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J. REID

AIR DRAFT SYSTEM FOR FURNACES

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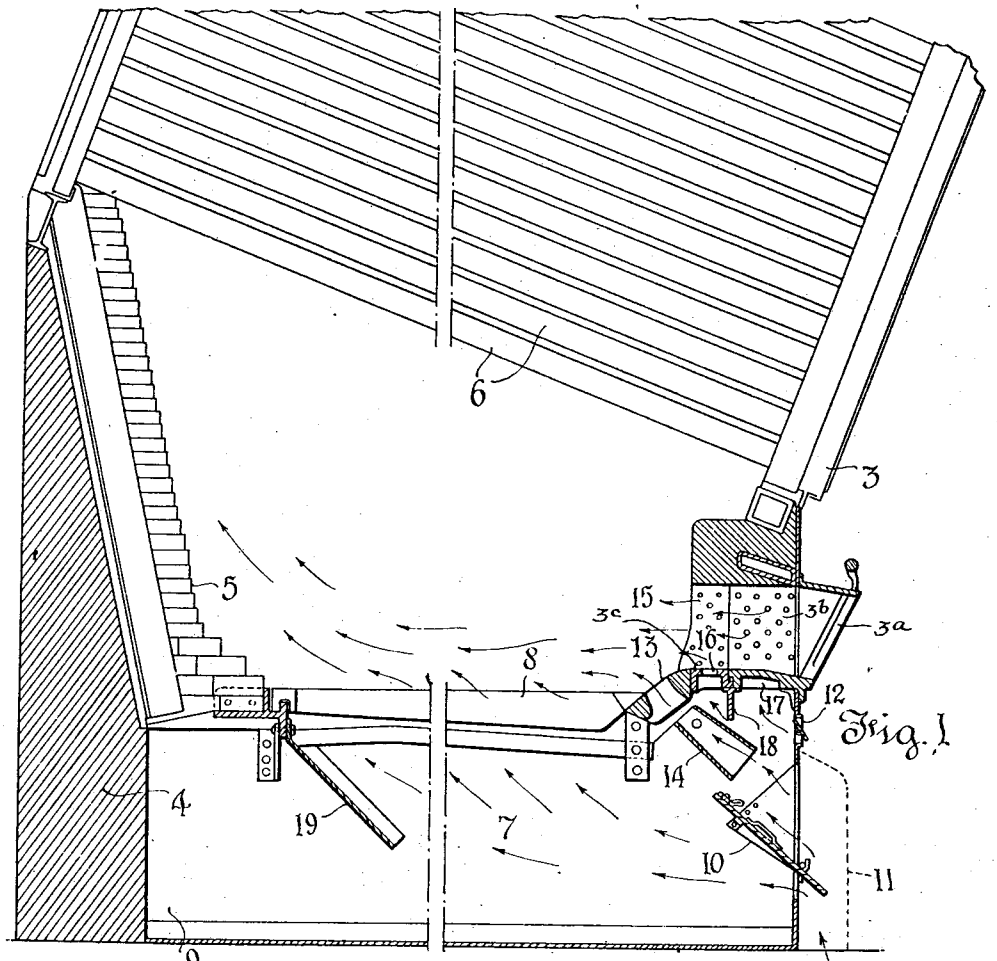



Fig. 1

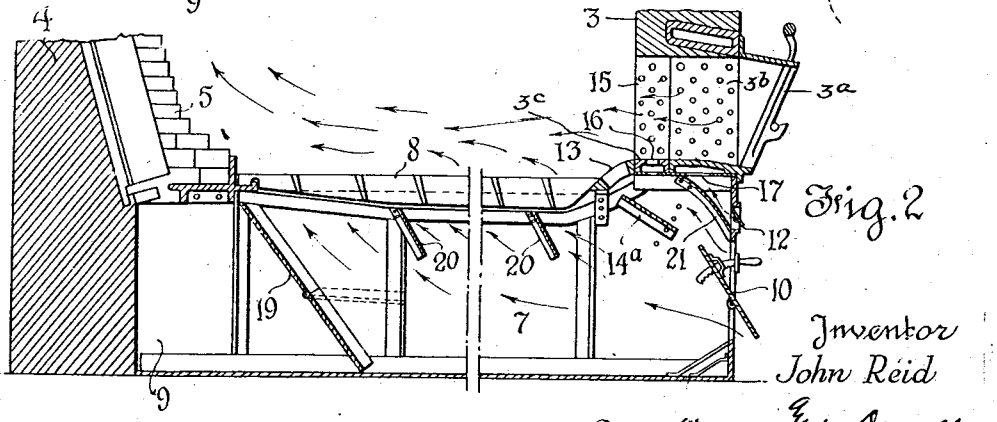



Fig. 2

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# UNITED STATES PATENT OFFICE.

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## AIR-DRAFT SYSTEM FOR FURNACES.

Application filed July 16, 1926. Serial No. 122,948.

This invention relates to boiler-furnaces and embodies desirable improvements over my U. S. Patent No. 1,470,876 dated October 16, 1923. It aims to improve the construction and operation of such furnaces, more particularly with reference to draft control.

One of the principal difficulties presented to the efficient operation of boiler-furnaces is in the proper supply, distribution and circulation of drafting air in adequate proportions to and through the furnaces. Unless the air supplied to the furnaces is properly distributed and circulated through and over the fires in proportions causing the fuel to be burned evenly and steadily over the full area of the grates, inefficient operation and waste of fuel will inevitably result. In the operation of marine engine boilers especially, for which drafting air must first be supplied to the hold of a vessel by means of air ventilators, efficient distribution or supply and effectual circulation of the air to and through the furnaces is problematical. It is therefore essential that the limited supply of air forced below for the induced drafting of ship furnaces should be utilized to the best advantage. To aid in supplying drafting air to the furnaces, forced draft systems are very generally employed, but while such systems may assist in supplying available air to the furnaces, they do not eliminate the difficulties encountered, nor enable the furnaces to be operated at maximum efficiency, especially in ships where there are a number of furnaces to be kept in operation simultaneously. One of the reasons for the incomplete success of such systems is that in addition to the problem of supplying requisite amounts of air to the furnaces, there is also the problem of effecting a proper distribution and circulation of the delivered air therethrough. This latter problem seems to have been largely overlooked by marine engineers, as there has been very little done to overcome it in practice during the past several years.

In boiler-furnaces of the different types in general use, particularly in marine work, the air supply has not heretofore been utilized to the best advantage within the furnaces, and the cost of operation is therefore excessive through loss of heat and waste of fuel in furnace constructions lacking in provision of proper means for controlling the air circulation therethrough. In furnaces of various types and constructions, I have observed that the fuel generally burns effectually only at the back of the grates. This obviously results from the fact that the air supplied to the furnaces, either by natural or forced draft, is allowed to pass largely uncontrolled through the ash-pit openings and is almost invariably drawn under the stack-draft directly toward the back of the grates where a very hot fire naturally results. Since the air is thus freely drawn to the back of the grates instead of being properly distributed over the entire fire-bed, the fuel at the front of the grates receives little if any drafting air and therefore burns very slowly and inefficiently. Furthermore, this slowly ignited and ineffectually-burned fuel at the front ends of the grates not uncommonly becomes smothered with green fuel resulting from the frequent stoking which is necessary in order to sustain the fires at the back of the grates. Large volumes of smoke and incompletely consumed gases from the fuel at the front of the grates are therefore continuously carried off through the funnels, with consequent loss of heat and undue waste of fuel.

In order to remedy this condition, which seems generally to be considered the result of insufficient air circulation through the furnaces, it is common practice to increase the speed of the draft fans so as to deliver the drafting air with greater force through the air trunks. This may ineffectually relieve the condition in one or more furnaces in a group, but inevitably disturbs or injuriously affects the operation of other furnaces. The practice also frequently imposes an overload upon the draft-fans and cannot possibly correct the condition in furnaces as heretofore constructed.

I have discovered that the most efficient and economic operations, with substantially complete combustion and great saving of fuel, depends upon the maintenance of a comparatively gentle but steady and properly controlled circulation of air to the furnace and through and over the fire-bed from the forward end of the grate, rather than by increasing the force of air circulation through the grate as is now done. I have also found that controllable means for properly distributing and directing ade-

quate proportions of air to circulate through and over the fire-beds under varying working requirements, induces the complete combustion of fuel over the entire grate-area and will materially increase the efficiency of boiler operation with great savings in fuel, regardless of the frequency or carelessness of stoking, since no part of the fire-bed is left unaffected by drafting air, so that rapid ignition and efficient burning of the fuel is assured. My discovery conclusively shows that the principle of operation and constructive designs of different types of boiler-furnaces in general use are defective and subject to material improvement.

The method embodying this invention and means for carrying the same into effect are based upon a somewhat different principle from that upon which different types of boiler-furnaces heretofore known and used have been designed to operate. This method and suitable means for effecting its practice in the operation of furnaces are readily adaptable to boiler-furnaces of various types of manufacture and require mere corrective changes in standard constructions, which changes are negligible in cost as compared with the great savings in fuel made possible within brief operating periods. The invention necessarily embodies changes of somewhat differing character and varying extent in the different types of boiler-furnaces now in use, but the necessary changes in each type are based upon the same operative principle of air draft and seek to accomplish the same effectual result. For this reason, the means for carrying my improved method into practice obviously may not be standardized beyond the fundamental principle and a general form of means embodying the invention for effecting the desired results in different types of furnaces.

The invention will best be understood by reference to the accompanying drawings in which a furnace of practicable form is shown adapted to be operated according to my improved method with means for assuring a proper distribution and adequate circulation of air through and over the fire-bed from the forward end of the grate so that the fires may be evenly maintained at maximum heat-producing efficiency with resulting economic consumption of fuel and prevention of waste.

In said drawings:

Fig. 1 is a sectional side elevation of an illustrative water-tube boiler of known type in which appropriate changes in the otherwise standard furnace construction have been incorporated to adapt the same to operation according to my improved method of air distribution and circulation through and over the fire-bed; and

Fig. 2 is a fragmentary sectional view of the lower part of the furnace, illustrating a practicable modification of the structure shown in Fig. 1.

Referring to the drawings, the illustrative furnace is shown constructed with the usual front and back walls or shells 3 and 4 respectively, a bridge with fire-back wall 5, water-tubes 6, a bottom ash-pit space 7 and grate-bar sections 8 spanning the ash-pit space from front structure to fire-back wall or bridge.

The ash-pit space of the furnace is advantageously divided into sections by means of diaphragm plates 9 disposed longitudinally under the grate-bars on partitioning lines between the ash-pit openings in the front structure of the furnace, only one of said plates being visible in the sectional views of the illustrative furnace-structure. Closing the ash-pit openings in the front structure of the furnace, ash-pit doors 10 are provided. Said doors are shown adapted to be swung inwardly on intermediate pivots rather than outwardly as is more common, and means are represented for holding said doors in the desired angular position. Air in adequate volumes may be supplied to the ash-pit openings either by natural or forced draft and in Fig. 1, the terminus of an air-feeding trunk 11 of a forced draft system has been indicated in dotted lines overextending the ash-pit door opening.

Between said ash-pit door and the fire door $3^a$ in the front-structure of the furnace, controlled louver-openings 12 are shown provided through which auxiliary supplies of air may be admitted for circulation around the hollow fire-door frames $3^b$ and through the inner perforate walls thereof over the fire-bed.

A hollow dead-plate 13 is shown disposed transversely along the front end of the grate through which a substantial or variable proportion of the air supplied through the ash-pit opening may normally be directed through and over the top of the fire-bed as indicated by the arrows.

Means for directing air through said hollow dead-plate is shown provided subjacent said plate and the fire-door frame. In Fig. 1, said means is represented in the form of an elongated flue-member or box-like structure open at opposite ends or sides, which may be divided into a series of funnel-like spaces by means of transverse partition plates. Said means or member, hereinafter referred to as the "air director", is shown pivotally mounted to swing in angular adjustable relation to the dead-plate and ash-pit door.

An opening 16 is shown provided in the sill or base-extension-plate $3^c$ of the fire-door frame structure, through which a sub-

stantial proportion of the air from the ash-pit opening will be directed upwardly into the fire door opening and thence over the fuel forwardly of the hollow dead-plate at the front of the grate, as indicated by the arrows. The air passing through said opening 16 and circulated with drafting effect over the fire-bed may be referred to as the "top air" supply.

Abutting the vertical edge of the perforate inner wall of the hollow fire-door frame on a line of partition or division between fire-door openings of the furnace, a perforate cast iron baffle-plate 15 is shown, into and through which air is supplied to the hollow shell of the furnace or the frame of the fire-door opening may be directed to jet or nozzle over the top of the fires above the aforesaid top air supply.

An opening 17 is shown provided in the outer wall of the hollow fire-door frame $3^b$ through which the auxiliary supply of air entering at the louver-opening 12 will pass to circulate around said frame and through the perforate walls thereof over the top of the fire-bed. A portion of this air passing around the fire-door frame may, as above suggested, be directed into and through the perforate baffle-plate 15 which is preferably triangular in cross-section so as to jet or nozzle in fan shape over the fire-bed with advantageous effect in supplementing the top air and auxiliary air supplies through the fire-door opening.

A plate 18 is shown secured to the bottom of the fire-door frame to provide a partition between the top air and auxiliary air-supply openings 16 and 17 respectively. An inclined air-deflecting plate 19 is also shown bolted to the bridge-plate at the back of the ash-pit space for a well known purpose.

From the foregoing description with reference more particularly to Fig. 1, it will be appreciated that air supplied to the ash-pit space, either by natural or forced draft, may be directed in proper proportions under, through and over the top of the fuel-bed so as to cause an even burning and complete combustion of fuel throughout its entire area, with increased efficiency and material saving of fuel in boiler operation.

In practice, the fire door $3^a$ is kept normally closed while the ash-pit door 10 should be set in angular position causing the most effectual distribution under working conditions of the air entering the furnace through the opening of said door. The air-director 14 should also be set in a position most effectually causing air to be directed through the hollow dead-plate 13 over the fire-bed. When these two elements have been fixed in effectual position, a substantial proportion of air entering the ash-pit opening over the top of the ash-pit door will obviously pass through said air-director and hollow dead-plate members under the suctional force of the funnel draft, with effectual draughting or combustive action upon the fire-bed at the forward end of the grate. A portion of the air supply entering the ash-pit opening will also pass or circulate below the air director and be drawn through the grate section along the front thereof. A hot fire and complete combustion of fuel at the forward end of the grate is thus assured, because the air passing through and under said air-director is adequately distributed over the width of the fire-bed, its force of flow being sufficient to penetrate the fuel-bed so as to produce effectual and rapid combustion.

Air entering or forced into the ash-pit space under the ash-pit door may be left free to circulate below the grates in the manner indicated by the arrows, as is common in present furnace constructions, thus supplying adequate proportions of drafting air for the fuel from below the grates. This air flowing under the grate tends to move more gradually toward the back of the grate section and will maintain a hot fire at that point as heretofore, while part of such air will be drawn through the fuel-bed at intermediate stages as it moves along the length of the grates by the suctional force of the top-air circulation. Should it be desired more effectually to break up or retard the flow of the bottom drafting air toward the back of the grates, deflector plates 20 similar to those shown in Fig. 2, may be provided at intermediate points along the length of the grate section to pocket the air so that it may be drawn through the grates at intermediate points from front to rear.

A proportion of the air entering the ash-pit space over the top of the ash-pit door will obviously pass over the top of the air-director and through the opening 16 in the extension-plate of the fire-door frame-structure, forwardly of the hollow dead-plate. This air, termed the top air supply which becomes quickly heated, passes over the top of the fire-bed, aiding the draft through said dead-plate so as to maintain an even and steady circulation of air over the fuel-bed at all times, thus assuring the effective and complete combustion of gases arising therefrom.

The auxiliary air supply entering through the louver-opening 12, passes through the opening 17 into the hollow fire-door frame to circulate therearound where it becomes heated and emerges through the perforate walls thereof so as to project or flow over the fuel-bed, thus augmenting the top air circulation over said fire-bed. A portion of this auxiliary air supply circulating through the hollow fire-door frame may be directed into and through the perforate baffle-plate 15 so as to jet or nozzle in spreaded flow

over the fire-bed with advantageous effect in supplementing the top-air draft as herein before stated.

By the means described for effecting the operation of a furnace according to my improved method of air distribution and circulation within the furnace, a maximum efficiency in performance with greater saving in fuel may be attained in spite of careless stoking. Should the hollow dead-plate member 13 become entirely covered with a bed of green fuel which interrupts the normal circulation of drafting air therethrough or completely smothers the air draft through the front of the grate section, the increased force of suction under the funnel draft, resulting at the forward end of the fuel-bed, will cause air supplied to the ash-pit space to be drawn proportionally in much greater volume and with increased force through the "top air" feed-opening 16 and through the perforate walls of the fire-door frame and baffle plate members over the fuel-bed, thus producing a stronger draft or circulation of air over the fire-bed in compensation for the air normally drawn through the dead-plate, whereby the smoke gases which would otherwise accumulate densely at this point, will immediately be cut and carried off through the funnel, while the normal air draft through said hollow dead-plate member will be gradually reestablished, so that the fuel will continue to burn effectually rather than smother the fire and the temperature at the forward end of the grate will be maintained at high degree permitting the desired chemical reactions of combustion to take place with resulting maximum efficiency in operation. The gradual restoration of the air draft through the hollow dead-plate member 13 under the above described conditions, is augmented by the corresponding force of suction created in the ash-pit space into which the air is drawn for distribution, whereby a portion of the air supply becomes trapped below the grates and above the air director from whence it is drawn strongly by the force of suction above the fuel-bed and pressed by the incoming volume of air below the fuel-bed so that it quickly finds its way through the dead-plate member and openings between the door frames, and provides an adequate volume or supply of air for the suction over the fire to feed upon. This is a highly advantageous feature resulting in a furnace constructed or modified in accordance with my invention.

It is of course important in the efficient operation of boiler-furnaces according to this invention, that air in adequate volume should be supplied to the furnaces through their ash-pit openings, as the hereinbefore described method and means for effecting a proper distribution and circulation of air within and through the furnaces in requisite proportions would not assure maximum efficiency in operation unless a sufficient volume is supplied thereto. The proper distribution and circulation of air through the furnaces is not alone sufficient to assure efficient operation and preventation of waste. The distributive volume of air supplied to the furnaces either by natural or induced draft must be sufficient to promote complete combustion of fuel without restricting the funnel draft or stifling the fires. However, suitable means for supplying adequate volumes or proportions of drafting air to the furnaces embodies subject-matter separate and distinct from the present invention and need not therefore be shown or described herein.

The advantages of my improved structure with provision for automatic correction by alternative flow of air in effective circulation under, through and over the top of the fuel-bed from the forward end of the furnace, will be obvious to those familiar with the difficulties presented to the effectual operation of boiler-furnaces as at present constructed and operated.

In the boiler-furnace construction of modified form shown in Fig. 2, an air-director element $14^a$ is shown in the form of an elongated plate-member mounted to swing on a pivot and adapted to be held in adjusted position. In such form, the air-director is more in the nature of a guide-vane than a flue-member as in the form shown in Fig. 1, but will function similarly to accomplish substantially the same result. When an air-director of this latter form is employed, the air entering the ash-pit opening over the top of the ash-pit door is permitted a somewhat less restricted distribution and circulation through the dead-plate and top air feed-opening 16, so that a larger proportion of the air may pass through the latter opening than would be the case in the first defined form. In the modified furnace structure, inclined deflector-plates 20 are shown provided at spaced intervals beneath the grate for the purpose of breaking up or retarding the circulation of air toward the back of the grate, entering the ash-pit opening below its door, as hereinbefore indicated in describing the operation with reference to the structure shown in Fig. 1.

In this figure also, an arcuate plate 21 is shown secured below the fire-door frame in substitution for the partition plate 18 in Fig. 1. This arcuate plate separates the air entering the ash-pit opening from the air entering the louver-opening 12, causing the latter supply to pass directly into the hollow fire-door frame $3^b$ and into the baffle-plate 15 through the perforate walls thereof over the fire-bed, as hereinbefore described with reference to the preceding figure. This

arcuate plate also provides a deflecting hood for the air entering the ash-pit opening and tends to direct its circulation over the air-director and through the top air feed-opening 16 as well as the dead-plate.

In the embodiment illustrated in Fig. 2, the means for adjustably holding the ash-pit door 10 in open position is shown in somewhat different form from that represented in Fig. 1. The air-deflector 19 in this figure is also of slightly different form and extent from that shown in the preceding figure, the lower part thereof in the latter figure being shown hinged and adapted to swing for convenience in cleaning out the ash-pit space.

The operation of the furnace illustrated in the modified structure is substantially the same as that hereinbefore described with reference to Fig. 1, the movable parts mentioned being similarly related and adjustable to position assuring a proper and adequate distribution and circulation of drafting air through and over the fuel-bed so as to cause the effectual burning and consumption of fuel.

From the foregoing description, it will be appreciated that the illustrated structures provide material improvements adaptable to boiler-furnace constructions of different types, which will eliminate faults in design and structure heretofore preventing the efficient and adequate distribution and circulation of drafting air therethrough. The highly beneficial results obtained according to my invention, enabling the efficient and economic consumption of fuel in boiler operation, will be obvious to those skilled in the art.

Since various changes in form and construction may be made and different combinations and sub-combinations may be embodied in a furnace in structural modification thereof, or in the development of new designs adapted to operate according to the method embodying this invention without departing from the spirit and scope thereof, I do not wish to be limited by the appended claims to the specific constructions and arrangements hereinbefore illustrated and described.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. The improved method of drafting a furnace, which consists in supplying air to the front of the furnace below the level of the grate in a continuous comparatively gentle flow; causing a portion of the air supply to pass under the grate with a retarded rearward movement; causing another portion of the air supply normally to pass through a section of the grate and rearwardly over the fuel-bed at the forward end of the grate; causing still another portion of the air supply to pass rearwardly over the fuel-bed from a point forwardly of the grate and forwardly of that portion of air supply passing through a section of the grate at the forward end thereof so as to provide a top air circulation effecting combustion of fuel at the forward end of the grate, thus aiding the induction through the grate and fuel-bed of the air circulating under the grate by the force of off-draft suction above the fire-bed; causing an additional portion of air supply to circulate around and into the furnace fueling opening and thence over the fuel-bed from points forwardly of that portion of air supply passing over the fuel-bed from a point forwardly of the grate so as to supplement the top air circulation and volatilize gases passing with the off-draft; said drafting air circulations being maintained with the fire door normally closed, whereby the air supplied to the furnace will be evenly and uniformly distributed under, through and over the bed of fuel to effect perfect combustion thereof throughout its entire area.

2. The improved method of drafting a furnace, which consists in supplying air to the front of the furnace below the level of the grate in a continuous comparatively gentle flow; causing a portion of the air supply to pass under the grate with a retarded rearward movement promoting its induction through the grate and fuel-bed at intermediate stages therealong; causing another portion of the air supply to pass normally through a section of the grate and rearwardly therefrom over the fuel-bed at the forward end of the grate; causing still another portion of the air supply to pass rearwardly over the fuel-bed from a point forwardly of the grate and forwardly of that portion of air supply passing through a section of the grate at the forward end thereof so as to provide a top air circulation effecting combustion of fuel at the forward end of the grate and aiding the induction through the fuel-bed of the air circulating under the grate; causing an additional portion of air supply to circulate around and into the furnace fueling opening and thence over the fuel-bed from points forwardly of said portion of air passing rearwardly over the fuel-bed from a point forwardly of that portion of air passing through a section of the grate at its forward end, so as to supplement the top air circulation and volatilize gases over the fuel-bed; said drafting air circulations being influenced by the force of off-draft suction above the fuel-bed and maintained with the furnace fire door normally closed, whereby the air supplied to the furnace will be evenly and uniformly distributed under, through and over the bed of fuel to effect perfect combustion thereof throughout its entire area.

3. The improved method of drafting a

bed of fuel on the grate section of a furnace, which consists in supplying air to the furnace in a continuous comparatively gentle flow under the suctional influence of the off-draft flue at a point below the level of the grate; causing a portion of the air supply to circulate under the grate with a retarded rearward movement promoting the induction of such air through the grate and fuel-bed at intermediate stages of its movement thereunder; causing a substantial proportion of the air supply to be directed normally upwardly through a section of the grate and over the fuel-bed from a point at the forward end of the grate; causing another portion of the air supply to be directed upwardly through the bottom of the furnace fueling opening and rearwardly over the fuel-bed from a point forwardly of that portion of the air supply normally passing through a part of the grate section so as to effect a top air circulation over the fuel-bed tending to aid the induction therethrough of the air circulating under the grate; and causing an additional portion of the air supply to circulate around and into the fueling opening and over the fuel-bed from points forwardly of that portion of the air supply passing through the bottom of the fueling opening, said additional portion of the air supply providing an auxiliary circulation of air over the aforesaid top air circulations for effecting the complete combustion of gases arising from the fuel-bed at the forward end of the grate whereby the air supply is evenly and uniformly distributed under, through and over the bed of fuel to effect perfect combustion thereof.

4. The improved method of drafting a furnace, characterized by supplying air in comparatively gentle flow to the forward end of the furnace at a point below the level of the grate; effecting a division and circulation of relative proportions of the air supply in diverging directions from the point of admission to the furnace; directing a portion of the air supply to move below the furnace grate with a retarded rearward movement promoting the induction of such air through a bed of fuel overlying the grate, at intermediate stages of its movement thereunder by the force of suction from the off-draft flue; directing a substantial portion of the air supply to pass normally through a section of the grate at the forward end thereof and over the bed of fuel in a comparatively gentle draughting action upon the fuel-bed so as to effect the combustion of fuel overlying the grate section at such points directing another portion of the air supply to pass upwardly through the bottom of the normally closed furnace fueling opening and rearwardly over the fuel-bed from a point forwardly of that portion of the air supply normally passing through a section of the grate so as to effect a top air circulation; and causing an additional portion of air supply to circulate around and into the furnace fueling opening and over the fuel-bed from points forwardly of that portion of the air supply passing through the bottom of said opening for supplementing the aforementioned circulations of air over the fuel-bed and effecting the combustion of any gases accumulating at the forward end of the fuel-bed, whereby air is evenly and uniformly distributed and caused to circulate under, through and over the bed of fuel to effect perfect combustion thereof over the entire area of the grate by the force of a gentle flow of air through the furnace.

5. The improved method of drafting a bed of fuel on the grate section of a furnace, which consists in continuously supplying air to the front of the furnace below the level of the grate at a rate of flow and in volume substantially directly proportional to the rate and volume of discharge through the off-draft flue; effecting a distribution and circulation of the air supply in relative proportions under, through and over the fuel-bed from the point of air admission to the furnace so that a portion of the air supply will pass normally through a section of the grate and rearwardly over the fuel-bed at the forward end of the grate and another portion of the air supply will pass continuously through the bottom of the furnace fueling opening and rearwardly over the fuel-bed from a point remote from and forwardly of that portion of the air supply normally passing through a section of the grate at the forward end thereof, while still another portion of the air supply is caused to circulate under the grate with a retarded rearward movement promoting the induction of such air through the fuel-bed at intermediate stages of its movement thereunder by the force of off-draft suction over the fuel-bed; an additional portion of air supply being simultaneously caused to circulate around and into the fueling opening and rearwardly along lines extending above the aforesaid top air circulations from points forwardly of that portion of the air supply passing through the bottom of the fueling opening to effect a supplemental top air circulation assuring complete combustion of fuel and gases over the entire area of the furnace grate.

6. The herein described method of supplying and distributing air in a furnace so as to effect complete combustion of fuel, which consists in introducing air at the front of the furnace below the fuel-supporting grate and effecting a retarded movement of a portion thereof beneath the grate toward the rear of the furnace; dividing and causing a portion of the air so introduced to pass upwardly at the front of the fuel-bed and rear-

wardly along the upper surface thereof while another portion is directed upwardly at a point nearer the furnace front and caused to move rearwardly therefrom so as to provide a top circulation of air overlying the first mentioned rearwardly moving portion, thereby inducing a flow of air supplementing and increasing the quantity of air flowing normally from below upwardly through the fuel-bed, and pre-heating and introducing pre-heated air at the front of the furnace to be commingled with the aforesaid portions passing upwardly and rearwardly along the top of the fuel-bed.

7. The herein described method of drafting a bed of fuel on a furnace grate, which consists in effecting a division and circulation of relative proportions of the air supply in diverging directions from the point of delivery to the furnace; causing a portion of the air supply to circulate under the grate with a retarded rearward movement promoting the induction of such air through the grate and fuel-bed at intermediate stages therealong, by the force of suction from the off-draft; causing another portion of the air supply normally to pass upwardly through a section of the grate at the forward end thereof and rearwardly therefrom over the fuel-bed; causing still another portion of the air supply to pass continuously upwardly through the bottom of the furnace fueling opening at a point forwardly of the grate and forwardly of that portion of air normally passing through a section of the grate, and rearwardly therefrom over the fuel-bed so as to provide a top air circulation for effecting the combustion of fuel at the forward end of the grate and aiding the induction through the fuel-bed of the air circulating under the grate, while causing an additional portion of air supply to circulate around and into the fueling opening and over the fuel-bed along lines extending above the aforesaid portions of top air circulation from points forwardly of the portion passing through the bottom of the fueling opening; that portion of the air supply normally passing through a section of the grate at the forward end thereof being caused to pass upwardly through the bottom of the fueling opening and rearwardly over the fuel-bed in supplementing volume and increasive force with the portion of air supply continuously passing therethrough, when a blanket of fuel is thrown upon that section of the grate through which said portion of air supply normally passes, thereby temporarily preventing the passage of said air therethrough; such increased volume and force of air circulation over the fuel-bed from a point forwardly of said fuel-blanketed section of the grate producing a rapid combustion of the blanketing fuel upon said section of the grate so that air may again find its way therethrough, thus quickly restoring the normal circulation of said portion of the air supply through said section of the grate, whereby an even and uniform distribution of the air supply is automatically maintained under, through and over the bed of fuel to effect the continuous and perfect combustion thereof.

8. In combination with a furnace having a fuel grate with hollow dead plate, an ash compartment, a normally closed fueling opening, and an off-draft flue; means for controlling the admission and effecting a division of an air supply to the furnace, whereby a portion of the air supply is directed under the grate with a retarded rearward movement; means causing another portion of the air supply to pass through the hollow dead plate and rearwardly of the furnace above the fuel overlying the grate; means located between the dead plate and the closure for said fueling opening whereby still another portion of the air supply is caused to pass through the bottom of the fueling opening and rearwardly therefrom over the fuel-bed; and means causing an additional portion of air supply to pass around and into said fueling opening and over the fuel-bed from points forwardly of said portion passing through the bottom of said opening.

9. In combination with a furnace having a fuel grate with hollow dead plate, an ash compartment, a normally closed fueling opening, and an off-draft flue; means below the level of the grate for controlling the admission and effecting a division of an air supply to the furnace, whereby a portion of the air supply is directed to circulate under the grate with a retarded rearward movement; means causing another portion of the air supply to pass upwardly through the hollow dead plate and rearwardly of the furnace in blasting action upon fuel overlying the grate; means causing still another portion of the air supply to pass upwardly through the bottom of the fueling opening and rearwardly therefrom over the fuel-bed from a point forwardly of the dead plate; and means causing an additional portion of air supply to pass around and into said fueling opening and over the fuel-bed from points forwardly of said portion passing through the bottom of said opening.

10. In combination with a furnace having a fuel grate with hollow dead plate, an ash compartment, a normally closed fueling opening, and an off-draft flue; means below the level of the grate for controlling the admission and effecting a division of an air supply to the furnace, whereby a portion of the air supply is directed to circulate under the grate with a retarded rearward movement; means causing another portion of the air supply to pass upwardly through the hol-

low dead plate and rearwardly of the furnace over the grate; means causing still another portion of the air supply to pass upwardly through the bottom of the fueling opening and rearwardly therefrom over the fuel-bed at a level above and from a point forwardly of the dead plate; means causing an additional portion of air supply to pass around and into said fueling opening and over the fuel-bed at a level above and from points forwardly of said portion passing through the bottom of said opening; and means tending to retard the circulation of that portion of air moving below the grate toward the rear thereof.

11. In combination with a furnace having a fueling opening and closure therefor, a back off-draft flue, an ash compartment and a fuel supporting grate with hollow dead plate member; means below the level of the grate for controlling the admission and effecting a division of an air supply to the furnace, whereby a portion of the air supply is directed to circulate under the grate with a retarted rearward movement; means for directing a portion of the air supply normally through the hollow dead-plate member and rearwardly over the fuel-bed at the forward end of the grate; means for directing another portion of the air supply upwardly through the bottom of the normally closed fueling opening and rearwardly over the fuel-bed from a point forwardly of the dead-plate member to aid combustion of fuel at the forward end of the grate; and means for effecting the circulation of an auxiliary supply of air around and into the fueling opening and rearwardly over the fuel bed along lines extending over the aforesaid top air circulations from points forwardly of that portion of the air supply normally passing through the bottom of said opening for volatilizing gases arising from the fuel at the forward end of the grate.

In testimony whereof I affix my signature.

JOHN REID.