No. 843,612. PATENTED FEB. 12, 1907.

J. M. W. KITCHEN.

SECTIONAL BOILER OR FURNACE.

APPLICATION FILED DEC. 22, 1905.

3 SHEETS—SHEET 1.

Fig. 1.

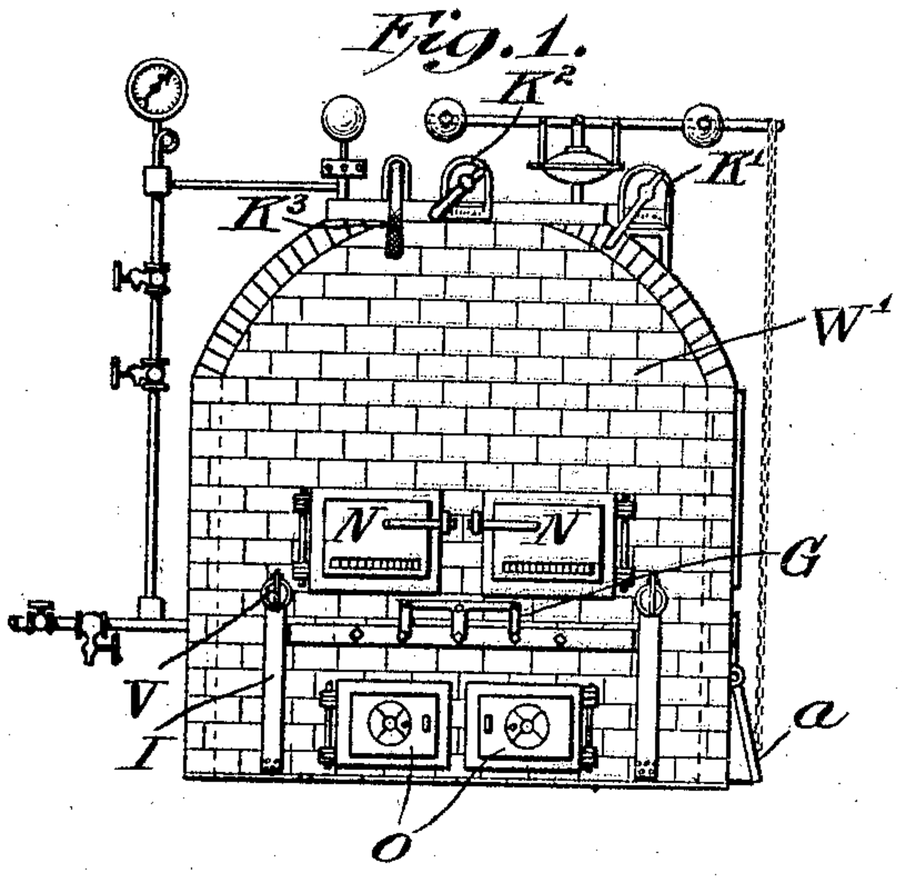


Fig. 2.

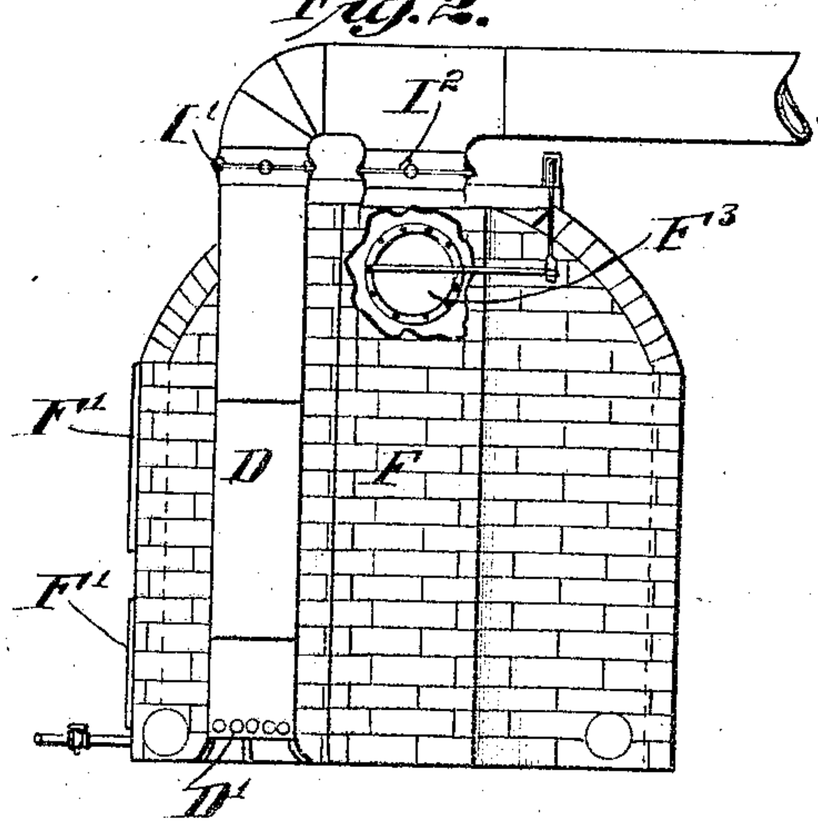


Fig. 3.

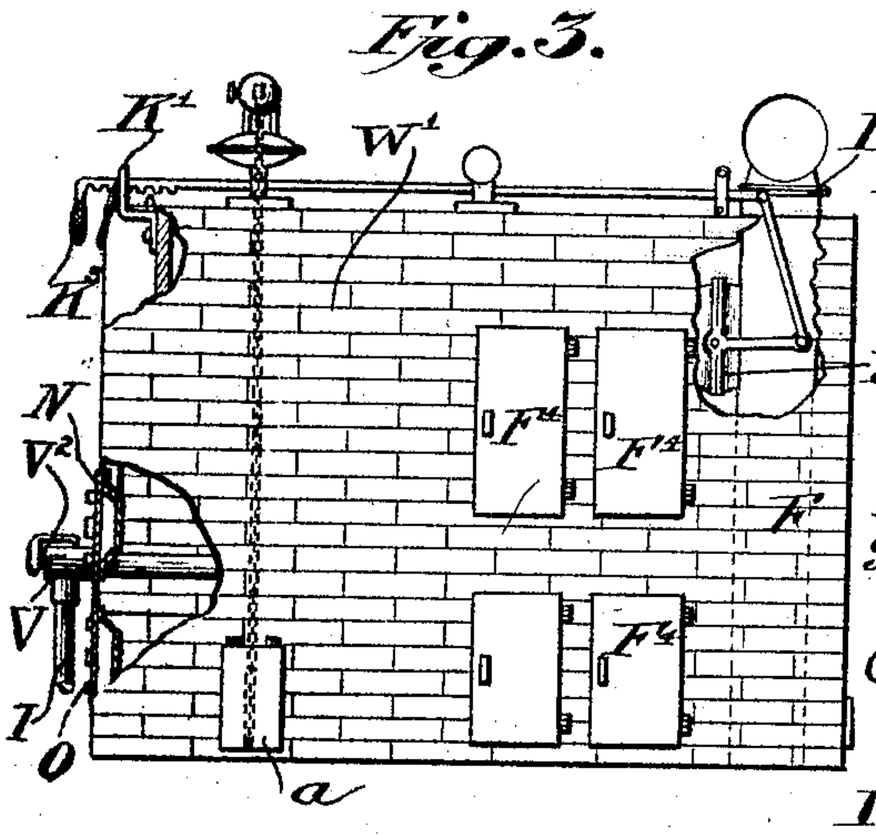


Fig. 4.

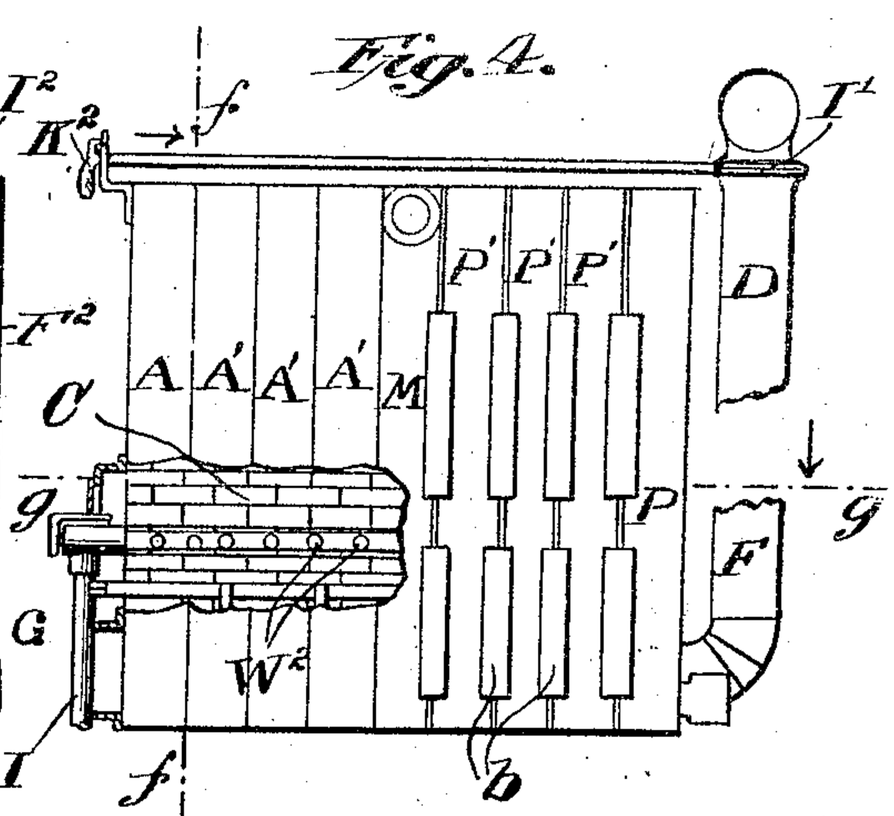


Fig. 7.

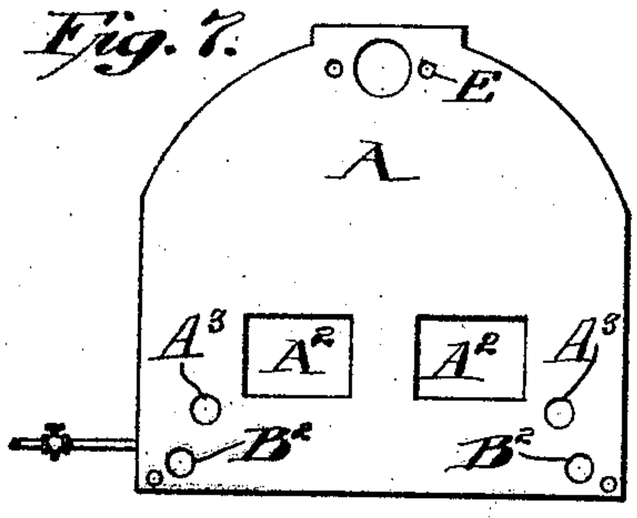
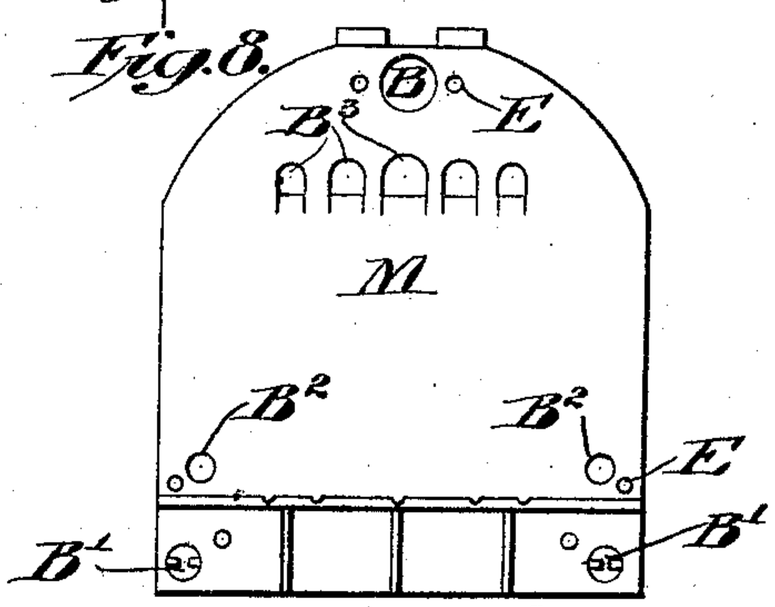


Fig. 8.



Attest:

C. D. Mitchell

Thomas Hill Low

Joseph M. W. Kitchen, Inventor:

by Geo. H. Strong

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No. 843,612. PATENTED FEB. 12, 1907.

J. M. W. KITCHEN.

SECTIONAL BOILER OR FURNACE.

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3 SHEETS—SHEET 2.

Fig. 5.

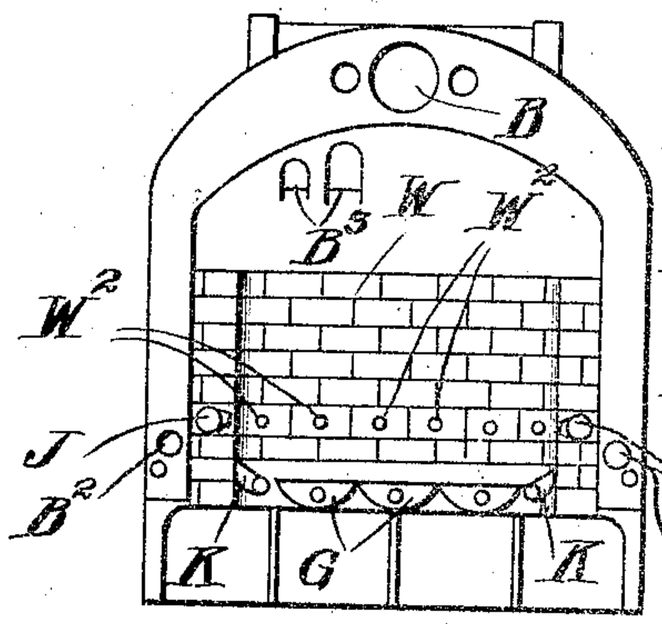


Fig. 6.

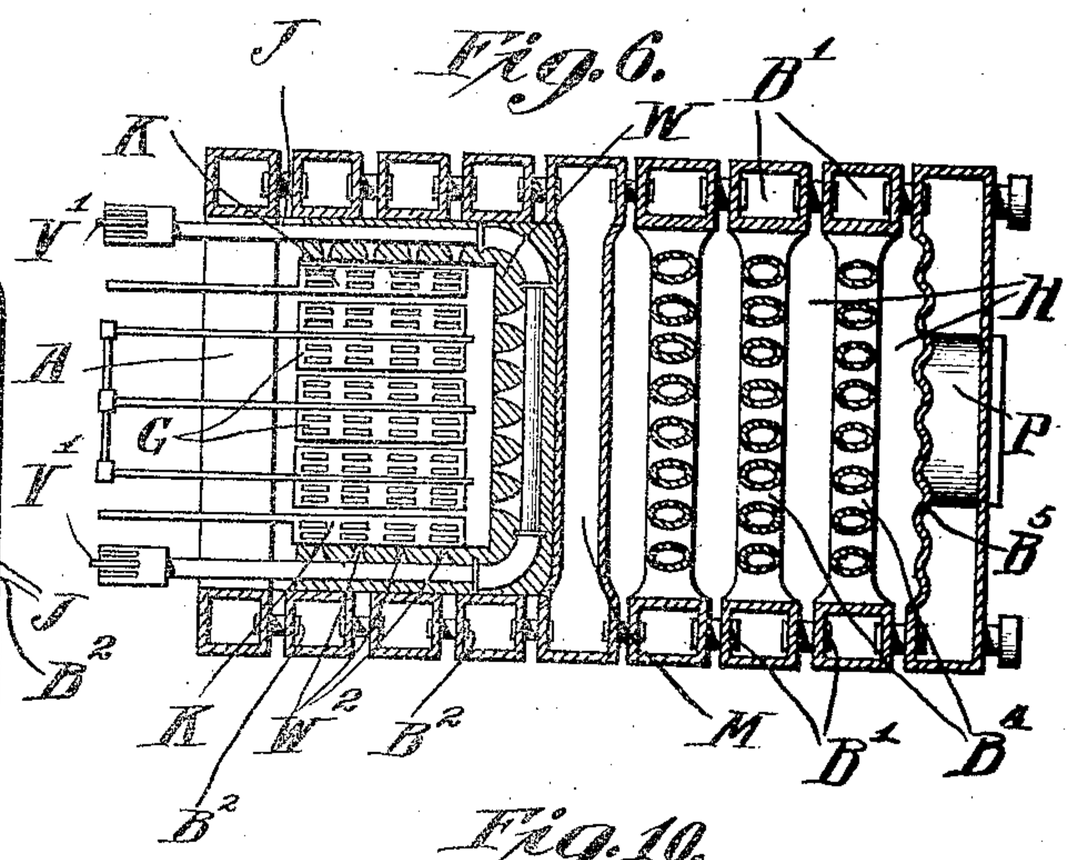


Fig. 9.

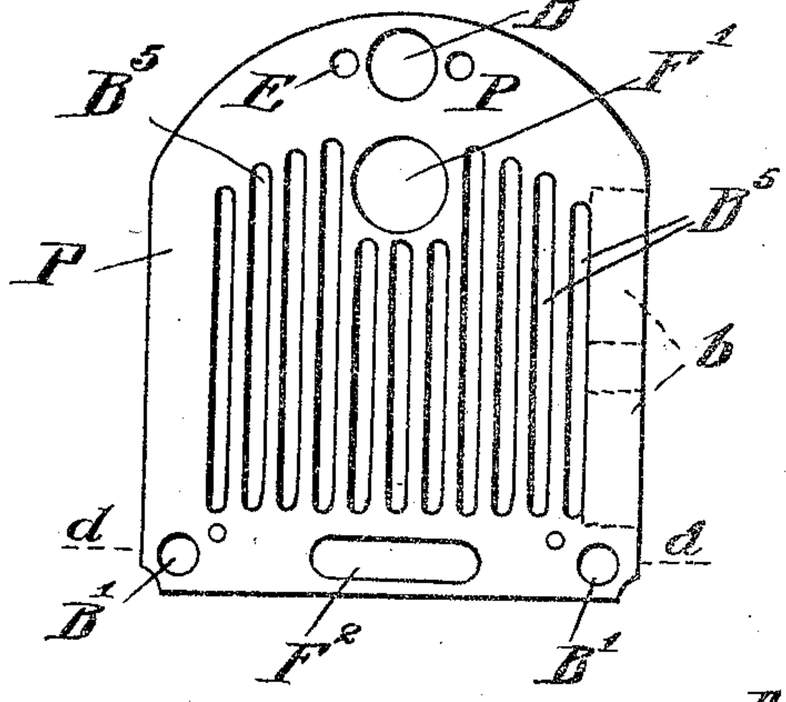


Fig. 10.

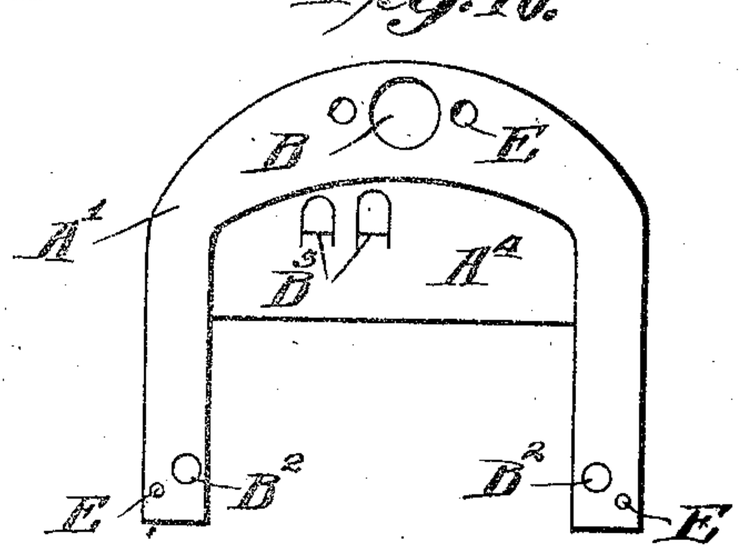


Fig. 11.

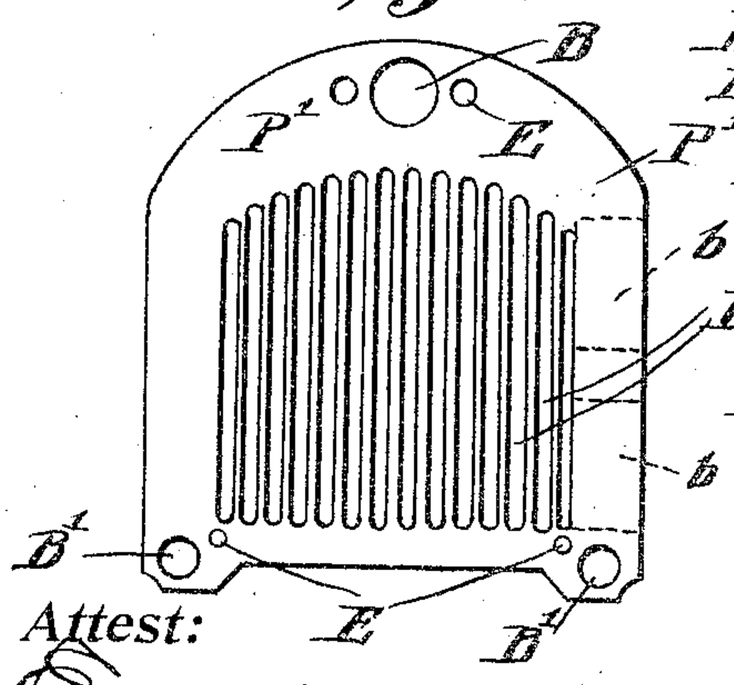
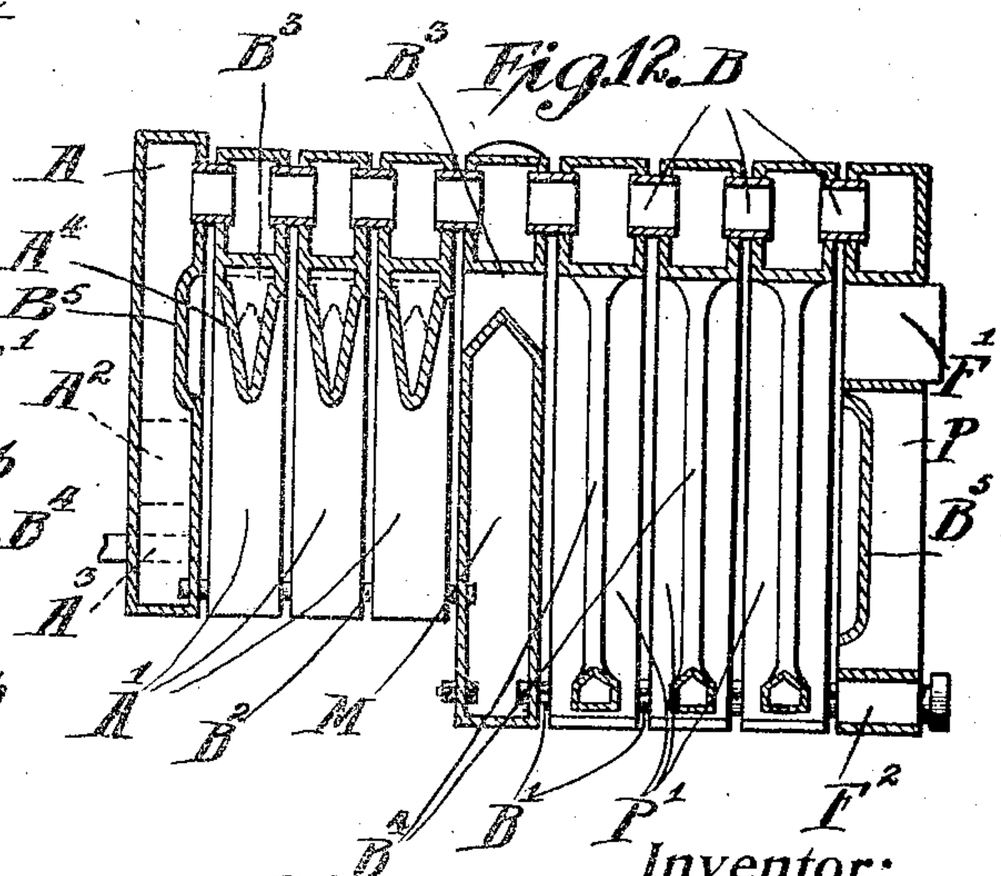


Fig. 12.



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No. 843,612. PATENTED FEB. 12, 1907.

J. M. W. KITCHEN.

SECTIONAL BOILER OR FURNACE.

APPLICATION FILED DEC. 22, 1905.

3 SHEETS—SHEET 3.

Fig. 13.

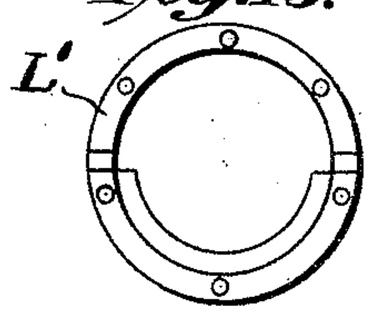


Fig. 14.

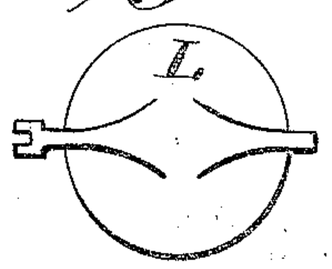


Fig. 15.

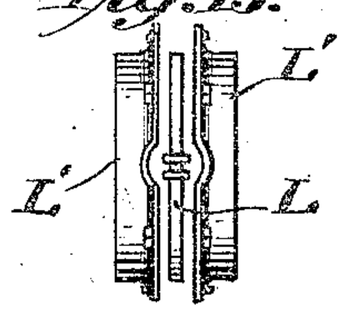


Fig. 20.

Fig. 21.

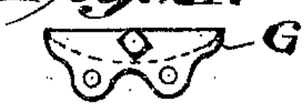


Fig. 16.

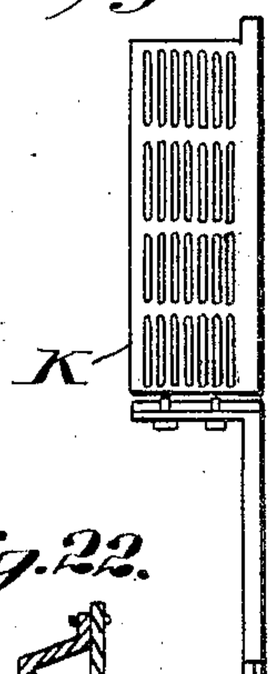


Fig. 17.

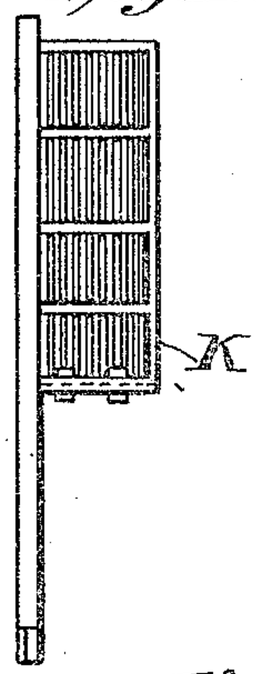


Fig. 18.

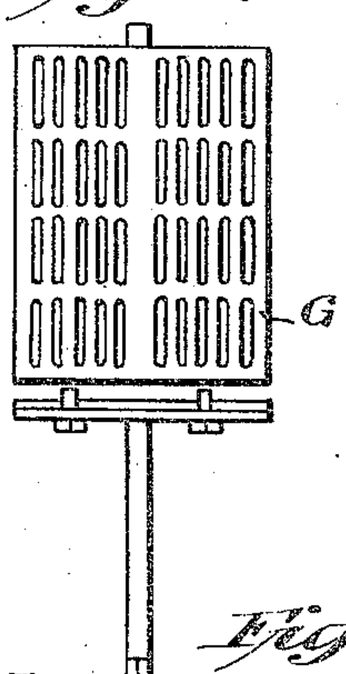


Fig. 19.

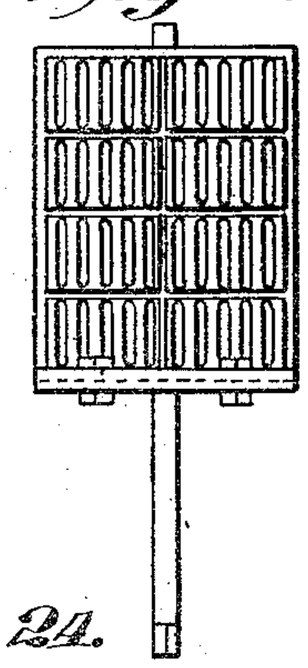


Fig. 22.

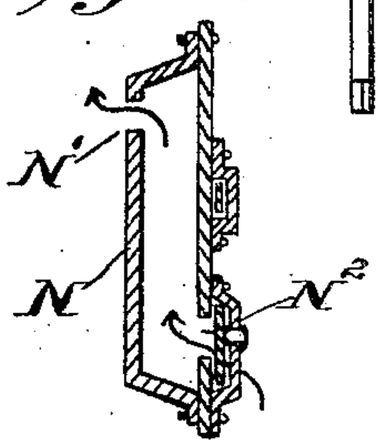


Fig. 23.

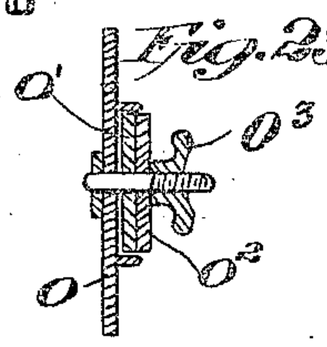


Fig. 24.

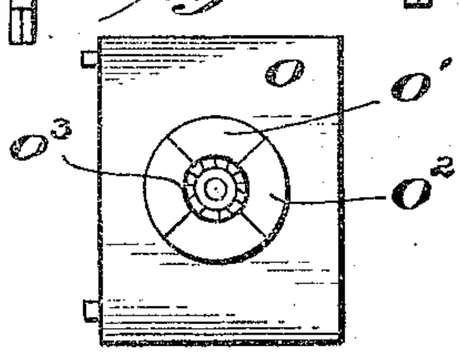


Fig. 25.

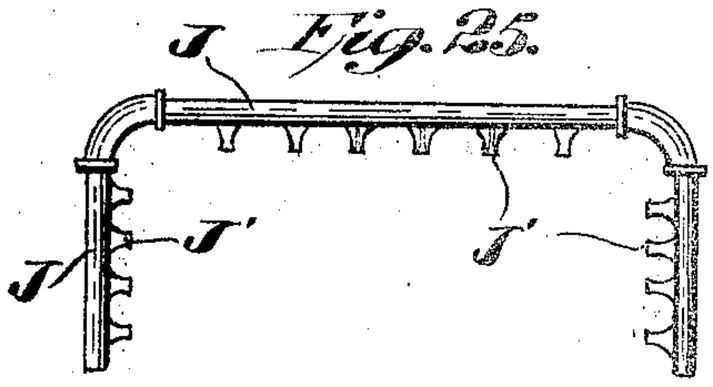


Fig. 26.

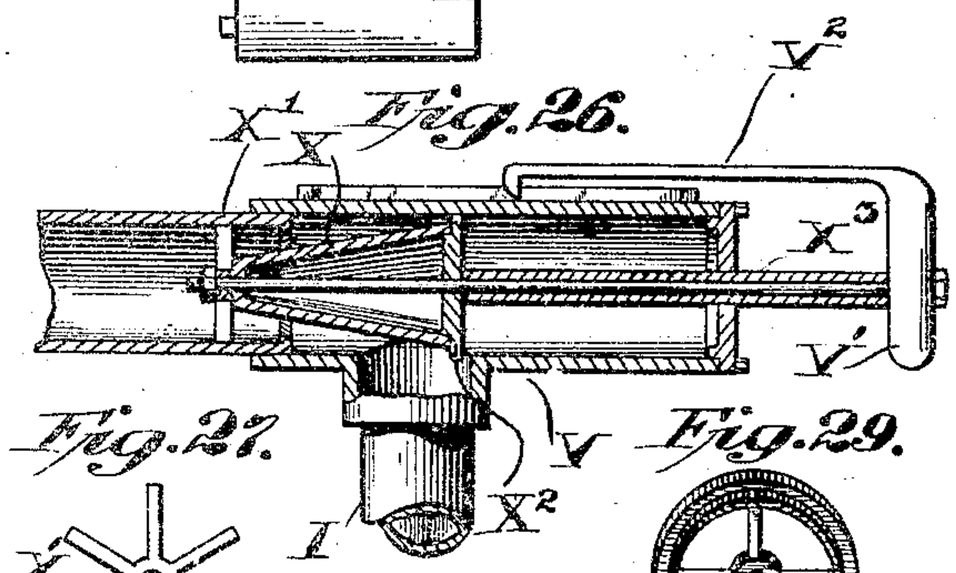


Fig. 27.

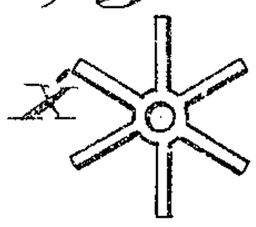


Fig. 29.

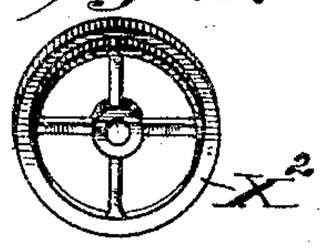


Fig. 31.

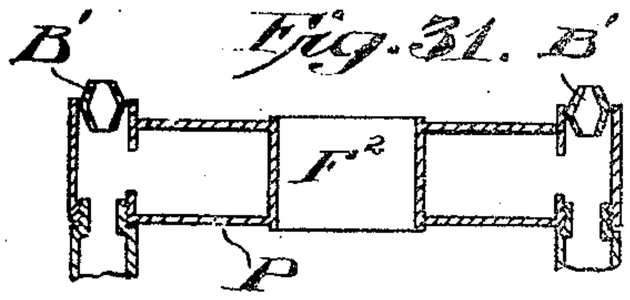


Fig. 28.

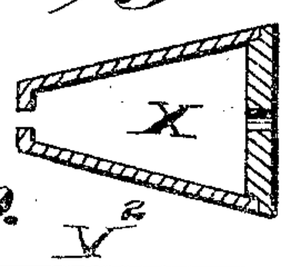
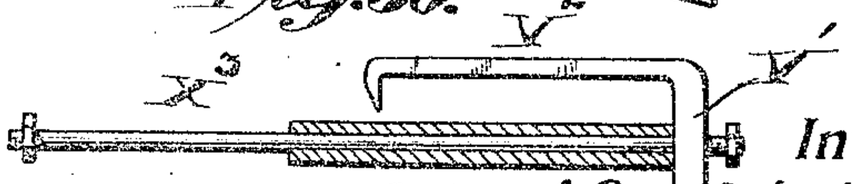


Fig. 30.



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UNITED STATES PATENT OFFICE.

JOSEPH M. W. KITCHEN, OF EAST ORANGE, NEW JERSEY.

SECTIONAL BOILER OR FURNACE.

No. 843,612. Specification of Letters Patent. Patented Feb. 12, 1907.

Application filed December 22, 1905. Serial No. 292,945.

To all whom it may concern:

Be it known that I, JOSEPH M. W. KITCHEN, a citizen of the United States of America, and a resident of East Orange, county of Essex, State of New Jersey, have invented certain new and useful Improvements in Sectional Boilers and Furnaces, of which the following is a specification.

The object of this invention is to prevent smoke formation, to economize in fuel, and to facilitate ease of management and use in sectional heating and power-producing apparatus.

The principles are adopted of accurately introducing air for combustion above and below the fire in needed amounts, of providing water of varying degrees of temperature inside of the boiler to receive generated heat of various temperatures, of applying horizontally the highest heat generated to the water in the boiler of the highest temperature, and progressively applying horizontally-generated heat of progressively lessening temperatures to water in the boiler of progressively lower temperatures; also, of progressive vertical heating of the water in the boiler from the lowest level to the highest level of the boiler.

In the accompanying drawings, Figure 1 is a front vertical view of the steam-heater incorporating my invention and surrounded with a brick casement. Fig. 2 is a rear view of the same, partly in section and with parts left out for clearness. Fig. 3 is a side vertical view of the same, partly in section. Fig. 4 is a side view of a water-heater, partly in section, but without a non-conducting casement, incorporating my invention. Fig. 5 is a cross-sectional view of the same, taken on the line *f f*, Fig. 4. Fig. 6 is a horizontal sectional view of the same, taken on the line *g g*, Fig. 4. Fig. 7 is the front section of this boiler. Fig. 8 is the middle section of the same. Fig. 9 is the rear section of the same. Fig. 10 is an intermediate section of the combustion-chamber. Fig. 11 is an intermediate section of the heating-cavity of the same boiler. Fig. 12 is a side vertical section of the assembled sections. Fig. 13 is one part of a damper-frame used in my invention. Fig. 14 is the damper used in connection with the frame. Fig. 15 is a side section of the damper and frame. Fig. 16 is a coking-plate used in my furnace. Fig. 17 is the under side of the same plate. Fig. 18 is the upper surface of a grate-bar. Fig. 19 is the under side of the same. Fig. 20 is a transverse section of the coking-plate. Fig. 21 is a transverse section of the grate-bar. Fig. 22 is a transverse section of the furnace-feed door. Fig. 23 is a transverse section of the ash-pit door. Fig. 24 is a front view of the ash-pit door. Fig. 25 is an air-conveyer and twyers. Fig. 26 is an air-duct and air-valve. Figs. 27, 28, 29, and 30 are parts of the air-valve and its handle. Fig. 31 is a cross-section of the rear section, Fig. 9, on the line *d d*.

The reference characters attached to the drawings represent as follows: A, a front section of a boiler; A′, an intermediate section of the combustion-chamber; A^2, a feed-door opening; A^3, air-duct openings; A^4, wedged-shaped dependent fold or process; B, upper push-nipple connections; B′, lower push-nipple connections; B^2, mid-level push-nipple connections; B^3, intercommunicating gas-openings; B^4, vertical gas-openings; B^5, corrugations; C, combustion-chamber; D, a dependent check-draft conduit; E, bolt openings; F, waste-gas flue; F′, upper smoke-exit; F^2, lower smoke-exit. F^3 is the smoke-exit damper; F^4, clean-out doors; G, grate-bar; H, a heating-cavity; I, a dependent air-conduit; I′, check-draft damper; I^2, smoke-flue damper; J, air-conveyer; J′, twyers; K, coking-plate; K′, check-draft indicator and handle; K^2, smoke-flue indicator and handle; K^3, handle of rod actuating upper draft-damper; L, damper-blade; L′, damper-frame; M, middle section of boiler; N, feed-door; N′, upper air-opening; N^2, lower air-opening; N^3, extension-frame; O, ash-pit door; O′, bed-plate; O^2, moving-plate; O^3, a hand-nut; P, rear section of the boiler; P′, intermediate section of heating-cavity; T, horizontal boiler-section; U, water-communicating pipes; V, air-valve; V′, a valve-handle; V^2, position-indicator; W, fire-brick wall; W′, exterior brick casing; W^2, air-apertures; X, cone of air-valve; X′, valve-guide; X^2, air-valve fitting; X^3, air-valve rod; Y, feed-water pipe: Y′, steam-pipe; Y^2, steam-draft inducer; Z, air-pipe; Z′, steam-dome; Z^2, steam-turbine; Z^3, fan; Z^4, centrifugal fan; Z^5, backflow stop-valve; *a*, automatic check-draft damper; *b*, clean-out opening.

The apparatus contains a combined furnace and combustion-chamber and an adjoining heating-cavity. In the combined furnace and combustion-chamber the aim is

to secure substantially complete combustion before the gaseous products of combustion are brought in contact with the heating-surfaces through the provision of a high run, a heat-retaining surrounding wall, and restricted water circulation in the water-holding envelop of the combustion-chamber. In the heating-cavity the aim is carried out of securing a first contact of the hot burned gases with the highest level of the transmitting-surfaces in a horizontal stratum, and for a further contact of said gases in successive strata of decreasing temperatures with other areas of the transmitting-surfaces of progressively lower temperatures at progressively lower levels with a final escape of the gases at the lowest level of the transmitting-surfaces, without having the gases make a second contact with transmitting-surfaces having a higher temperature. To best secure the aimed-for results, the combustion-chamber and heat-transmitting surfaces are elongated vertically so far as is practicably possible, taking into account the position occupied by the apparatus. By the introduction of variable numbers of sections in either compartment the relative size and efficiency of the two compartments may be so adjusted as to secure the best results.

There are three main sections—namely, front, middle, and rear. The front section is pierced for the openings of the fuel-doors. The middle section divides the two compartments imperviously except as to openings at a high level of the section. The rear section contains a controllable smoke-opening at a high level, which is kept more or less open when a fire is started and when an increase of chimney-draft is desired, and a spent-gas opening at the lowest level of the section, both openings connecting with the chimney-flue or smoke-pipe at the rear of the apparatus. As a check-draft to the chimney-draft a vertically-placed conduit runs from near the floor-line to or above the upper level of the apparatus and connects with the smoke-flue at the highest possible level. It has a large transverse diameter and has provision for the entrance of air at or near the floor-level and is controlled by an obstructive damper, which allows more or less air to be carried through it into the smoke-flue or entirely closes its lumen. The column of cold air which it contains prevents hot gases from being emitted downwardly through its lower orifice. This damper and the damper controlling the smoke-flue and that controlling the upper opening in the rear section have actuating-rods running to the front of the apparatus and are there connected with handles and indicating-dials and means for retaining the handles in any desired position.

The legs of the side sections and the lower part of the front section rests on the sides and front of the ash-pit walls at about the level of the grate-line. The middle and other more posteriorly located sections are carried to or near to the floor-line. The lower part of the middle section forms the back wall of the ash-pit. The sections forming the heating-cavity have openings at the side through which the heat-absorbing surfaces can be reached and cleaned. All of the sections between the front and rear sections are made reversible, so that the clean-out openings may be reached from either side of the apparatus. All the sections are joined by push-nipples located at the highest point and at the lowest levels of the legs of the sections. The sections are held together by long bolt-rods.

To prevent radiation from the exterior of the apparatus, provision is made to cover its exterior surface with brickwork. To bring the various doors of the apparatus flush with the exterior of the brickwork, extension-door frames are provided, which are bolted to the sections at the several door-openings of the sections. At the same high level as the openings of the middle section the intermediate sections of the combustion-chamber have their transmitting-surfaces extended in area by downward folds of the iron skin of the sections forming dependent wedges; but such provision of structure is not intended to abstract heat from the burning gases low down in the combustion-chamber, as is usually done in most structures of this class, it being my aim to prevent contact of the heat generated by the burning fuel with heat-absorbing surfaces until after combustion has been effected.

To assist in preventing a loss of heat in the fixed and gaseous fuel until after combustion is perfected, the lower push-nipples of the front of the middle section and of the other sections of the combustion-chamber are of a contracted caliber, which prevents a too free circulation of water into the sections surrounding the combustion-chamber, it being the purpose to keep the walls of the lower part of the combustion-chamber as hot as possible to encourage perfect combustion. Under forced use the entire height of my combustion-chamber is filled with ignited gases. The push-nipples of the lower parts of the sections of the heating-cavity are of a larger caliber, so as to afford a freer passage of water through them and up through the sections of the heating-cavity. As a further prevention of loss of heat from the burning fuel I in preferred forms line the side walls of the combustion-chamber with fire-brick. In order to control a too strong chimney-draft, I connect with the smoke-pipe of my boiler a dependent air-conduit, which runs from near the floor-line to and communicates with the smoke-pipe. This is controlled by a damper, which when opened checks the draft without closing the

lumen of the smoke-pipe, or I may put a damper in the bottom of the chimney-flue to effect the same purpose.

The nature of the grate I use in my invention varies in accord with the nature of the fuel used. In simpler forms I use a coking-plate bar at the sides of the general grate-surface and on the same level. In this form fuel is placed on these lateral coking-plates and after coking the fuel is turned toward the middle of the combustion-chamber by quarter-revolution of the coking-plate shaft. In order to prevent the adhesion of the movable draft-plates of the ash-pit and fuel-feed doors through corrosion, I insert a non-corrosive bed-plate in the body of the door and have the movable plate also made of a non-corrosive nature. Usually I have such plates of iron nickel-plated. In case of a revolving plate I provide a set-screw to hold the movable plate in any desired position.

In this heater there is no passing of the heating-gases twice over heat-absorbing surfaces at the same level and of the same temperature excepting in the vault of the combustion-chamber. Inasmuch as I absorb the highest heat in the vault of the combustion-chamber, the sections have the dependent wedge-shaped elongations before referred to to allow the radiated heat from the fire to penetrate directly to the highest level. At a high level in these combustion-chamber sections I have gas-passages, but these openings are of restricted size to hold back in a measure the risen hot gases in the upper part of the spaces between the sections and bring increased upward pressure of the hot gases against the metallic absorbing surfaces of the sections; but still a certain slow flow of gases occur through these openings of the sections toward the smoke-pipe. As these sections are made reversible and the openings are made on one side of the median line of the sections, by staggering these openings on both sides of the median line a longer travel of the heating-gases is secured. In this boiler I provide for the progressive contact of heating-gases in a horizontal travel with heat-absorbing surfaces of progressively lower temperatures, the gases gradually and progressively losing heat as they progress horizontally from the front to the rear of the boiler. To facilitate this aim, the gas-passages in the intermediate sections of the heating-cavity are so narrow that after passing the openings in the middle section the gases must spread out laterally and be brought in full contact with all the full breadth of the intermediate sections at various levels. With the upper gas-opening in the rear section open the gases travel into the smoke-pipe by that opening, and this is a condition which generates a very intense high rate of combustion, a requirement necessary in very cold weather, but with more moderate weather this direct exit of gas is closed and the gases travel downwardly in the heating-cavity and leave the cavity at its lower opening, being progressively brought into contact with heat-absorbing surfaces of progressively lower temperatures until the gases finally emerge from the heating-cavity at a temperature not greatly higher than that of the feed-water, which is introduced at the lowest level of the heating-cavity.

The gas-openings in the middle section are at a high level and are collectively of an extent equal to the extent of either of the exit-openings of the rear section. The middle-section openings are large enough to pass all the gases coming out of the combustion-chamber, but the openings in any one of the intermediate sections of the combustion-chamber are only large enough to pass a part of the gases generated in the chamber. The lower parts of the various gas-openings in the several sections are pointed or peaked upwardly to allow soot, ashes, and other dust to slide off of them downwardly.

The fuel-feed door has an inner protective metal shield fastened to the front plate of the door. This inner plate has a few holes horizontally placed near the top. The front plate has a few air-holes horizontally arranged near the bottom of the door and controlled by a slide. This arrangement gives an air-space between the two plates and provides for a current of cool air therein, gradually heating the same. This prevents undue radiation from the outer plate and prevents the lowering of the critical temperature of the gases above the fire, as in the case where a large amount of air is introduced over the fire through the door and through a numerously-perforated protective inner plate. I provide for a more widely-diffused air introduction in small streams widely separated which provides for a more complete mixture of air and volatilized gases and prevents undue cooling of the gases at any point.

The air-valve, of which a vertical section is shown in Fig. 26, is composed of a guide, (see Fig. 27,) a valve-cone, (see Fig. 28,) the cone-plate, (see Fig. 29,) and the bolt and handle and external indicator. (Shown in Fig. 30.) When in position, the indicator points to slots cast in the top of the incasing T, (shown in Fig. 26,) and thus shows whether the valve is open or shut.

With the grate-bars shown in Figs. 16 to 21, inclusive, the grate-plates are detachable from the front shafts, being bolted there to enable easy introduction into the furnace and to allow of the use of grate-plates fitted for different depths of the furnace and for the nature of the fuel used.

What I claim as new, and desire to cover by Letters Patent, is—

1. In a sectional hot-water or steam heater, the combination of means, (first) for distribut-

ing heating-gases equably over the heating-surface of said heater and to gain pressure from atmospheric weight acting in said heater against said surfaces by a restricted size of the gas apertures and passages in the sections of the heater, (second) for varying the amount of water passing through the various sections to prevent too rapid loss of heat in the burning fuel and to provide a water-recipient of low temperature at varying locations in said heater for the absorption of large volumes of low degrees of heat; (third) for the progressive absorption of the heat generated by the apposition of counter-currents of heating-gases and feed-water, the gases being applied progressively to the heating-surfaces from the front of the heater to the rear and from a high level of the heater to a low level, the water being introduced at the rear of the heater at a low level and conveyed from the rear to the front of said heater and from a low level to a high level; (fourth) for preventing the passage of heating-gases over heat-absorbing surfaces of a temperature higher than the temperature of the gases in contact with the surfaces, thus losing heat to the gases, (fifth) for applying the most intense heat first to the heat-absorbing surfaces at a high level, and for a progressive application of said gases in horizontal strata of equal temperatures at progressively-lower levels and a final exit of said gases at a low level; (sixth) for inducing a direct updraft in said heater and for inducing an indirect plunging-draft in said heater; (seventh) for smoke prevention and for perfecting the combustion of volatilized gases, said seventh-named element comprising means for mixing air with said smoke and gases by over-fire mass of air introduction in divided currents distributed around the periphery of the combustion-chamber at a low level and a vertically-elongated run in the combustion-chamber for mixing and combining air with the volatilized gases; (eighth) for preventing premature loss of heat from the fuel at a low level of said heater by interposition of non-conducting means; (ninth) for protecting said means for air introduction from destructive heat; (tenth) for varying the relative areas of the heat-absorbing surfaces receiving directly the radiant heat of the fire, of the so-called flue-surfaces receiving indirectly the conveyed heat in the gases, and of the grate-surfaces, said tenth-named element comprising a combustion-chamber and an adjacent heat-economizing cavity and provision for adding to or removing sections in said chamber and in said cavity without damage or loss to the original structure of said heater; (eleventh) and for preventing the escape of coal-gas from said heater by construction and arrangement of the parts for an equilibrious balance of gases of equal densities in horizontal strata at the same levels.

2. In a sectional boiler, the combination of a water-conveying conduit at a low level, heat-absorbing sections supplied from and rising above said conduit, and gas apertures and passages in said sections, said apertures and passages being contracted in size and constructed, located and disposed to retard the passing of gases therethrough and to distribute the said gases over the heating-surfaces of said boiler, for preventing short-circuiting of said gases through a part of said passages, and to gain through atmospheric weight and upward pressure acting in said boiler measurable increase of pressure of said gases against the heating-surfaces of said sections and to gain time for the absorption of the heat from said gases.

3. In a sectional boiler, the combination of a plurality of sections constructed and located to convey currents of heating-gases away from the zone of greatest heat production and to convey water in a current reverse to the route traveled by said heating-gases, the water in said sections progressively absorbing heat of progressively-lowering temperatures in the travel of said gases away from said zone of greatest heat production, the water in the section furthest from said zone and being first introduced in said section, being the coldest and absorbing the lowest degrees of heat, and the water in the section nearest said zone being hottest and absorbing the higher degrees of heat, said gases not passing over heat-absorbing surfaces having a higher temperature than the gases brought unto contact with said surfaces, a horizontal water-conduit at a low level of said sections supplying water to said sections, means for regulating the flow of water traversing each section, and a high-level conduit connected with the top of each section for conveying away the heat absorbed into the water of each section.

4. In a sectional boiler, the combination of water-containing sections forming a combustion-chamber, said combustion-chamber having a high run free from heat-absorbing surfaces in the line of rising products of combustion, except at a high level, to gain time for perfecting combustion, water-containing sections forming a heat-economizing cavity, the said chamber and said cavity being separated by a water-containing section impervious to gases between said chamber and said cavity except at the highest level of said chamber, and gas-passages at said high level, said passages being no larger in size than is necessary to collectively pass the gases combined in said chamber and being contracted in size and located to spread out the gases laterally over the full width of said combustion-chamber at a high level and to gain pressure of heating-gases against the heat-absorbing surfaces of said chamber, said cavity having a highly-located exit for waste gas

and a low exit for waste gas, and said cavity extending from said high level to the floor-line on which the boiler rests.

5. In a sectional boiler, the combination of water-containing sections forming a combustion-chamber having a high run for combining gases, water-containing sections forming a heat-economizing cavity, waste-gas exits at both high and low levels of said cavity, said chamber and cavity being separated by a water-containing section impervious to gas except at a high level, and having gas-apertures of contracted size at a high level for distributing gases and gaining increase of pressure against the heating-surfaces, said cavity being extended to the floor-line on which the heater rests, and means for introducing over-fire air for combustion through the front of said boiler.

6. In a sectional boiler, the combination of a combustion-chamber having a high run for preventing loss of heat at low levels in said combustion-chamber, and a heating-cavity, said chamber and said cavity being formed by a front section, a middle section, a rear section, and intermediate combustion-chamber sections, said sections having corrugations cast in the face of such parts of the sections as are exposed to the heat generated, said middle section having at a high level apertures of a restricted size to spread laterally the gases of combustion, said intermediate sections having wedge-shaped downwardly-prolonged processes having gas-apertures of restricted size at a high level in said processes and located at one side of the median line of said intermediate sections, said intermediate sections by alternation in assembling having said apertures staggered on first one side and then on the other side of said median line for increasing the line of travel of the heating-gases in the vault of said combustion-chamber, said rear section having both high and low level exits for the waste gases of combustion.

7. In a sectional boiler, the combination of means for progressively absorbing the heat traversing said boiler in progressively-located sections, said means comprising contracted apertures and passages in the sections of said boiler, said apertures being constructed and disposed to spread out laterally over each section the heating-gases and to gain increased pressure against the heating-surfaces of each section and to gain time for the absorption of the heat in the gases passing successively through the sections of said boiler.

8. In a sectional heater, comprising a high-run combustion-chamber and an adjacent heat-economizing cavity, the combination of a front section, a middle section, a rear section, multiple intermediate sections in the combustion-chamber, and multiple intermediate sections in the heating-cavity, said sections being constructed and formed for the flow of heating-gases and water in counter-currents through said heater, the water being introduced at the back of the rear section at a low level.

9. In a sectional boiler, the combination of a combustion-chamber and an adjacent heating-cavity comprising a front section, a middle section, a rear section, multiple intermediate combustion-chamber sections, and multiple intermediate heating-cavity sections, said intermediate sections being perforated with gas-passages of restricted size and disposed to prevent the too free passage of gases through only a few of said passages for spreading the gases the entire width of said boiler and for preventing short-circuiting of gas through part of the passages to the neglect of other passages and to gain pressure against heating-surfaces.

10. In a sectional boiler, the combination of water-containing sections forming a combustion-chamber, water-containing sections forming a heat-economizing cavity, and a grate, said sections comprising a front section, a middle section, a rear section, intermediate combustion-chamber sections, and intermediate heat-economizing sections, said intermediate sections being attachable and detachable without damage or loss to the original structure of said boiler, said grate being extensible, said middle section being impervious to gases except at a high level but having contracted communicating passages at said high level, said sections being constructed and disposed to convey counter-currents of heating-gases and water through said boiler without passing said gases over said heating-surfaces of a higher temperature than the gases brought in contact with said surfaces, said water being introduced at a low level and at the rear of said boiler, said combination being for varying the relative areas of heat-absorbing surfaces to grate-surfaces, and to gain increase of efficiency of absorbing heat from the varying conditions of chimney-draft and rates of combustion.

11. In a sectional heater, the combination of a front section, a middle section, and a rear section, said sections forming a combined furnace and combustion-chamber having a high run and an adjoining heat-economizing cavity, the surfaces of the said front and rear sections where exposed to the heat generated in said heater having corrugations and dependent processes for enlarging the area of heating-surfaces and for forming the vault and sides of said chamber and cavity, said middle section having no corrugations, but having highly-located gas-apertures of contracted size, said rear section having both high and low exits for smoke and gas, feed-water being first introduced at a low level of said rear section, the hottest heating-gases being first applied to the heating-surfaces in the upper part of said chamber and then

being applied at the highest level of said cavity and then being progressively applied in successive strata of declining temperatures to the lowest level of said cavity without again passing over the heating-surfaces of said heater.

12. In a sectional boiler, the combination of a high-run combustion-chamber and an adjoining heat-economizing cavity constructed and arranged for the ascent of heating-gases in the combustion-chamber and for their descent in the economizing-cavity, a waste-gas exit at a low level of said cavity, said chamber and said cavity being separated by a partition impervious to gas except at a high level, dependent wedge-shaped processes projecting from the vault of said chamber with the apices directed downwardly, contracted gas-apertures at the highest level in the said chamber communicating with said economizing-cavity and disposed in horizontal relation to pass the gases equably through each of said apertures and to spread out heating-gases horizontally in the upper part of said chamber.

13. In a sectional boiler, the combination of a high-run combustion-chamber, an adjoining heat-economizing cavity, said combustion-chamber having a front section and a section which divides imperviously said combustion-chamber from said cavity except as to contracted apertures at a high level, said contracted apertures being for spreading gases, said cavity having a rear section having both high and low level gas-exits, intermediate attachable and detachable sections for said chamber and said cavity, and push-nipples connecting said sections at a high level and at a low level, the push-nipples joining the sections of the combustion-chamber being of a smaller caliber than the push-nipples joining the sections forming the said cavity.

14. In a sectional boiler, the combination of sections forming a combustion-chamber having a high run and heating-surfaces at a high level open to the impact of the direct radiant heat of the fire, and an adjacent heat-economizing part containing heat-absorbing surfaces or so-called flue-surfaces for the indirect absorption of the lesser degrees of heat of the heating-gases remaining in the gases after leaving said combustion-chamber, said combustion-chamber and said heat-economizing part being separated imperviously except at a high level, gas-passages at a high level of contracted size for spreading gases and increasing gas-pressure against absorbing surfaces, said sections being attachable and detachable without damage to the original structure of the boiler, said boiler being substantially free from so-called flue-surface in said combustion-chamber, said sections being arranged for the passing in apposition of heating-gases and water in counter-currents through said boiler.

15. In a sectional boiler, the combination of a high-run combustion-chamber, dependent processes or deep corrugations in the vault of said chamber for intercepting and holding back risen hot gases and for receiving directly the impact of radiant heat, contracted gas-passages at a high level to spread gas and gain increase of pressure against absorbing-surfaces, and flue-surfaces outside of said combustion-chamber arranged and disposed for a temperature of said flue-surfaces lower than the temperature of the gases in contact with said flue-surfaces, the sections of said boiler being free from said flue-surfaces at levels and positions where the temperature of said flue-surface is higher than the temperature of the gases that are brought in apposition with said flue-surfaces at said levels and positions.

16. In a sectional boiler, the combination of a combustion-chamber and an accessory heating-cavity, said chamber and said cavity being composed of sections comprising means to increase or decrease their number in said boiler without damage or loss to the original structure of said boiler for varying the relative areas of grate-surface and direct heat-absorbing surfaces for radiant heat to the area of so-called flue or indirect heating-surfaces, the heating-surfaces receiving direct radiant heat from the fire being in the said combustion-chamber and the surfaces receiving indirectly the heat from gases being in the said cavity, the sections comprising surfaces receiving directly radiant heat from the fire being substantially free from flue-surface so called at a level where said surfaces are of a temperature above the temperature of the gases which are brought in contact with said surfaces, the construction and arrangement of said flue-surfaces preventing the passing of gases over surfaces having a higher temperature than the temperature of gases brought in contact with said surfaces.

17. In a sectional boiler, the combination of a combustion-chamber having heating-surfaces to receive the directly-radiated heat of the fire at a high level of said chamber but being substantially free from so-called flue-surface in said chamber, and flue heating-surfaces accessory to said combustion-chamber, said flue-surfaces being back of said combustion-chamber opposite to the fuel-feed doors of said boiler and being arranged to receive at a high level of said accessory surfaces the heating-gases and to convey the said gases from said high level to or near to the floor-line on which said boiler stands and through an exit for waste gas at a low level without said gases being again brought in contact with heating-surfaces of a temperature equal to or higher than the gases brought in con-

tact with said surfaces, and a high-level exit for waste gases in said boiler for a direct updraft in said boiler.

18. In a sectional boiler, the combination of means for securing a high run for combining gases in said boiler to gain time for combining the gases, means for preventing the absorption of heat into the water of said boiler from said gases before the completion of combustion, means for making application of the greatest intensity of the heat generated and for its absorption at a high level of said boiler, means for securing progressively the absorption of the heat at progressively-increasing horizontal distances from its place of generation and at progressively-lower levels and for preventing the repassing of heating-gases over absorbing-surfaces of a higher temperature than the temperature of the gases, means for securing accurately the necessary admission of air and its diffusion with the combustible gases traversing said boiler for the completion of the combustion of said gases, means for preventing the short-circuiting of the heating-gases through a part only of the gas-passages of said boiler, means for preventing the corrosive immobilization of the parts controlling the functions of said boiler, means for preventing the escape of the gases of combustion through the avenues for air admission, means for varying the relative areas of the heat-absorbing surfaces of said boiler, and means for protecting from destructive heat the means for introducing air into said boiler, said combination coacting to secure completion in the combustion processes and the more complete transmission in said boiler of the heat generated.

19. In a sectional boiler, the combination of sections so constructed and disposed as to form a combustion-chamber and also a heating-cavity, said chamber and said cavity being separated imperviously by a water-traversing section except as to communicating gas-passages at a high level, the said combustion-chamber having a high run and having dependent processes in the vault of said chamber, said processes being pierced by gas-passages of a restricted caliber, some of said sections forming said cavity being detachable intermediate heat-absorbing sections, the sections forming the combustion-chamber being constructed to assemble with and coact with means for feeding and coking fuel at both sides of said combustion-chamber and for moving said fuel to the center of said combustion-chamber and for shaking and dumping said fuel, said combination being arranged for securing free access to the front of said boiler and to said combustion-chamber for the management thereof.

20. In a sectional boiler, the combination of means for forming with sections of said boiler a high-run combustion-perfecting cavity, said cavity and its formative sections comprising means for the introduction into said cavity of divided currents of air for securing the highest heat in the upper level of said cavity, said combination providing water-traversing sections so constructed and arranged as to secure the progressive absorption of heat traversing said boiler into the water of said sections, the highest heat being absorbed in the sections nearest the source of heat, and the lowest degree of heat being absorbed in the sections farthest from the source of heat, a water-conveying conduit, each of said sections being connected at a low level with said water-conveying conduit, and a conduit connecting all of said sections at their highest level for conveying from said boiler the heat thereinto transmitted, said elements coacting to secure a higher evolution of heat from volatilized gases passing through said boiler and a more complete transmission of the heat generated.

21. In a sectional boiler the combination of sections with water and steam cavities therein, part of said sections forming the upper part of the dome of a combustion-chamber, part of said sections forming a heat-economizing cavity, said sections assembling with and coacting with means for introducing overfuel air for combustion, said combustion-chamber part of said boiler being composed of a front section having apertures for fuel introduction and apertures for feeding air through said section, a section that is the rear section of the combustion-chamber and the front section of the heating-cavity, intermediate sections comprising the sides and vault of the combustion-chamber part, said heating-cavity comprising a rear section and intermediate detachable sections for extending the heat-absorbing surfaces of said boiler, a highly-located exit from said cavity for waste gases of combustion, and a second exit for exhaust-gases located at a low level in said cavity.

22. In a sectional boiler, the combination of sections so constructed and arranged as to form a combustion-chamber and also a heating-cavity, said chamber and said cavity being imperviously divided by a water-traversing section except as to gas-passages at a high level, a conduit for conveying away the transmitted heat, said sections being connected at a high level with said conduit, a low-level conduit for conveying water to the several sections, said sections being connected at a low level with the low-level conduit, the apertures of the last-named conduit leading into the sections of the heating-cavity being relatively large for allowing a free flow of water into the sections of said heating-cavity, the apertures of the conduit leading into the sections of the combustion-chamber being relatively small to retard the flow of water into the sections comprising the combustion-chamber to prevent premature loss

of heat in the fuel to the water in the combustion-chamber sections before combustion has been perfected.

23. In a sectional water or steam boiler, the combination of sections constructed to form a high-run combustion-chamber, a heating-cavity of sections arranged to absorb progressively the heat from the heating-gases from the front of said cavity to the rear of said cavity and from a high level of said cavity to a low level of said cavity, the structure of said sections restricting the flow of water through the sections forming the combustion-chamber for preventing too great reduction of the heat in said chamber, means for air introduction through the front of said combustion-chamber, and means for protecting said air-introducing means from too much heat, for heating said air and for assisting in the retention of heat in burning gases at a low level of the sections of said chamber.

24. In a combined sectional boiler and furnace the combination of sections comprising a heating-cavity and a combustion-chamber having a high vertical run for securing time and space for air admixture and combination with volatilized gases and structure for retaining said combined gases in the vault of said chamber and for securing pressure of said gases against the heat-absorbing surfaces of said vault, and means for the introduction of air for combustion through the front of said combustion-chamber and for its diffusion low down in said chamber and for accurately controlling air thus introduced and for preventing the immobilization through rusting of said controlling means, said sections being constructed for restricting the flow of water through the sections forming the said combustion-chamber and for gaining a larger flow of water through the sections forming the said heating-cavity for preventing in said boiler the lateral loss of heat from the lower levels of said combustion-chamber and for gaining the heat of a perfected combustion of gases at a high level in said boiler and for the more perfect transmission of large volumes of low degrees of heat in said heating-cavity.

25. In a combined sectional boiler and furnace, the combination of sections forming a heating-cavity, sections forming a combustion-chamber having a high vertical run, said cavity and said chamber being imperviously separated by a water-traversing section except as to communicating gas-apertures of a restricted area at a high level in said last-named section, and a non-conducting wall lining the lower surface of said separating-section in the combustion-chamber for preventing the heating of the water in said separating-section at a low level and thus depriving the opposite absorbing-surfaces of said section in the heating-cavity of heat-absorbing abilities for absorbing heat of low degrees of temperature.

26. In a steam or hot-water heater, the combination of sections forming a combustion-chamber having a high run, dependent processes in the vault of said chamber, staggered apertures of restricted caliber in said processes, means for introducting air around the periphery of said chamber and for accurately controlling said air both as to amount and continuity of introduction, means for protecting the lower sides of the section of the combustion-chamber from excessive heat and for protecting said air-introducing means from destructive heat, sections forming a heating-cavity adjacent to said chamber, gas-passages at a high level between said chamber and said cavity, the sections forming said cavity being constructed and disposed to spread the heating-gases over the full width of said cavity and for progressively losing heat to said sections commencing at said gas-passages and extending to the sections farthest from said passages and for losing heat progressively to all the sections of said cavity from a high level to a low level, a highly-located gas-exit for said cavity and a low gas-exit for said cavity, controlling-dampers to said exits, and rods for the control of said dampers carried to the front of said heater, means on said sections coacting with said rods for holding said rods in desired positions, and means for preventing escape of coal-gas from said combination against the upward action of atmospheric pressure including a check-draft, said sections being connected with push-nipples at a high level and at a low level, the push-nipples of the sections forming the heating-cavity being of larger diameter, the push-nipples of the sections forming the combustion-chamber being of small diameter, said variation in the size of the push-nipples being for varying the recipient temperatures of the water in the various sections and to prevent some lateral transmission of heat low down in said combustion-chamber, said sections being attachable and detachable for varying the relative areas of heat-absorbing surfaces to the grate-surface used in combination with said boiler, the various sections, gas-passages and coacting parts being so constructed and disposed as to maintain in said combination an equilibrious balance of gases of equal temperature in horizontal strata.

27. In a sectional boiler and in combination therewith, sections containing gas-traversing apertures of contracted area, said apertures having an inverted-V-shaped formation at their lowest level for preventing the deposition and accumulation of dust in said apertures from the gases carried through passages of said boiler.

28. In a combined sectional boiler and furnace, the combination of sections forming a

combustion-chamber having a high run, sections forming a heating-cavity, said chamber and said cavity being divided by a water-traversing section impervious to gases except as to gas-apertures at a high level, said sections comprising attachable and detachable intermediate combustion-chamber sections and attachable and detachable intermediate heating-cavity sections, said sections being constructed and disposed for a restricted circulation of water through the sections forming the combustion-chamber and for a larger flow of water through the sections forming the heating-cavity, and means for introducing, conveying and diffusing air for admixture with volatilized gases around the lower part of the inner periphery of said chamber, and for preventing the downward flow of hot gases through said means against the upper pressure of atmosphere and for controlling the air thus introduced and for preventing immobilization of said controlling means through rusting and for protecting from excessive heat such air-introducing means.

29. In a sectional water or steam boiler comprising a combustion-chamber and an adjacent heat-economizing cavity means for restricting the flow of water through the sections forming the said combustion-chamber for preventing imperfect combustion through a too rapid loss of heat from the fuel in said chamber at a low level, and means for securing a full flow of water through the sections forming the said heating-cavity for providing water of a low or good recipient temperature in the sections of the said heat-economizing cavity.

30. In a sectional water or steam boiler, the combination of individual sections, a water-conduit connected with each section at a low level, a conduit connected with each section at a high level, means for controlling the flow of water into each section or each group of sections having analogous functions, means for burning fuel, means for admixing air in divided currents with volatilized gases, a high-run combustion-chamber, said sections being constructed, arranged and disposed to distribute the gases of combustion over the whole of the heat-absorbing surfaces of each section and to absorb the heat of said gases progressively from the location of most intense heat generation away from said location, said construction comprising contracted gas-passages, the water in the sections nearest to said location being the hottest and the water in the section farthest from said location of heat generation being the coolest.

Signed at New York, N. Y., this 21st day of December, 1905.

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Witnesses:

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