubes, and smoke box to flow freely and be in relatively proper amount for satisfactory combustion efficiency with substantial elimination of excessive dilution with its cooling effect on the products of combustion flowing to the smoke box. The freeing and equalizing of the gas flow areas throughout the system eliminates the necessity for increased exhaust back pressure to overcome the effect of the draft control restrictions embraced in present day locomotive designs. The reduction of back pressure thus made possible by freeing the gas flow areas is of positive aid in increasing the locomotive efficiency and output. The methods and apparatus involved in the accomplishing of these ends forms the basis of the present invention.

Accordingly, among the objects of the present invention is the provision of a method and apparatus for automatically controlling the suction pressures utilized in producing induced draft between predetermined limits.

Another object is to provide an apparatus which prevents suction pressures in excess of a prescribed limit.

Another object is to provide a damper system which automatically allows air to enter the smoke box in amount sufficient to prevent the suction pressure exerted on the products of combustion therein from exceeding a prescribed amount.

Another object is to provide a damper system

for preventing the suction pressure exceeding a definite upper limit under conditions of a low rate of fuel feed, and a higher suction pressure at higher rates of fuel feed.

A further object is to provide a system wherein a major portion of the previously used restricting baffles and the like may be eliminated and a more uniform suction pressure exerted on the outlet ends of the fire tubes of the boiler, with free flow areas provided for the products of combustion.

A further object is to facilitate the drafting so as to permit a controlled flow of hot products of combustion through the superheater portion of the boiler, thus raising or lowering, as desired, the superheat temperature of the steam produced, with resultant increase in the Rankin cycle efficiency and decrease in the amount of steam required when this temperature is above that previously attained with the conventional design.

A still further object is to not only reduce dilution with its cooling effect on the products of combustion in the fire box but also to reduce their velocity in contact with the heating surfaces so as to permit time for greater heat transfer, while preventing the carriage of excess amounts of abrasive material and burning solid fuel past the heating surfaces, thus reducing the firing rate of the combustible to a point conforming with the actual requirements of the engine.

A still further object is to produce a method and apparatus for the automatic controlling, and balancing of the smoke box draft within limits desired for minimum and maximum demands for air required for combustion.

A still further object involves the use of means for delivering the controlled suction pressure reducing air directly to the base of the smoke stack, thus avoiding any stresses and strains in or on the front end of the locomotive due to variations in temperature within the smoke box occasioned by the admission of such air.

Still further objects and advantages of the present invention will appear as the description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then consists of the steps and means hereinafter fully described and particularly pointed out in the claims, the annexed drawings and the following description setting forth in detail certain means and modes of carrying out the invention, such disclosed means and modes illustrating, however, but several of the various ways in which the principle of the invention may be used.

In said annexed drawings:

Figure 1 is a sectional front elevation through the front end of a conventional locomotive smoke box, at a point directly in front of the smoke stack, showing in diagrammatic manner a simplified assembly of one form of the present invention.

Figure 2 is a side elevation of a locomotive front end with part of the smoke box shell removed to illustrate an installation having a modified form of the construction.

Figure 3 is a perspective view of a locomotive front end with the shell diagrammatically shown and partially broken away to reveal the mechanism illustrated in Figure 2, certain of the parts being omitted for purposes of clarity.

Figure 4 is a side elevation of a locomotive front end with part of the smoke box shell broken away to show a modification of the construction illustrated in Figure 2.

Figure 5 is a partially sectioned elevational view taken along the line 5—5 of Figure 4 looking in the direction of the arrows.

Figure 6 is a sectional view through a modified form of automatic air inlet valve assembly.

Figure 7 is a sectional view through another form of automatic air inlet valve assembly.

Figure 8 is an enlarged fragmentary sectional view showing a preferred form of inlet valve sealing means.

Figure 9 is a side elevational view of a preferred form of louvres and operating mechanism as viewed from the right side of Figure 5.

Figure 10 is a partially sectioned top view of a major portion of the apparatus shown in Figure 9 with certain parts of the air inlet valve assembly shown in detail.

Figure 11 is a top view of a modified form of the louvre operating assembly of Figures 9 and 10.

Figure 12 is a front elevational view of the louvre operating assembly shown in Figure 11.

Figure 13 shows in diagrammatic manner a convenient means of connecting the fuel valve of an oil fired locomotive to the steam valve which controls the louvres on one of the air inlet assemblies.

Referring more particularly to Figure 1 of the drawings, the locomotive front end has a shell 1 through which a smoke stack 2 projects in conventional manner. The lower end of the smoke stack is normally provided with a removable depending extension 3 having a flared bottom portion 4 commonly called a petticoat. Directly below the smoke stack extension is an exhaust stand 5 having a nozzle 6 for directing exhaust steam from the locomotive driving cylinders (not shown) up the smoke stack in conventional manner forming a seal therewith so as to produce a partial vacuum in the locomotive front end which is commonly termed the smoke box. In order to induce some draft when the locomotive is standing still, or using little driving steam, a blower ring 7 is mounted at the upper end of and around the exhaust stand nozzle. This ring is connected by means of pipe 8 to the live steam generated in the boiler. A suitable valve (not shown) enables the fireman to control the delivery of live steam to ring 7 which is suitably perforated to deliver steam up the smoke stack and thus create a moderate induced draft. In the standard A. A. R. (Association of American Railroads) front end construction the smoke box is provided with a diaphragm 9 (Figures 1 and 2), table plate 10, baffle plate 11, and netting 12. The use of baffle plate 11 permits choking the area for flow of products of combustion so that it is smaller than the free area of the fire tubes through which the smoke flows from the fire box (not shown) to the smoke box. In this manner the suction pressure range back of the diaphragm 9 is lower than that behind screen 12 and in front of diaphragm 9. In accordance with one phase of the present invention the passageway for smoke through the smoke box to the smoke stack is increased in size until it is large or larger than the total free area through the fire tubes thus making possible substantial equalization of the suction pressures in front of and back of the diaphragm. This can be substantially effected by removing baffle plate 11, although the invention is not limited to that specific alteration. One or more air inlet assemblies 13 and 14 may then be installed in front of diaphragm 9 or at some other point subject to high suction pressures, and such assemblies individually adjusted to ad-

mit air when a predetermined suction pressure is reached, thus maintaining a substantially constant upper suction pressure limit or limits. This upper suction pressure is preferably determined by tests or computation so as to limit the maximum amount of air drawn through the fire box to that which will efficiently burn all of the fuel required to meet the maximum steam demand. This procedure prevents excessive dilution and cooling of the products of combustion, reduces the carriage of cinders and burning fuel particles out through the smoke stack, and improves the efficiency of heat absorption by reducing the maximum rate of travel of the products of combustion past the heat absorbing surfaces.

A preferred form of air inlet assembly 13 consists of a housing 15 (Figure 5) open at both ends and provided with a valve seat ring 16 having a suitable gasket 17 (Figure 8) against which disc valve 18 seals when in closed position. Typical of gasket material usable as shown in Garlock woven asbestos packing which is cemented, driven into place, and its projecting face leveled. Soft metal with a suitable high melting point, preferably over 600° F., may be driven into place and faced, and one such material is annealed copper. For convenience of assembly and operation, disc valve 18 is radially mounted in fixed position on shaft 19 which is supported and endwise movable through suitable bearings in outer and inner supporting members 20 and 21. The bearings in these supporting members may be of various types of construction and to typically illustrate same the outer supporting member 20 is shown as having a typical stationary slide fit bearing 22, while the inner supporting member 21 is provided with a movable bearing in the form of a pair of grooved pulley sheaves 23. In order to hold the valve in closed position until a predetermined maximum suction pressure within the smoke box has been reached, suitable weights 24 of required size and quantity may be utilized, and these in turn are connected to disc valve 18 by means of cables 25 passing over suitable pulley sheaves 26. For convenience of operation these pulley sheaves may be mounted on horizontal shaft 27. In order to protect and stabilize the weights 24 while avoiding leakage of air past same into the smoke box, a suitable housing 28 closed at its lower end and joined to the smoke box shell 1 by means of an anchoring member 29 may be used. A convenient means of joining weights 24 to a pair of disc valve operating cables 25 involves the use of a T-shaped member 30 mounted as shown. The invention, however, is not limited to that specific assembly and the showing of same is to be considered as diagrammatic of the various equivalent constructions of this type. For convenience of joining the valve assembly housing 15 to smoke box shell 1 in manner permitting ingress of air through the valve when open, a tubular member 31 of suitable construction and size may be used. One convenient form of this consists of the flanged member shown which is adapted to be welded in air tight manner to shell 1, as well as bolted or otherwise conventionally fastened to housing 15 so as to permit disassembly and removal of the latter when repairs are to be made which necessitate such removal. The general combination of air inlet assembly 13 with shell 1 as thus described, is typically shown in preferred location in Figure 1, and various details of same are illustrated in Figures 4 and 5.

A modified construction of the air inlet valve, in partially open position, is shown in Figure 6

wherein a disc valve 18a is pivotally mounted on hinge 32 and provided with an eye bolt 33 to which a cable 25a may be attached. This cable in turn preferably passes over a pulley sheave 26a suitably mounted on shaft 27a. The cable then extends downward into housing 28a through a suitable opening in cover disc 34, and has weights 24 of suitable size and amount mounted thereon in conventional manner. A valve seat ring 16a with gasket 17 thereon cooperates with disc valve 18a to form a seal therewith at all times when the suction pressure acting on disc valve 18a does not exceed the predetermined suction pressure which weights 24 are adapted to counterbalance. With this type of construction the valve assembly may be built directly into tubular anchoring member 29a which is joined in fixed position to shell 1. If it is desired to connect this valve assembly to some localized point of application of suction pressure reducing effect a suitable tubular member 35 may be utilized and this member to facilitate disassembly of the system is preferably provided with a flange 36 adapted to be joined to flange 37 of anchoring member 29a by means of bolts 38 or the equivalent.

Another modified form of air inlet assembly is shown in Figure 7. In the place of weights this construction utilizes a compression spring 39 to hold disc valve 18b in closed position, and yet allow same to open as shown when the suction pressure effect thereon exceeds the closing pressure exerted by spring 39. The valve may be easily adjusted for opening at a predetermined suction pressure by threading the outer end of shaft 19a and providing same with a nut 86 and lock nut 87 for adjusting the spring compression pressure to the desired point. The use of a spring controlled inlet valve permits starting the admission of suction reducing air to the smoke box at a predetermined suction pressure and yet permits the suction pressure to raise appreciably the further disc valve 18b is moved inward to admit increasing quantities of air. This effect is obtained through the increasing resistance of the spring as it is progressively compressed. Under these conditions with a locomotive operating under heavy load near its maximum pulling capacity and at relatively high suction pressure generation, this spring balanced valve can be so proportioned as to allow the upper suction pressure to be maintained at a slightly higher level, thus increasing the draft and facilitating increased steam generation. The housing 15b in this case would be provided with valve seat ring 16 for use as previously described. The shaft 19a, if desired, may be supported at both ends as shown in connection with shaft 19 in Figure 5, but for simplicity of construction the apparatus has been illustrated in Figure 7 as utilizing a single stationary slide fit bearing 22 carried by an outer supporting member 20a.

The maximum suction pressure to be applied in the smoke box at the point of admission of smoke thereto is preferably controlled so as to prevent the drawing of excessive amounts of air through the system during periods when the rate of fuel feed is low. To take care of this the smoke box assembly, as shown in Figure 1, may be provided with a pair of air inlet assemblies 13 and 14. The assembly 13 for instance being set for the admission of air to restrict the suction pressures in the smoke box to a predetermined maximum suitable for high combustion efficiency under substantially peak fuel feed conditions. The assembly 14 on the other hand may be set to open at a predeter-

mined lower suction pressure in the smoke box thus taking care of the maximum suction pressure decided upon for use in connection with low quantity fuel feed operation. When the fuel feed exceeds a predetermined low or intermediate rate then it is desirable to raise the suction pressure in the smoke box so as to permit the maximum suction pressure to be increased to the limit for which air inlet assembly 13 has been set. To accomplish this the flow of air through air inlet assembly 14 may be automatically stopped when the rate of fuel feed exceeds a predetermined amount, and a convenient means for accomplishing this will now be described.

Referring to Figures 9 and 10 the air inlet assembly 14 is provided with a tubular member 40 having louvres 41 and 42 pivotally mounted therein and adapted to substantially prevent the passage of air through tubular member 40 when said louvres are moved to closed position. For clarity of illustration these louvres are shown in partially opened position. Fixedly mounted on the upper end of shafts 43 and 44, which have louvres 41 and 42 respectively anchored thereto, are a pair of slotted lever arms 45 and 46. Mounted above these slotted lever arms is an endwise movable rod 47 supported by suitable bearings in extending arm members 48 and 49. Rod 47 in this construction is provided with conventional means for preventing rotation of same, a thing which may be easily accomplished, for instance, by keying or feather keying the shaft and a corresponding bearing, or by making a portion of the rod square and the bearing through which it slides of like cross section for a free sliding fit therewith throughout the full travel of the rod. The showing in Figures 9 and 10 is intended to diagrammatically illustrate this general type of construction. Mounted on the under face of rod 47 in position to operatively cooperate with the slots in slotted lever arms 45 and 46 are a pair of slot engaging members 50 and 51. Mounted on one end of rod 47 is a compression spring 52 adapted to normally hold the louvres in full open position. Nut 89 and lock-nut 90 threadedly engage rod 47 and provide variations of the compression of spring 52 to take care of the adjustment of the louvre operating steam pressures to meet the particular requirements involved for opening and closing the louvres at the chosen fuel feed rate, or the like. A piston 53 is joined to the other end of rod 47 and slidably fits a cylinder 54 mounted on extending arm member 49. A pipe 55 connects the outer end of cylinder 54 to a suitable source of fluid pressure such that when the fluid pressure delivered through pipe 55 into cylinder 54 exerts sufficient pressure on piston 53 to overcome the compression resistance of spring 52, the piston will move to the left, and through the agency of the members connected to the louvres 41 and 42, will close same. Where a locomotive is stoker fired, the rate of fuel feed to the fire box depends upon the pressure of the steam delivered to the stoker operating engine. By connecting pipe 55 to the inlet steam line of the stoker operating engine (not shown) by means of pipe 56, this steam pressure will also act on piston 53 so as to close the louvres 41 and 42 as soon as the fuel feed exceeds the predetermined minimum at which the apparatus has been adjusted. This permits air inlet assembly 14 to be adjusted to maintain a maximum suction pressure limit, lower than that of air inlet assembly 13, suited to conditions of low fuel feed operation wherein a moderate draft will supply all of the air necessary for

proper combustion of the fuel being fed into the locomotive fire box. Then as soon as this fuel feed exceeds the amount for which air inlet assembly 14 has been adjusted, the increased steam pressure delivered to the stoker operating engine will also act on piston 53 in cylinder 54 to close louvres 41 and 42 and automatically cut off further flow of air into the locomotive smoke box through air inlet assembly 14. Air inlet assembly 13 which is adapted to limit the maximum suction pressure in the smoke box to that higher suction pressure which has been determined to be satisfactory under conditions of maximum fuel consumption, will then become effective in controlling the upper suction limit. Assembly 13 then maintains control of the maximum suction pressure in the smoke box until such time as the feed is again reduced to a point where the steam pressure on the stoker engine, through connection 55 to cylinder 54, allows piston 53 to move back to the right under influence of spring 52. This automatically opens louvres 41 and 42 so that air inlet assembly 14 once more controls the maximum suction pressure at the lower suction pressure level. A trap 57 is used to conventionally withdraw condensed steam from the louvre operating steam system. In order to make it possible for the fireman to increase the maximum suction pressure limit even under low firing rates, a valve 58 may be used to connect cylinder 54 to a source of higher steam pressure, thus closing louvres 41 and 42. Under such conditions a check valve 88 is used in pipe 56 to prevent back flow of steam which would automatically speed up the stoker driving engine and feed of fuel to the fire box. Valve 58 may be either mounted within the locomotive cab (not shown), or a lever 59 may be extended to the cab for remote control operation of valve 58. This same valve may be used for controlling the maximum draft of hand fired engines by means of direct operation of same by the fireman or engineer. Instead of using steam to operate the piston for opening and closing the louvres, compressed air may be used in equivalent manner. The invention is not limited to the use of one or two air inlet assemblies with a louvre assembly on a lower pressure inlet assembly, but rather a plurality of such assemblies may be used to step up the suction pressure as required and the showing in the drawings is intended to diagrammatically illustrate same.

Where the present invention is used on an oil fired locomotive the fuel oil feed valve 60 (Figure 13) may be connected by means of lever 59a to valve 58 so that the two valves will operate in unison when oil feed lever 61 is operated, thus again making possible the control of the maximum suction pressure level in accordance with rate of fuel feed.

A modified construction of the louvre operating mechanism is shown in Figures 11 and 12. In this construction shafts 43 and 44, to which louvres 41 and 42 respectively are joined, have extending arms 61 and 62 mounted thereon and connected by a tying link 63 so that the two louvres operate in unison. Extending arm 61 carries an extension 64 slidably fitting the bore of a slidable member 65 which in turn is connected to rod 47a by means of a pivot member 66. Cylinder 54a and piston 53a in this construction are arranged for double action operation. Steam is delivered to the cylinder through pipe 55 as previously described while pipe 67 is connected to a suitable steam trap or the equivalent, the former being illustrated in Figure 9. Live steam is used

in this assembly to return louvres 41 and 42 to open position when the steam delivered through pipe 55 drops below a predetermined point. The louvre opening steam system operates on live steam, normally at boiler pressure, delivered through pipe 68 to pressure reducing valve 69 the outlet of which is connected by means of pipe 70 to the cylinder at the end of same opposite to the end connected to pipe 55. The steam pressure in pipe 70 is preferably controlled through pressure reducing valve 69 so that louvres 41 and 42 will open and close when the rate of fuel feed goes below or above a predetermined amount. Pipe 71 connects the cylinder to a suitable trap or the equivalent (not shown) for draining condensate from the lower edge of the cylinder at the end connected by pipe 70. In order to relieve the pressure in pipe 70 when same exceeds the pressure delivered by pressure reducing valve 69, a small relief valve 72 is preferably connected to pipe 70. This type of construction permits venting extra pressures in pipe 70 caused by movement of piston 53a to the left under influence of steam pressure delivered through pipe 55. The movement of piston 53a back and forth in cylinder 54a causes slidable member 65 to move on pivot member 66 and slide lengthwise of extension 64 of extending arm 61 thus opening or closing of louvres 41 and 42 depending upon the direction of motion of piston 53a.

Air inlet assemblies 13 and 14 instead of opening directly into the smoke box of the locomotive as shown in Figure 1 may be connected to an open bottom air distributing hood 73 (Figure 5) by means of tubular connecting members 74 and 75. The hood 73 preferably extends slightly below the flared bottom 4 of depending extension 3 of the smoke stack 2. The bottom edge of this hood is also preferably beveled slightly inward to aid in directing the flow of air as well as products of combustion into the bottom of the smoke stack. Where the smoke stack is of round horizontal cross section construction it is normally most convenient to make the hood of similar outline although the invention is not limited to such shape so long as the principles of the present invention are complied with. The term "hood" as used herein is intended to broadly cover an inverted trough like member which is open at its bottom so as to form an outlet from the hood through such opening. The use of a hood in this manner presents the advantages of distributing and delivering suction reducing air directly to the bottom of the smoke stack for passage out of the smoke box in manner substantially preventing any cooling of the smoke box. This avoids unnecessary stresses and strains on the front tube sheet 76 (Figure 4), superheater headers and units 83, and other highly heated steam containing parts of the system, as well as all other exposed interior surfaces of the smoke box.

In preferred construction where the present air inlet system is used for limiting the maximum suction pressure in the locomotive smoke box, the table plate 10, screen 12, and baffle plate 11 shown in Figure 2 are removed, and diaphragm 9 reconstructed. An assembly of this nature is typically shown in Figures 4 and 5. The diaphragm 9a illustrated in these figures has an upper screen 77 and a lower screen 78. An adjustable upper damper plate 79 and an adjustable lower damper plate 80 are adapted for movement over screens 77 and 78 respectively to control the proportionate rate of flow of hot products of combustion therethrough. Locomotives, which utilize what is

commercially known as the Elesco superheater, have two types of fire tubes and these consist of the smaller tubes 81 and the larger tubes 82 in which the superheater unit tubes 83 are placed.

It is thus to be noted that by controlling the proportionate flow of hot products of combustion through the small and large fire tubes, the amount of superheating of the steam can be varied over a considerable range. To facilitate this the area between the diaphragm 9a and front tube sheet 76 may be partitioned off by means of a substantially U-shaped partition member 84 which in effect boxes in the area of the front tube sheet 76 which includes the large tubes 82. It is thus obvious that by raising upper damper plate 79 to provide a larger opening for products of combustion through upper screen 77 and choking off part of the opening through screen 78 with lower damper plate 80, a higher percentage of the hot products of combustion will pass through the upper or superheater portion of the boiler with resultant higher superheat and greater efficiency based on the Rankin cycle. Any ashes, small cinders, or dust tending to collect in the bottom of the smoke box at its front end may be automatically removed and passed out of the smoke stack by means of suction pipe 85. Modification of diaphragm 9a as shown in Figures 4 and 5 makes inspection of the front tube sheet 76, tubes 81 and 82, and superheater parts easy to accomplish, in contrast with the inspection difficulties encountered with present standard A. A. R. construction.

Tests of the present invention on a 4-8-4 northern type stoker fired locomotive operating at various loads shows that twelve inch diameter inlets and disc valves, of the type shown in Figure 5, operate exceptionally well. Air inlet assemblies 13 and 14 in this construction were set at a suction pressure differential of 0.8" expressed in inches of water. The suction pressure with this type of control was reduced in front of the front tube sheet an average of at least 2 inches of water pressure below the average previously maintained with the restricting conventional design baffles while maintaining efficient combustion for all of the requirements of the locomotive. This resulted in reduced velocity of the products of combustion through the fire tubes, as well as a marked decrease in fuel consumption. The apparatus was adjusted so that the change from lower maximum to the upper maximum draft occurred when the steam pressure to the stoker engine exceeded 30 pounds per square inch gage. As soon as this rate of fuel feed was exceeded the louvres automatically closed on air inlet assembly 14, whereupon air inlet assembly 13 set for the higher suction pressure went into full operation. Numerous tests with this system showed that the suction pressures in the front portion of the locomotive smoke box could be maintained at substantially the same pressures as those directly in front of the front tube sheet. This produced a more uniform burning fire bed, higher efficiency of steam generation, and substantial elimination of smoke due to better and more even combustion. These improvements and more uniform operating conditions also made possible the increasing of the internal diameter of the exhaust stand nozzle $\frac{3}{8}$ inch, i. e. from $8\frac{3}{8}$ inches to $8\frac{3}{4}$ inches which resulted in an average reduced back pressure on the driving cylinders of approximately 6 pounds with greater power efficiency and a quieter exhaust, and also made possible the increasing of the grate opening area to one com-

parable to the free area of the tubes, thus permitting a lower velocity flow of air through the grates in amount sufficient for efficient combustion. This reduced velocity in turn greatly reduced the loss of unburned and partially burned coal through the smoke stack.

Other modes of applying the principle of my invention may be employed instead of those explained, change being made as regards the means and steps herein disclosed, provided those stated by any of the following claims or their equivalent be employed.

I therefore particularly point out and distinctly claim as my invention:

1. A method of controlling draft created in a steam generator by the flow of a gaseous fluid through a space in the steam generator wherein suction pressure is to be maintained at a substantially constant predetermined value over a prescribed portion of the operating range, which comprises the steps of introducing in controlled amount a separate suction reducing gaseous fluid into said space when the suction pressure therein tends to exceed the predetermined value, raising said suction pressure by stopping substantially the whole flow of said suction reducing gaseous fluid under conditions when same would normally flow into said space, and again releasing the flow of suction reducing gaseous fluid when control at said substantially constant predetermined value is again to be utilized.

2. A method of controlling draft in a steam generator, as set forth in claim 1, applied to draft regulation in a locomotive smoke box, in which suction is created by flowing exhaust steam through said smoke box and out of a smoke stack connected thereto, which includes the steps of controlling the upper limit of the suction pressure created by the exhaust steam at an intermediate and substantially constant level for low rates of fuel feed by admitting air into the smoke box at said intermediate level to limit the suction pressure approximately at that level, while at high rates of fuel feed the upper limit of the suction pressure thus created is raised to a suitably higher substantially constant pressure level by admitting air into said smoke box at substantially said higher level in variable controlled amount sufficient to limit the maximum suction pressure approximately at said predetermined higher level which is below that to which the suction pressure would otherwise normally rise.

3. In a method of the character described, the steps which comprise flowing a gaseous body under pressure through a restricted area in manner creating a suction pressure therein, admitting a second gaseous fluid into said restricted area when said suction pressure rises to and reaches a predetermined level, the amount of said second gaseous fluid admitted being controlled in manner holding the maximum suction pressure in said restricted area substantially at said predetermined pressure level, and changing said predetermined pressure level to a different pressure level in accordance with change of maximum suction pressure requirements.

4. In combination, a smoke box, means for creating induced draft suction pressure in said smoke box, and means to automatically limit said suction pressure so that it does not greatly exceed a predetermined level which is below the maximum to which it would normally rise, said last named means comprising an assembly for admitting a gaseous fluid, such as air, into said smoke box when the suction pressure therein ex-

ceeds a predetermined level, said assembly having a housing, a valve seat member in said housing, a valve movable to and from said seat, and means for holding said valve against said seat when the suction pressure in the smoke box is at least substantially below the predetermined level, and yet permit same to leave said seat and admit suction reducing gaseous fluid in controlled amount into said smoke box when the suction pressure rises to at least said predetermined level.

5. In combination with a smoke box and means for creating draft suction pressure therein, of valve means adapted to automatically open to admit a suction reducing gaseous fluid, such as air, into said smoke box when the suction pressure therein reaches a predetermined level, and automatically close when said suction pressure drops below said predetermined level, a second valve means constructed for operation in like manner to the first but at a higher predetermined suction pressure level, and means for shifting the suction pressure control from the first valve means to the second and back in accordance with which predetermined upper suction pressure in the smoke box is chosen to control the admission of suction reducing gaseous fluid.

6. In combination with a smoke box and means for creating draft suction pressure therein, of valve means adapted to automatically open to admit a suction reducing gaseous fluid, such as air, into said smoke box when the suction pressure therein reaches a predetermined level, and automatically close when said suction pressure drops below said predetermined level, a second valve means constructed for operation in like manner to the first but at a higher predetermined suction pressure level, and means for shifting the suction pressure control from the first valve means to the second and back in accordance with which predetermined upper suction pressure in the smoke box is chosen to control the admission of suction reducing gaseous fluid, said suction pressure shifting means comprising pivotally mounted louvres adapted to substantially prevent fluid flow through said first valve means when said louvres are in closed position, and means for opening and closing said louvres.

7. In combination with a smoke box and means for creating draft suction pressure therein, of valve means adapted to automatically open to admit a suction reducing gaseous fluid, such as air, into said smoke box when the suction pressure therein reaches a predetermined level, and automatically close when said suction pressure drops below said predetermined level, a closeable separate means for controlling the flow of suction reducing gaseous fluid to said valve means, means for moving said separate means alternately from wide open to completely closed position and back, and means for controlling the time of movement of said separate means from one of said positions to the other.

8. A railroad locomotive provided with a smoke box, a smoke stack connected and extending a short distance into said smoke box, and means for directing steam into the inner end of the smoke stack to create a suction pressure in said smoke box, in combination with a hood around the lower end of said smoke stack, said hood being open at its bottom and closed at its top, an open passageway means connected to the side of said hood to facilitate flow of gaseous fluid therinto, and an inlet valve means adapted to automatically open to admit suction reducing gaseous fluid, such as air, through said open pas-

sageway means into said hood when the suction pressure in said smoke box reaches a predetermined amount and automatically close when said suction pressure drops below said predetermined amount.

9. In a method of controlling suction pressure at least at one predetermined level in a compartment, the steps which comprise creating suction pressure in said compartment, said suction pressure normally rising above said predetermined level if not controlled, admitting a suction reducing gaseous fluid in controlled amount into said compartment when said suction pressure rises to said predetermined pressure level, controlling the flow of said suction reducing gaseous fluid admitted into said compartment so as to hold said suction pressure from rising substantially above said predetermined pressure level, stopping substantially the whole flow of said gaseous fluid when a higher predetermined pressure level is to be maintained in said compartment, and releasing the whole flow of said gaseous fluid into said compartment when the predetermined lower pressure level is to be again maintained therein.

10. In a method of controlling suction pressure in a compartment, at least at two predetermined levels therein, by means of independently operating inlets thereto for gaseous fluid, the steps which comprise creating suction pressure in said compartment, said suction pressure normally rising above said predetermined levels if not controlled, admitting a suction reducing gaseous fluid into said compartment when said suction pressure has risen to the lowest of said predetermined levels, controlling the amount of said suction reducing gaseous fluid admitted into said compartment so as to hold said suction pressure from rising substantially above said predetermined lowest level, stopping the flow of said gaseous fluid when a higher predetermined pressure level is to be maintained in said compartment, separately admitting a suction reducing gaseous fluid in variable amount into said compartment as soon as said suction pressure reaches the predetermined higher pressure level, controlling the amount of said suction reducing gaseous fluid admitted to said compartment so as to hold said suction pressure from rising substantially above said predetermined higher pressure level, and releasing the flow of said gaseous fluid into said compartment at the lower control level when the suction pres-

sure is to be again controlled therein at said lowest predetermined pressure level.

11. In an automatic draft regulator for steam locomotives, the combination with a smoke box and means for creating suction pressures therein, of an air inlet valve adapted to normally open and admit air in controlled amount into the smoke box when the suction pressure therein tends to exceed a predetermined level, means for rendering said inlet valve inoperative and closed when a higher predetermined suction pressure level is to be maintained in said smoke box, a second inlet valve adapted to open and admit air into said smoke box in controlled amount when the suction pressure therein rises to a predetermined higher level and tends to exceed same, and means for controlling the operation of said means for rendering said first inlet valve inoperative, whereby the suction pressures in said smoke box may be readily shifted from one upper level to another.

12. In combination with a smoke box and means for creating draft suction pressure therein, of valve means adapted to automatically open to admit a suction reducing gaseous fluid, such as air, into said smoke box when the suction pressure therein reaches a predetermined level, and automatically close when said suction pressure drops below said predetermined level, means for rendering said inlet valve inoperative and closed when higher suction pressure is to be maintained in said smoke box, and means for controlling the operation of said means for rendering said inlet valve inoperative, whereby the suction pressures in said smoke box may be readily shifted from said predetermined suction pressure to a higher suction pressure and back.

13. In combination with a smoke box and means for creating draft suction pressure therein, of valve means adapted to open and admit a suction reducing gaseous fluid, such as air, into said smoke box when the suction pressure therein reaches one level of a series of predetermined levels, and automatically close when said suction pressure drops below said level, and means for completely shifting from one predetermined level to another of said series, the pressure at which said suction reducing gaseous fluid is admitted to said smoke box.

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