

W. L. HARDER.
COMBUSTION FURNACE.
APPLICATION FILED MAR. 13, 1919.

1,354,741.

Patented Oct. 5, 1920.

3 SHEETS—SHEET 1.

Fig. 1.

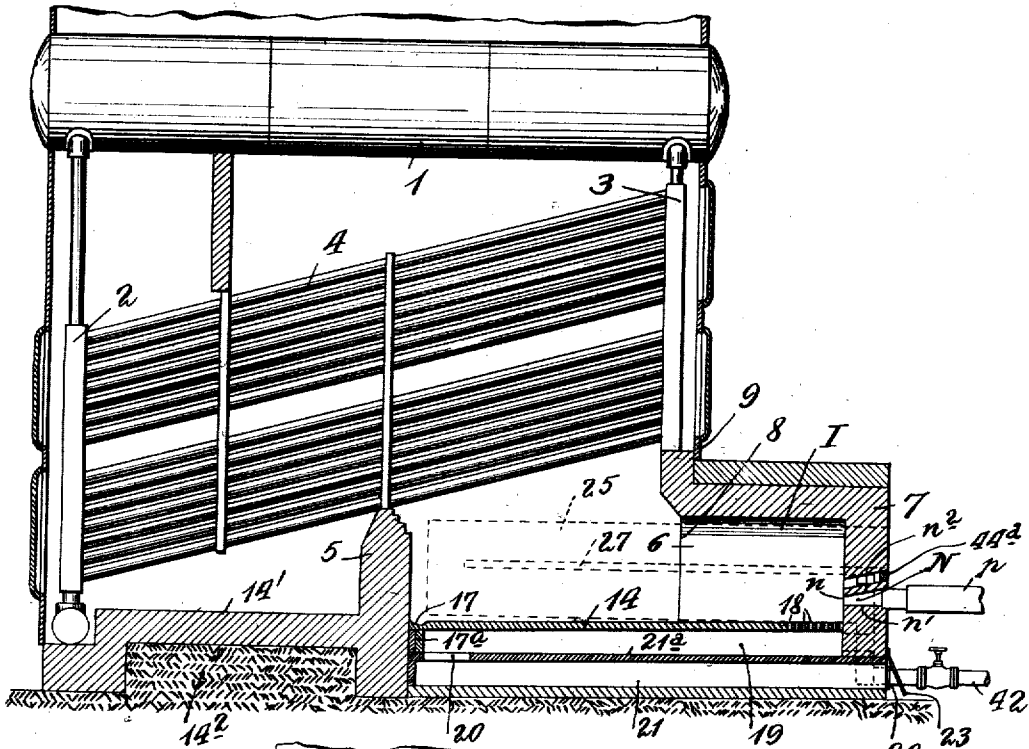
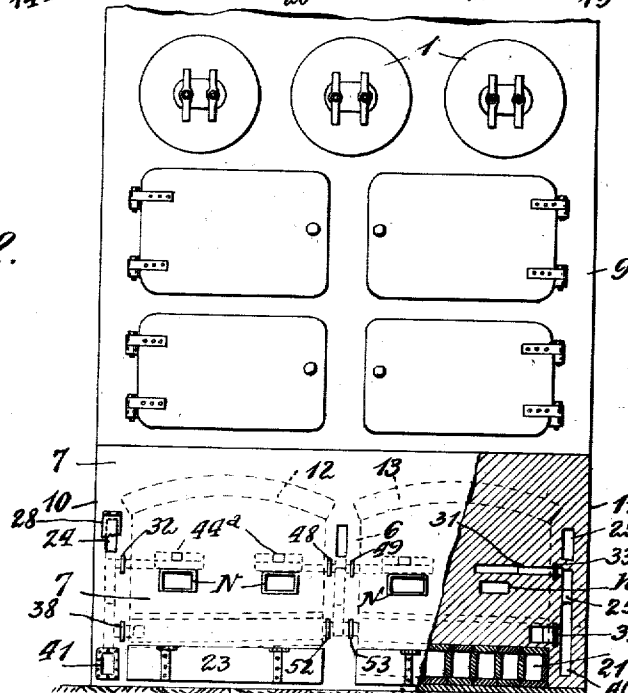


Fig. 2.



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3 SHEETS—SHEET 2.

Fig. 3.

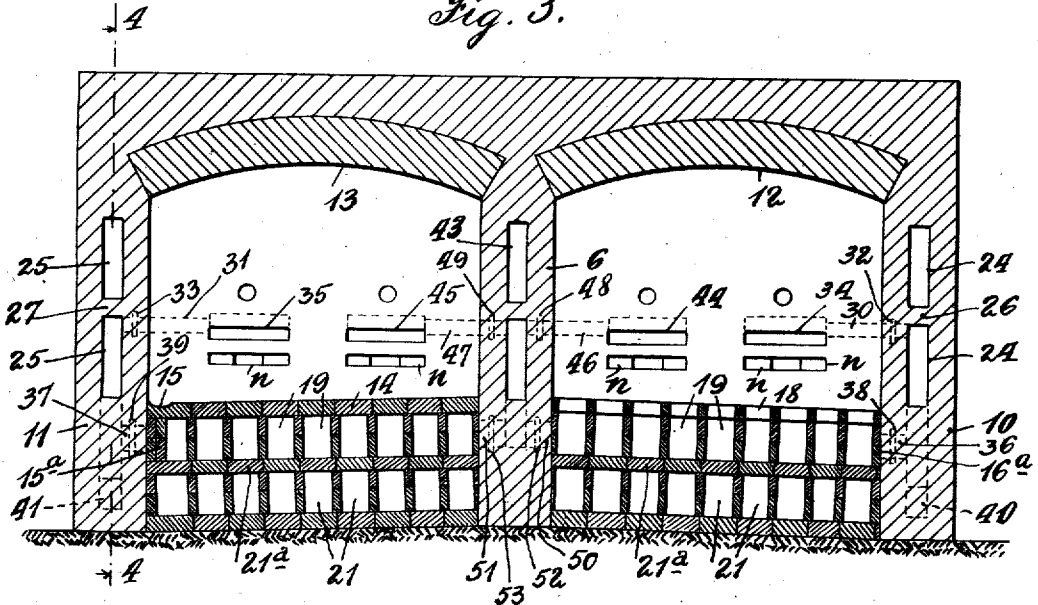
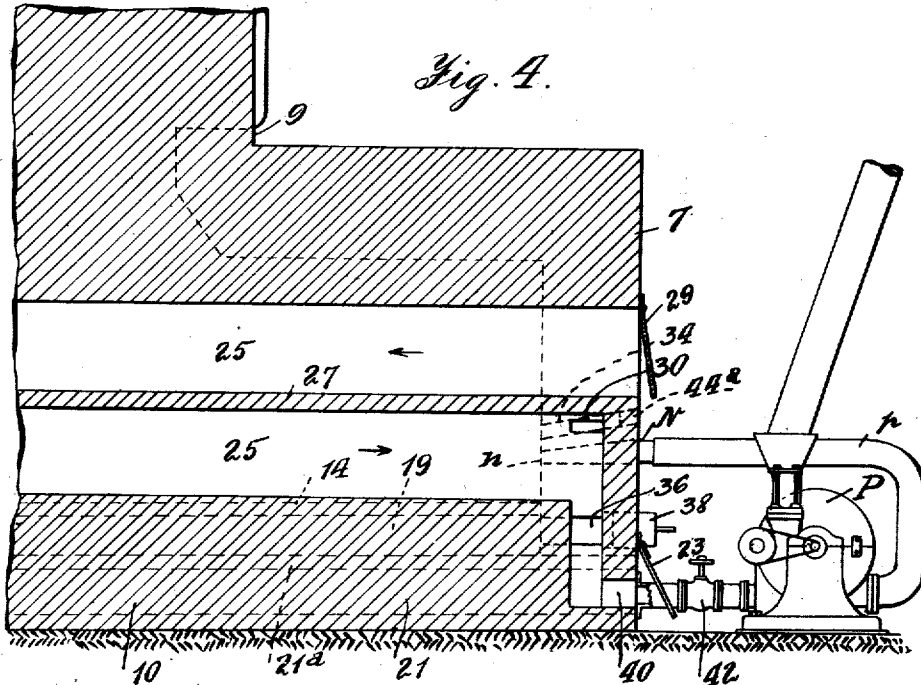


Fig. 4.



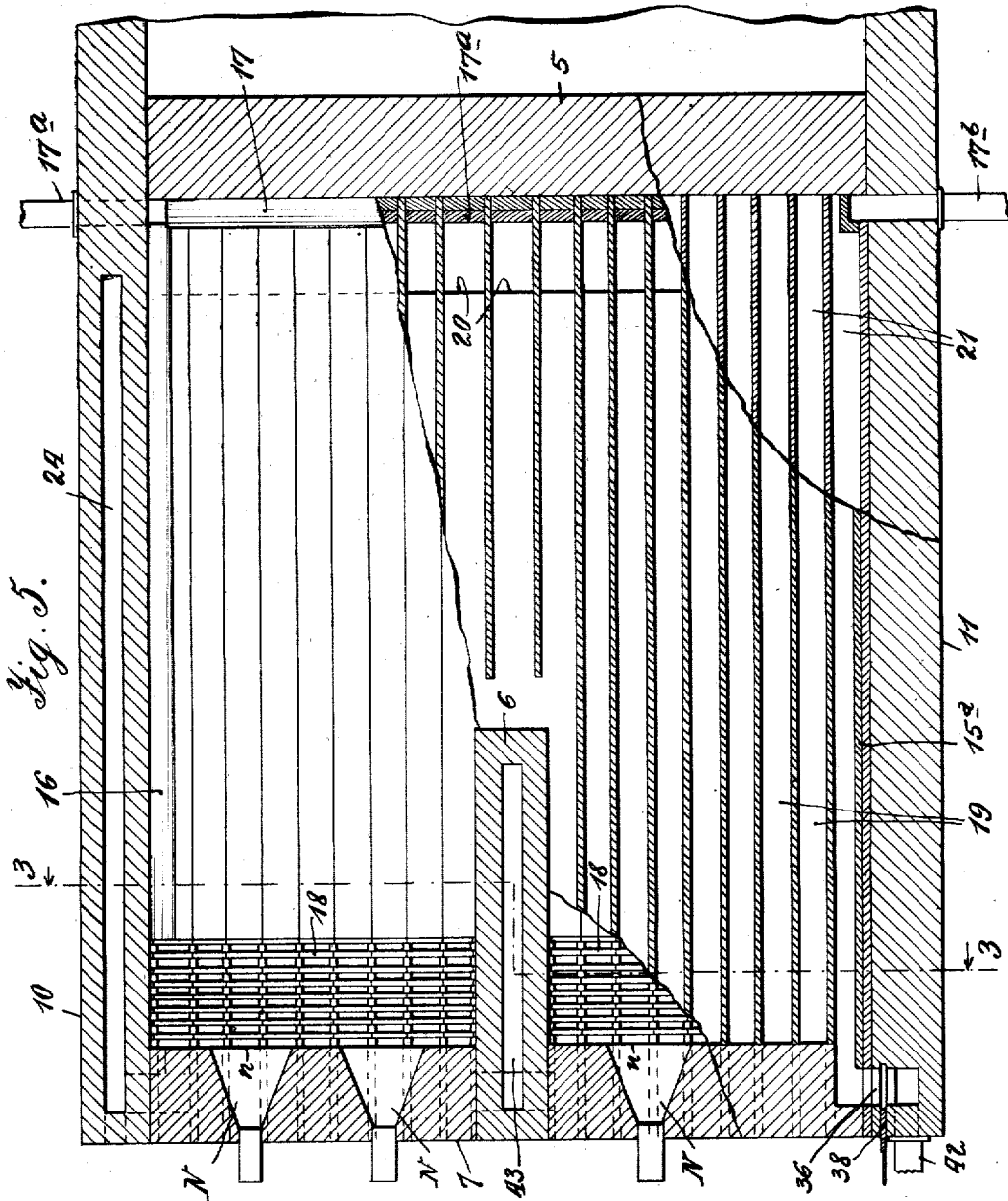
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3 SHEETS—SHEET 3.



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UNITED STATES PATENT OFFICE.

WILLIAM L. HARDER, OF BIRMINGHAM, ALABAMA, ASSIGNOR TO HARDER FURNACE & ENGINEERING CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

COMBUSTION-FURNACE.

1,354,741.

Specification of Letters Patent.

Patented Oct. 5, 1920.

Application filed March 13, 1919. Serial No. 282,367.

To all whom it may concern:

Be it known that I, WILLIAM L. HARDER, a citizen of the United States, and a resident of Birmingham, in the county of Jefferson and State of Alabama, have invented certain new and useful Improvements in Combustion-Furnaces, of which the following is a specification.

My invention relates to improvements in furnaces and is directed particularly toward providing a furnace which will successfully utilize "injected" fuels; that is, fuels of a character which may be continuously fed into the furnace.

More specifically, the invention herein disclosed relates to a furnace which may utilize fuels capable of vaporization or suspension in a gaseous fluid until ignited and brought to a point of proper attenuation in a gaseous or semi-gaseous form to provide complete combustion.

The object of the invention is to provide a furnace into which the fuel is so introduced and suspended in an oxidizing medium as to permit ready ignition and complete combustion, with the consequent high heat values and economies attending perfect combustion.

It is also an object of the invention to control the ignition and high heated point obtained in complete combustion without liability of impairing the elemental structure (such as a boiler) through too intense and localized application of the heat evolved from the complete combustion.

The invention also contemplates in its objects a means for moving the slag and products of combustion and the utilization of the waste heats and radiated heats incident to ordinary types of combustion furnaces, boiler furnaces and the like.

Finally, it is the primal object of the invention to provide a furnace in which the fuel may be brought to a temperature and maintained in an oxidizing medium, said medium having a temperature of such coincidence and co-relation to that of the fuel as will give a most efficient ignition point and practically complete oxidization of the fuel, whereby the gases developed will at-

tain a heat which may be utilized and absorbed as they are passed through the furnace and elements (for instance, boiler tubes), delivering a very high percentage of the heat units possible of development with any given fuel.

The invention comprises the disclosures, constructions, and arrangements of elements hereinafter described, claimed, and illustrated in the accompanying drawings, and any proper modifications thereof.

The invention is specifically illustrated herein as applied to a heat furnace for a boiler of the Babcock & Wilcox type, this being merely an adaptation which illustrates the inherent characteristics and advantages of the invention.

Referring to the drawings:

Figure 1 is a longitudinal section through the improved furnace structure and super-imposed boiler.

Fig. 2 is a front face view of the elements illustrated in Fig. 1.

Fig. 3 is a cross sectional view through the ignition chamber looking toward the front of the furnace on the line 3—3 of Fig. 5.

Fig. 4 is a fragmentary longitudinal section on the line 4—4 of Fig. 3.

Fig. 5 is a horizontal section through the ignition and combustion chambers back to the bridge-wall.

To more clearly define the invention herein disclosed, I refer to my issued Patent, No. 793,070, dated June 27, 1905, which shows an example of a preheating medium for producer gas and air commingled and ignited in a highly refractory ignition chamber, which arrangement has been very successful in practice, but which lacks certain elements of perfection and economies which are very important to the securing of perfect combustion of certain types of fuels.

The invention hereinafter disclosed, while embodying the basic principle of utilizing a preheating means for a fuel and its oxidizing air, also embodies elements which make it adaptable for various types of fuel; safeguards the destructive properties of the high temperatures attained; prevents radia-

tion losses; and utilizes the excess heat and radiating losses for effecting complete combustion of fuel of the character which could not readily and safely be preheated before introduction to an ignition chamber and combustion chamber.

In developing the invention hereinafter described, I have utilized, I believe, to the best advantage, well-known principles and theories of combustion and heat transference, with a view to delivering through my apparatus the greatest possible percentage of the potential heat energy of any given fuel.

I have also applied in practice the theoretical requirements to conserve and deliver the full quota of potential energy of a fuel by what may seem, at first glance, to be quite obvious means, but which, so far as known to me, have not been embodied in a practical commercial form for heating furnaces.

I have developed and produced my invention with well known theories in mind and with theories which may or may not be my own and which may or may not be correct and in strict agreement with those of the text-books. However, I have under actual test conditions secured results which, with the application of my invention, surpass to an amazing degree any results possible of attainment in the ordinary furnace and boiler constructions prior to the application of my invention thereto.

It is a well known and established fact that the value of any fuel depends upon two principal factors—one of which is the calorific power and the other calorific intensity or pyrometric effect; in other words, the sensible temperature of the products of combustion.

The calorific power of a fuel is substantially constant, irrespective of the method of burning, and whether it is oxidized by the oxygen of the air or by other reactive oxides. With these established rules in mind, I have developed my invention upon the theory that the calorific intensity or pyrometric effect may be utilized, under proper control, to deliver for a given purpose greater values than secured in the ordinary and well known types of furnaces which have already been brought up to a high state of efficiency.

In this development, I have endeavored to take advantage of every possible condition to utilize and deliver the actual heat energy, producible from the potential energy of any fuel, at the moment of dissolution of its chemical union.

It has been found that the calorific intensity of a fuel may be very considerably enhanced when the combustion takes place with preheated air. This applies as well to solid as gaseous or liquid fuels. It is also a fact that the higher attenuation secured

in the fuel; that is, a gaseous condition of fuel, when brought to the burning point at high temperatures, will produce a heat that can only be resisted by the most refractory substances. This fact also makes it impossible to secure the theoretical values under a boiler with the ordinary types of apparatus. If it were possible to employ such an arrangement under the tubes of a boiler or in its combustion chamber, the amount of heat which would be usefully applied would be small in comparison with that developed. It follows that the stack temperature is enormously high over the ordinary requirements to give proper and active draft through the combustion chamber.

Attempts have been made to utilize such high temperatures in the so-called "regenerator furnaces" or "recuperators," but, attempts to utilize the high heats developed at the burning point in such a structure have required tremendously expensive furnace construction, utilizing, through a cellular mass of fire-brick, the excessively high temperatures developed in the gases for heating gas or air or both. While there is some saving in the actual calories of heat, the main thought in such furnaces has been to reduce the stack temperatures to some 300° to 400°. Such furnaces are mainly used for reduction purposes; that is, the reduction of other materials by the application of intense heats, rather than the capturing and controlling of the available potential energy of a substance for delivery in the form of energy, such as steam.

Referring to the particular fuels, it is well known that a theoretical calorific value of liquid fuel, such as oils and hydro-carbons, can be more nearly realized in practice than the theoretical calorific value of coal. This is due to the facility of securing better combustion by the artificial admixture of air with such a fuel. This is accomplished in various ways by an atomizing process. It follows to a degree that the practical evaporative results attained by the heat transference are proportionately higher with the liquid fuel than with coal, the relative advantage being shown by the proportions of two tons of liquid fuel to three tons of coal.

I have found that, even with the atomizing processes such as heretofore used, and whether effected with air or steam, there will not be a deliverance of as great a calorific economy as can be attained in the use of my invention. I attribute this, in particular, to the fact that full advantage is not taken of the principles of convection, conduction, and radiation, all of which are present in the combustion and burning of any material, whether solid or gaseous.

Compressed air, utilized in the atomizing process or apparatus, of itself expands and, in expanding, absorbs heat which must be

substantially equal to the thermal equivalent of the work expended upon its compression.

Moisture (water) injected with a fuel fed to a furnace is not only extremely injurious, but lacks economy.

Moisture will delay the combustion and will produce a dull flame rather than the required short and bright white flame which may be utilized if properly controlled.

Where moisture is present, the water must be decomposed chemically into its constituent elements; namely, hydrogen and oxygen. This will absorb a marked percentage of heat which might otherwise be made available for the direct transference of the potential energy of the fuel to the boiler or the like.

The delays of combustion due to moisture are co-related with a postponement of the proper vaporization of the fuel at the nozzle. It takes place at the upper portion of the combustion chamber, at the tubes of the boiler, or even at the base of the chimney, with resultant heat losses, to say nothing of the direct injury to a boiler structure.

Where producer gas is employed, it is necessary to provide for a complete combustion and breaking up of the gas for thorough oxidization, at a point where the residual products of combustion are set free. At the moment of ignition, combustion of the major elements may be utilized for delivering the full calorific intensity.

In employing the term "combustion," it indicates the process of burning or the oxidization of the substance to be burned, producing flame and evolution of heat. The oxidization in the present instance is accomplished through the oxygen of air and the combining and utilizing, through heat reductions, of the various principles of convection, conduction, and radiation which will give, as nearly as possible, complete oxidization of the basic fuel and its elements.

As more fully hereinafter defined in describing the structural elements of a device for carrying out the invention, it will be obvious that I accomplish what has been heretofore neglected, in the way of utilizing to the utmost the heat calories which have been attracted by cold air or cold surfaces and lost through convection, conduction, or radiation.

The main principle embodies an arrangement of preheating ducts and chambers, combined and co-related with the ignition chamber, in which ignition of the fuel takes place and through and from which the combustion of the fuel and its component elements may be controlled as to their appreciable calorific employment.

This preheating effects the saving of all the calories ordinarily abstracted by cold air, permitting the employment of a lesser quantity of fuel to secure a given effect, and

with a consequently reduced quantity of stack gas.

I am able with my invention to carry sufficiently high temperatures at localized points, and without liability of danger or disruption to the elements designed to absorb the heat, to break up and burn coal directly to CO_2 , effecting an economy.

This is indicated by a comparison with producer gas where three distinct steps are required; namely, the gasifying of the fuel, through heat action; the piping of the gas to the furnace; and the burning of the gas.

There is a loss of potential energy in burning the carbon of the coal to CO_2 and the reaction to CO , to say nothing of the losses incurred in the breaking up of the union of the oxygen and hydrogen of the steam employed in blowing the producer. There is also a three to seven per cent. formation of CO_2 in the producer in large volumes of inert nitrogen, running as high as forty-eight to fifty-two per cent., to say nothing of the carbon deposits in the form of soot in the gas pipes or sewers.

Producer gas installation for a given unit costs approximately five times more, for instance, than a coal pulverizing unit of equal capacity, and the gas unit would occupy approximately six times the space. It would be impractical to install a H. P. boiler to burn producer gas, though quite practical to utilize a coal pulverizer.

With the direct use of coal, in pulverized form, there are advantages if it can be consumed and converted directly to CO_2 H_2O , as can be done practicing my invention. More complete combustion of coal can be secured in a given space. Higher temperatures can be secured in less time. Starting a furnace or boiler with powdered coal, a high temperature can be secured and steam raised in one fourth the time required for producer gas. The product of combustion from powdered coal, being of higher temperatures than those of producer gas, transfers the heat more readily and, in view of the reduced quantities, will carry less to the stack or chimney.

In utilizing any fuel, I contemplate taking every advantage of the three named principles of heat transference.

By convection, I utilize unequally heated products of combustion to aid in the production of temperatures which would utilize all of the gases to the utmost.

By conduction, I anticipate transferring, by contact between contiguous particles of matter, the heat developed.

By radiation, I utilize calories which would ordinarily be lost as effective heating media for the boiler or the like.

The radiated waste heat values, which, in ordinary furnace constructions are lost, are absorbed by air to be subsequently utilized.

This is accomplished by taking advantage of radiation and its characteristic differences from conduction and convection, as applied to heat. The calories lost, through
 5 conduction and convection, to the proper maintenance of an ignition point, are reclaimed, through radiation, to a considerable degree and with a marked efficiency when utilized to enhance ignition and combustion of the fuel.

In the accompanying drawings, I have illustrated the invention in conjunction with a powdered coal fuel supply. This has been done merely for the purposes of illustration,
 15 as it exemplifies one of the most difficult conditions of securing very sure and controllable ignition and most perfect combustion of a fuel in a heater or boiler.

Powdered coal, of course, approximates
 20 the liquid fuel, and it is possible with my invention to so surround and completely oxidize every particle of the dust, at temperatures effective for disposing of the waste products, or stack gases. Unusual
 25 economies are possible, making the powdered coal equal to, or better, than the liquid fuel.

It will be understood that the salient features of my invention and discovery relate
 30 to the method of heat control and the apparatus which makes the control possible. This may be employed with a coal pulverizer, as illustrated in Fig. 4, or with any desired fuel capable of vaporization or suspension in a gaseous fluid, such as preheated
 35 air when ignited and until its combustible contents are consumed by complete combustion.

Any desired type of pulverizer may be
 40 employed and these devices usually embody pulverizing elements with provision for taking in air along with the coal as it is pulverized, and providing additional air required for combustion through a regulable
 45 damper or the like for the outlet connection or conduit extending from the pulverizer to the furnace.

In such a device, each minute particle of coal or dust is divided and separated from
 50 other particles and is surrounded by air to theoretical requirements, so that it is in fact suspended in the oxidizing medium.

With the application of my invention and method, such a pulverizer may be used with
 55 no appreciable excess air and, through complete and controlled combustion, the calorific value of the coal may be nearly, if not wholly, recovered as appreciable evaporative energy. The flue or stack gases are
 60 such as result from a perfect combustion, and it is quite possible to reduce stacks both in height and area.

It is possible for me to deliver pre-heated air both to the pulverizer and to the furnace
 65 or its ignition chamber. The means for

providing this are such as to utilize heat values which are ordinarily lost or neglected in the ordinary type of boiler.

Referring to the drawings, the invention is illustrated in connection with a boiler of
 70 the Babcock & Wilcox type, which needs no particular description. In fact, I have illustrated this standard type to indicate the applicability of my invention to the ordinary boiler furnace construction.

The boiler head 1, manifolds 2, 3, tubes 4,
 75 bridge wall 5, and casing and masonry required for emplacement are not disturbed. I simply remove the grate bars, fire-box appurtenances, and ash pit forward of the
 80 bridge-wall, and build in my apparatus which extends forward of the boiler, providing an ignition chamber or furnace I.

This ignition chamber is lined with highly refractory material capable of sustaining
 85 high temperature. It is illustrated in duplex form with a dividing partition or wall 6, extending from the front wall 7, of the ignition chamber to a point 8, substantially in
 90 the plane of the original front wall 9, of the boiler casing. This partition and the side walls 10, 11, support the arches 12, 13; all the walls, arches, etc., being of refractory material.

There is a floor 14, for the ignition chamber which extends back to the bridge wall 5,
 95 and slopes away on opposite sides from the partition wall 6, terminating in gutters 15, 16. There is also a transverse gutter 17, formed at the rear of the floor adjacent to
 100 the bridge-wall 5. The purpose of the inclined floor and gutters is to carry away the slag which results from burning of the fuel, which slag may be drawn off through tap openings or conduits 17^a, 17^b. The flooring
 105 14, adjacent to the front wall 7, and the burners, is opened up with checker-brick 18, to provide air inlets from flues 19, extending immediately below the floor 14. These
 110 flues 19, open adjacent to the bridge-wall 5, through passages 20, into flues 21, which open through the front wall, below the ignition chamber, as at 22, and are controlled by
 115 air dampers 23. All of this sub-structure below, and including, the floor 14, is of a highly refractory material which will withstand the high temperatures of the ignition chamber and, through conduction, radiation,
 120 and convection, will preheat atmospheric air passing through the conduits 21, and 19, and checker-brick openings 18, to the forward section of the ignition chamber.

The floor 14, is upon substantially the same level as the floor 14', of the boiler furnace at the rear of the bridge-wall. This
 125 floor may if desired be made of refractory material and underpacked with earth, as at 14², the purpose being to reclaim, through reflected radiation, as much as possible of the heat of the gases which pass from the
 130

ignition chamber I and the combustion chamber, about the tubes of the boiler upon progressing to the stack.

The inter-connecting flues or ducts 21, 19, are arranged one above the other with a partition 21^a, of fire-brick or refractory material. As these ducts are arranged in parallelism below the entire floor of the ignition chamber and combustion chamber back to the bridge-wall, there is ample allowance for such conductance of the very high heat of the chambers, as will insure delivery of air at a high temperature directly below the fuel nozzles N.

The vertical walls of the flues or ducts may be formed with refractory fire-brick of somewhat thinner dimensions than those of the ignition chamber floor 14, and partition 21^a; though below the slag gutters 15, 16, 17, it is advisable to provide a solid backing 15^a, 16^a, 17^a, as insurance against the ingress of slag to the air ducts, should the gutters burn through.

The fuel nozzles N, are built into, and extend through, the front wall 7, of the ignition chamber. They are of flaring form, terminating in rectangular nozzle openings *n*, within the ignition chamber I, and having cylindrical or tubular connections extending without the chamber for connection with the fuel feed conduits *p*, of the pulverizer P.

The lower side *n'*, of the flaring nozzle is in a horizontal plane, while the upper side *n''*, is angularly disposed thereto to give slight restriction and aid in distribution of the fuel in what is practically a horizontal sheet. It follows that there is a constant web or sheet of fuel going forward in the ignition chamber, in intimate contact with the highly heated air passing up from below the nozzles through the checker-brick openings 18. In fact, the volume of the air in its preheated condition is such as to first support or suspend the particles of fuel; and, secondly, to tend to rise and break through the sheet of injected fuel. As a result, the carbonaceous fuel is completely enveloped in, and supported by, the air, bringing the oxygen and hydrogen contents thereof into successive and most intimate and perfect mechanical and chemical admixture and combination with the fuel.

The more rarefied and elastic gases naturally tend to rise and impinge against the highly heated roof or arches of the ignition chamber and must be forced back against the film or sheet of fuel.

In practice, this phenomenon may be observed as the carbon particles of the fuel carry on through the medial line of the ignition chamber until complete combustion is effected.

To insure such a desirable operation and to give a definite control, I provide arrange-

ments for introducing highly heated air just over the fuel nozzles as well as from below, as heretofore described.

The side walls 10, 11, and the partitions 6, all of which are of highly refractory material, are made hollow or, more properly, have chambers or conduits therein which are substantially co-extensive with the heights and depths of the walls, except for division webs or partitions. They serve various purposes in the air preheating system, and have added functions in preserving the wall structures of the ignition and combustion chambers and conserving the heat energy produced by the combustion of the fuel.

The walls 10, 11, have chambers 24, 25, centrally divided by horizontal partitions 26, 27, in such manner as to form continuous air conduits in each wall.

The portion of the chambers above the partitions 26, 27, open to atmosphere through the front wall of the ignition chamber and are controlled by suitable dampers 28, 29.

These chambers or conduits extend nearly to the bridge-wall, so they are effective throughout the ignition and combustion chamber walls.

The chambers below the partitions 26, 27, may be placed in communication to supply highly heated air for introduction with the fuel; may be directed into the ignition chamber above the fuel nozzles; or may be led into the conduits of the preheating system below the floor of the ignition chamber.

Conduits 30, 31, controlled by dampers 32, 33, lead from the respective chambers 24, 25, to air boxes 34, 35, over the respective nozzles of the burners N, thus providing the required volume of controlled and highly heated air above the fuel.

Conduits 36, 37, controlled by dampers 38, 39, connect the chambers 24, 25, with the air conduits below the floor of the ignition chamber, thereby providing any additional preheated air which may be required below the fuel nozzles.

Conduits 40, 41, extending through the front wall of the ignition chamber, connect with the pulverizer P, or other source of fuel supply, through suitable valve-controlled pipes, one being illustrated at 42, Figs. 1 and 4.

The dividing partition 6, has a similarly arranged chamber 43, which communicates with air boxes 44, 45, through conduits 46, 47, formed in the front wall of the ignition chamber and controlled by dampers 48, 49. Touch-off openings for the burners are shown with removable plugs at 44^a.

The chamber also communicates, through conduits 50, 51, controlled by dampers 52, 53, with the preheating conduits below the floor of the ignition chamber.

It will be obvious that the above arrangement makes it quite possible to secure any desired preheated air in quantity as required and under control, for introduction directly with the fuel, or under or above the fuel as the latter is introduced to the ignition chamber.

With the hollow walls, I absorb in a utilizable medium (preheated air) such heat values as would be dissipated or lost through conduction and radiation; and, by their use, prevent destruction and deterioration of the wall structures of the furnace. The life of the furnace structure is materially enhanced and the excess and otherwise destructive heat units are usefully employed to effect great economy in fuel consumption and give more perfect combustion and controllable heat values.

The system and apparatus, while applicable to any fuel, is particularly advantageous when used with pulverized coal. First, what are waste heats in an ordinary furnace, due to conduction and radiation in the furnace walls, are utilized to safely raise the pulverized coal to a temperature, upon introduction to the ignition chamber, approaching its ignition point, and with no appreciable chilling or reduction of temperature condition in the ignition chamber.

The carbon will be readily and completely converted with active burning gases and even the unconsumed slag will serve its purpose in delivering up its heat for pre-heating the air through conduction and radiation.

For purposes of illustration and comparison: Producer gas, as employed in my prior patent, must first be made by the application of heat to the fuel, with attendant heat losses as compared with the potential energy of the fuel. To secure the most economical delivery of the theoretical calorific value of the gas, it must be preheated and ignited in contact with preheated air, as indicated in my prior patent.

Pulverized coal, used in the manner and the apparatus herein described, can be ignited and converted into burning gases directly in the furnace, thus saving the heat losses incident to the conversion of coal to producer gas and the subsequent losses due to cooling down and to the securing of complete combustion of the gas. There is no cooling down of the gas, produced and propagated upon ignition of the pulverized coal in contact with the heated oxidizing medium, until after complete combustion has been realized.

Whether I utilize powdered coal or other fuel, I employ a new principle and control by introducing air either below, or above, or both at the same time; and by providing for preheating, as desired.

The oxygen of the neutralized strata of air has a greater chemical affinity for the hydrogen of the gas produced in burning a fuel (coal) than it has for the carbon. The hydrogen must be satisfied before oxidation of the carbon content can begin. The affinity of the hydrogen of the fuel for the oxygen of the air tends to hold the hydrogen element with its carbon elements in a definite zone and prevents disruption of the stream and the flying of the hydrogen to the top of the furnace, where its available heat for breaking up and consuming the carbon would be less effective.

If there is no air introduced below and only above, there is a tendency for the hydrogen element of the fuel, due to its affinity for oxygen, to immediately rise, with consequent burning of these elements at the top of the furnace and out of the direct zone of the carbon element. As a result, there is incomplete oxidation, or slow oxidation, of the carbon, and the flue gases immediately indicate an excess of unconsumed carbon.

With preheated air properly balanced either below or above the inflowing fuel, the carbon will be converted to CO which, being a burning gas, will deliver its heat as it travels through the medial zone of the combustion chamber and is consumed and reduced to CO₂ before it passes beyond the ignition chamber. This is made possible by the immediate union of the hydrogen and oxygen elements to H₂O which will develop heat in the zone to aid in the conversion of the carbon to CO and CO₂. With this system, it is possible to reclaim the calorific values of the CO₂ as no harm results from the impingement of said gas against the chilling surfaces of the boiler and appurtenances of the furnace.

In other words, the fuel is burned between the nozzle and within the confines of the ignition chamber, to CO₂. At any rate, complete combustion of the fuel is effected within said limits of the ignition chamber, which is the hot zone of the furnace.

As one pound of hydrogen burning to H₂O produces 9 lbs. of vapor with the development of 62,100 B. T. U's, and one pound of carbon burns to 3.67 lbs. CO₂ with the development of 14,600 B. T. U's, the resultant 76,700 B. T. U's is evidence of the economy.

Obviously, the exact details and structural forms required for any particular installation may be modified to suit the exigencies of the particular case in hand. So long as the principles and methods hereinabove carefully set forth are utilized, the particular means should be considered as falling within the scope and intent of the invention, which contemplates and secures economies in appreciable heat development and

reclamation thereof from fuels heretofore unattained and with less expensive apparatus.

What I claim as my invention and desire to secure by Letters Patent is:

1. A furnace having an ignition and combustion chamber, conduits through which the combustion-supporting medium passes and where it is heated, ducts from the conduits into the combustion chamber, nozzles through which fuel is delivered, in a state of suspension, into the atmosphere of the combustion chamber, located between the said ducts, and means for independently controlling the delivery of the combustion-supporting medium through the said ducts, whereby the volumes thereof on the opposite sides of the fuel delivered from the nozzles may be varied, thereby controlling the zone of combustion.

2. A furnace having an ignition and combustion chamber, conduits in the walls of such chamber having communication with the atmosphere and through which air to support combustion is passed and where it is heated by the radiated heat losses of the combustion chamber, ducts opening from the conduits into the combustion chamber, nozzles through which fuel is delivered in a state of suspension into the atmosphere of the combustion chamber, located between the said ducts, means for controlling at will the passage of air to the said ducts, whereby the volumes of air, on opposite sides of the suspended fuel, may be varied and the zone of combustion thereby controlled.

3. In a combustion furnace, a main casing within which a boiler is disposed, a combustion chamber within said casing, an auxiliary casing of refractory material formed in extension of the main casing and providing an ignition chamber opening into the combustion chamber, conduits formed in the bottom and side walls of the ignition chamber and combustion chamber, fuel openings extending through the front wall of the ignition chamber, controllable ducts in the walls of the ignition chamber communicating between the ducts of the side walls and the ducts of the bottom of the chamber, said ducts in turn opening through the floor of the ignition chamber adjacent to the front wall, controllable ducts extending from the ducts of the side walls and opening to the ignition chamber above the fuel openings, and means for connecting the ducts of the walls with the fuel openings, whereby the fuel is introduced to the ignition chamber with and inclosed by a highly preheated oxidizing medium.

4. In a combustion furnace, a combustion chamber, an ignition chamber formed in extension thereof, a bridge-wall in the combustion chamber, ducts formed in the walls

of the ignition and combustion chambers and extending therethrough to the bridge-wall, one end of said ducts opening to atmosphere, the opposite ends having connections for delivering absorbed heat back to the ignition chamber, fuel inlet nozzles extending through the front wall of the ignition chamber, means for introducing fuel through said nozzles, said means including connections with the ducts of the walls of the ignition and combustion chambers, means for introducing preheated air to the ignition chamber below the fuel nozzles, and controllable connections from the ducts of the side walls for delivering preheated air above said nozzles.

5. In a combustion furnace for burning finely divided fuel, means for pulverizing said fuel, a combustion chamber, and an ignition chamber formed in extension thereof, the walls of said ignition chamber being provided with ducts forming an insulation for said walls, and providing a means for absorbing waste heat conducted there-through, controllable connections from said ducts to the pulverizing means, whereby the pulverized fuel is introduced to the ignition chamber in a highly heated state with the heated oxidizing medium, fuel nozzles extending through a wall of the ignition chamber, means for preheating and introducing air to the ignition chamber below the point of introduction of the fuel, means for introducing the preheated air from the walls of the ignition chamber above the point of introduction of the fuel, and means by which the relative volumes of the highly heated oxidizing medium, introduced respectively above and below the fuel, may be varied, thereby controlling the zone of combustion.

6. In a combustion furnace for burning finely divided fuel, means for pulverizing the fuel, and means for introducing said fuel in a finely divided state to an ignition chamber, said means including a highly preheated oxidizing medium heated by waste radiation from the heat developed in the ignition chamber, an ignition chamber having hollow walls providing insulating and heat absorbing chambers, said chambers opening through controllable valves to the atmosphere and connected through controllable valves with the fuel pulverizing means, and connections for introducing at will the preheated oxidizing medium to the ignition chamber with, below, and above the point of introduction of the fuel to the ignition chamber.

7. A furnace having an ignition and combustion chamber, conduits in the walls of such chamber open to the atmosphere, ducts opening from the conduits into the combustion chamber, nozzles through which the

fuel is delivered, in a state of suspension, into the atmosphere of the combustion chamber, located between the said ducts, means for controlling the flow of external air into said conduits, and means for controlling and diverting the flow of the heated air from the conduits to the combustion chamber through the said ducts, whereby the relative volumes of heated air delivered through the said ducts may be varied and controlled, thereby controlling the zone of combustion.

8. The herein described method of burning fuel in a confining chamber and utilizing the heat thereby produced, which consists in absorbing the waste heat radiated through the walls of the chamber by the air employed to support combustion of the fuel, feeding the fuel into the chamber so that it is in suspension in the atmosphere thereof, introducing the air preheated as stated into the combustion chamber in volumes as required by the demands of combustion by the natural draft induced thereby, on opposite sides of the fuel, and varying the relative volumes of air supplied to the fuel from opposite sides to control the zone of combustion.

9. The herein described method of burning fuel and utilizing the heat thereof, which consists in introducing the fuel into a highly heated combustion chamber in a suspended state, absorbing the waste heat values of radiation of the combustion chamber in an oxidizing medium, reintroducing the heat values absorbed in the oxidizing medium to the combustion chamber along with the oxidizing medium, controlling the relative volumes and location of the heated oxidizing medium, with reference to the fuel, whereby the burning gases evolved after the ignition of the fuel are in a controlled zone to aid in the complete combustion of the fuel and reduction of the carbon content thereof to CO_2 .

10. The herein described method of burning fuel in suspension and utilizing the generated heat thereof, which consists in introducing the fuel into a highly heated ignition chamber, absorbing the waste heat values of radiation in an oxidizing medium, suspending the fuel in and between volumes of the highly heated oxidizing media heated by the waste radiated heat of the ignition chamber, the volume of said highly heated oxidizing media introduced above and below the strata of injected fuel varying with the re-

quirements of combustion, and confining the fuel in a localized zone as it is burned, whereby the hydrogen content is first satisfied by the oxygen of the heated medium and provides in a localized zone a burning gas, the heat of which aids in the complete combustion of the carbon content as it is satisfied by the oxygen of the heated media and is burned from CO completely to CO_2 .

11. The herein described method of burning fuel in suspension and utilizing the generated heat thereof, which consists in introducing the fuel into a highly heated ignition chamber, absorbing the waste heat values of radiation in an oxidizing medium, suspending the fuel in and between volumes of the highly heated oxidizing medium heated by the waste radiated heat of the ignition chamber, the volume of said highly heated oxidizing medium introduced above and below the stratum of injected fuel varying with the requirements of combustion, thereby effecting a control of the zone of combustion.

12. The herein described method of burning fuel in suspension and utilizing the heat thereof, which consists in introducing the fuel in a state of suspension into a highly heated combustion chamber, introducing a heated oxidizing medium into the furnace to support combustion of the fuel and regulating the relative volumes of the fuel and the oxidizing medium according to the requirements of complete combustion, by confining the fuel between volumes of the oxidizing medium independently controllable at will, whereby the zone of combustion is localized and controlled.

13. In a combustion furnace, a main casing within which a boiler is disposed, a combustion chamber within the casing, an auxiliary casing of retractory material formed in extension of the main casing, and having a central partition wall and providing a duplex ignition chamber opening into the combustion chamber, conduits formed in the walls of the ignition chamber and in the partition for providing a preheated oxidizing medium for the furnace, and controllable ducts for delivering said preheated medium with and about the fuel introduced to the ignition chamber.

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Witnesses:

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