Figure 11, as trains may be run by the perfect combustion of the fuel, by adopting the "Improvements in Means for Assuring Perfect Combustion."

rom the boiler through "A," and connecting "A" with the inner tubes, "E" "E" (see Figures 1, 2, 3). By

A with

3). By

air to circulate through the hollow grate bars and headers.

Figure. 11, as trains may be run by the perfect combustion of the fuel, by adopting the "Improvements in Means for Assuring Perfect Combustion."

it, and of making it elastic to the extent of an immense power, that subserves the requirements of this progressive age, and it possesses the power of converting the water into a gas of resistless energy.

What then is heat? Scientists say it is a form of motion in the particles of a body; increase the motion, or cause friction amongst the particles, then heat is caused; the quantity of heat produced by the friction of the bodies, whether in solids or liquids, is proportional to the motion, friction or work expended; everyday experience of the ironworker and others in industrial pursuits demonstrates that heat is a form of energy or energizing power, whether in solids, liquids or gases—all have a molecular structure.

We owe our heating power to hydrogen and carbon; some of the fuels contain little or no hydrogen, as, for example, coke, charcoal and anthracite coal, while other fuels, such as wood, peat and bituminous coal contain both hydrogen and carbon. The latter fuels are very volatile, and when combustion is perfect the heat evolved is the same as if the hydrogen and carbon in the fuel were burned separately. Hydrogen combines with oxygen to form water, and in that act of union liberates the greatest heat known to scientists, one gram by weight being sufficient to raise 34,462 grains of water from 32° to 212°, hence the calorific power of hydrogen is represented as 34,462 thermal units. The calorific power of carbon burnt with the requisite amount of air is 14,544, but if burnt in oxygen this may be increased to 18,317 heat units. It is from the act of union that the heat is evolved, and the law of proportions in respect to the chemical affinities are fixed by natural laws, that science has expressed in figures, thus:

When 11^{97} parts by weight of carbon unite with 31^{92} parts by weight of oxygen to form 43^{89} parts of carbonic acid, the heat emitted by the act of union is sufficient to raise 96,960 parts by weight of water from 32° to 212°. And when two parts by weight of hydrogen combine with 15^{96} parts by weight of oxygen to form 17^{96} parts of water, the quantity of heat liberated by the act of union is sufficient to heat 68,924 parts of water from 32° to 212°.

What is combustion? It is a chemical action between two agents in the affinity of one for the other. When, therefore, the conditions of union are unfavorable the combustion will be imperfect; combustibles are either carbonaceous or hydrogenous, and it is necessary to the efficiency of a combustible that the combustion be gaseous; *therefore, in the union of the gases of combustion in the furnace is perfect combustion*, no smoke consumer can so effectually do the work of combustion as the gases within the furnace in their natural affinity and proportions each for the other. Now, what does imperfect combustion mean in figures? In the perfect combustion of one pound of carbon there is evolved 14,500 units of heat, but in the imperfect combustion of one pound of carbon only 4,400 units of heat are evolved, the imperfectly consumed, highly-heated gases and uncombined air escaping up the chimney as soot, causing the temperature of the furnace to be lessened, leaving ashes and clinker. Too rapid a flow of air will also reduce combustion; even a gas flame may be rendered non-luminous by an excess of oxygen cooling the flame down, while, therefore, imperfect combustion will result from an insufficiency of air or oxygen, an excess of air or oxygen may be detrimental to perfect combustion.

It will thus be seen that combustion is an energetic union of bodies, solid, liquid or gaseous, in well-known proportions, according to the affinity of each for the other; that these bodies consist of hydrogen, hydrocarbons, or carbonaceous fuels uniting with pure oxygen or the oxygen of the atmosphere, rendered gaseous, giving out heat in the act of union.

For "careful firing," as described by the Chicago journal, the responsibility is wholly placed upon the stoker; very often the designer of the locomotive is more especially responsible. Stokers are to be commended for "careful firing," and many do minimize the waste from the smoke-stack, but it is too much to expect, as expected by not a few railway men, perfect combustion of fuel by stokers in "careful firing," this is tantamount to expecting the stokers to manage the almost unmanageable air. Many highly paid, responsible railway men have the idea that they can never get enough or too much air, and every device, some of them commendable, is resorted to, to draw or force strong currents of air under and through the grate-bars; in doing this, in some cases, they may see from the small pieces and nuggets of unburnt coal, as well as from the fine particles of carbon as smoke, lifted from the fire-bed, and expelled through the smoke-stack, proof that they may have "too much" of that "good thing." Perfect combustion takes place according to the density, rather than because of strong currents, of the air, excess of such being hurtful in cooling the temperature of the furnace, but, notwithstanding, if the furnace conditions are otherwise favourable to perfect combustion, the same amount of heat may be generated though the temperature be lowered by the diffusion, in the greater volume, of the products of combustion by reason of the excess of air. Slow combustion gives out little heat and much uncombined carbon, causing, with loss of heat, smoke and soot; this may be avoided by an intimate and sufficient mixture of air in the furnace, but how is a stoker in all circumstances and under all conditions of the atmosphere to supply that sufficiency? or how guard against a hurtful excess of air through the devices in use for driving or drawing strong currents of air through the grate-bars, through the burning fuel? As a hot body will cool faster in a strong current of air than in a still atmosphere, so will a strong current of air through the burning coal suffer loss of its oxygen in passing through the incandescent fuel, and failing in intimate mixture with the gases of the combustibles will cause a reduction in the temperature, hurrying with it, as soot, smoke and flame, the uncombined carbon and gases of the combustibles that should do service by combustion in union in the furnace. Smoke consumers have been devised to seize upon such particles of carbon and other matter in the form of soot or smoke in transit to the chimney, for the purpose of burning them, but as carbon requires red heat, or say 800° to 1000° for ignition, and then only burns slowly, it will be seen that it is hardly possible to burn smoke after it has left the furnace, and such devices are accordingly not satisfactory to the extent proposed to be accomplished by their use. Every engineer and stoker has proof of the non-burning properties of smoke after it has left the furnace, in the difficulty of making steam in boilers with unclean flues, and proof also might be found of the non-burning qualities of soot or smoke by a trial to burn the rafters in works heavily coated with soot or smoke.

The function of combustion being an act of union between substances combining with oxygen, it is essential to the efficiency of the combustible that the solid fuel be reduced, that the result of the combustion be gaseous, and it is essential to the prevention of smoke —to perfect combustion, that the gases be intimately intermixed or diffused in the furnace where generated, with a sufficiency of oxygen before combustion.

The importance attaching to this intermixture of gases with a sufficiency of oxygen, will be appreciated by reading the following extract from a standard authority:—

"If, before reaching the upper layers of carbon or cinder, the air has parted with all its oxygen to form carbonic acid with the production of heat, then the carbonic acid combines with part of the remaining carbon to form carbonic oxide without producing heat. The loss may, therefore, amount to one-half of the fuel, some have stated it as high as three-fourths. If this oxide, when it gets above the fuel, meet with air before cooling, it burns with a pale blue flame, restoring part of the lost heat, but to what extent has not been determined."

The records of many tests show that when bituminous coal is heated in retorts it yields up 20 to 30 per cent. of volatile hydrocarbon, robbing the fuel of a large portion of its weight of carbon; the very same result ensues when fresh coal is shovelled into a boiler furnace, when the volatile constituents are burned above the fuel on the grate, or escape up the chimney unconsumed and smoky. As the constituents of the coal are burned separately, they are first disunited by heat, the carbon separating from the hydrogen in small particles, and as hydrogen ignites at the lower temperature, it is the first to be consumed, or the first to leave the furnace unconsumed, carrying with it the unburned particles of carbon. If consumed in the furnace, and the temperature is sufficiently high to ignite the carbon in the requisite density of air for perfect combustion, a dazzling white flame will result, but in proportion as the flame changes to redness or darkness, there will be indications of reduced heat, until, from lack of temperature in the furnace the particles of carbon pass off as soot, or smoke unconsumed.

Patents are taken out in Great Britain, the United States, Canada and applications to foreign countries, for "improvements in means for assuring perfect combustion." The improvements are a new departure from the means usually resorted to for effecting, but not effecting, perfect combustion, and to consume, but not wholly consuming, the smoke. The specification following fully explains the aims and claims of the inventor :—

To all whom it may concern :

Be it known that I, John Livingstone, of No. 31 York Chambers, Toronto Street, in the City of Toronto, Province of Ontario, in the Dominion of Canada, manufacturer, have invented certain new and useful

Improvements in Means for Assuring Perfect Combustion.

and I do hereby declare that the following is a full, clear and exact description of the same, reference being made to the accompanying drawings of one form of the device, in which it is made to apply to a Portable Boiler of the Locomotive type.

And I do hereby declare the nature of my invention for "assuring perfect combustion," and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement :

That my invention relates to that class of devices by which steam is introduced into the furnace in the form of a gas to aid combustion.

That it is for use as a part of, or as an attachment to, furnaces of every kind, for the purpose of increasing the efficiency of the furnace and to perfect the combustion of the fuel.

That it is for the decomposition of the steam into its gaseous parts, and ejection into the furnace.

That it is for use to accelerate motion amongst the particles uniting in combustion in the furnace.

That the form of the device and parts thereof is and are of necessity varied as to shape, according to the size and kind of each furnace or boiler, according to the room space available, and where available, on a boiler, in a boiler, in a furnace, or in a place in close proximity thereto for any part of the device.

That the nature of my invention will more fully appear from the subjoined description, and the novelty will be pointed out in the claims.

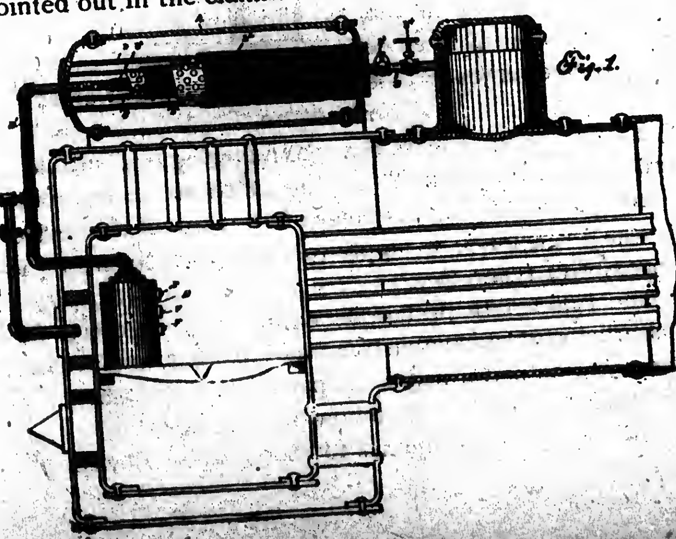

Fig. 1.

Figure 1 is a longitudinal section of a boiler, showing the furnace and my apparatus connected thereto. In the boiler may be placed zinc pieces, scrap metal, shavings or strips of metal.

Fig. 2.

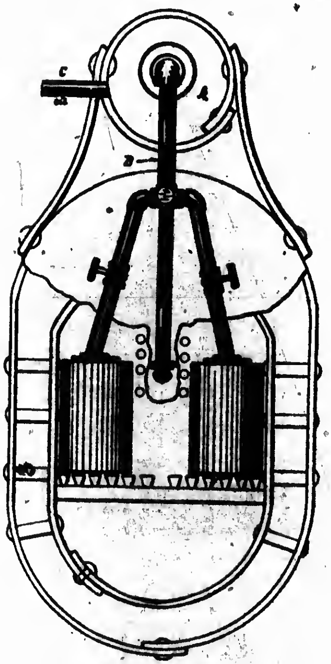

Figure 2 is a transverse view of a boiler, with the front plates of the boiler removed so as to show the inside of a furnace and part of my apparatus, the superheaters, therein.

Fig 3.

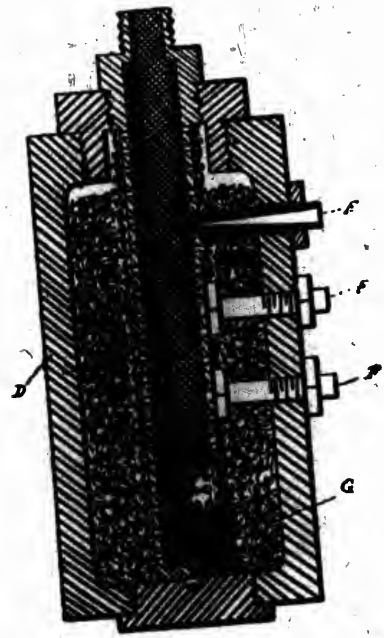

Figure 3 is an enlarged section of the superheaters 'D" "D", with combination therein.

Fig. 4

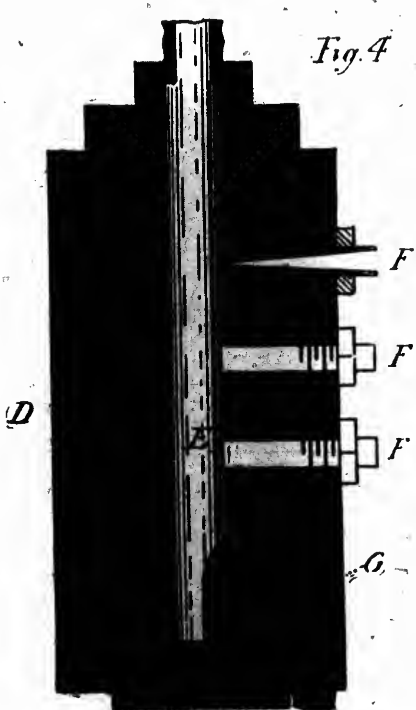

Figure 4 is an enlarged section of superheaters "D" "D" with no combination therein.

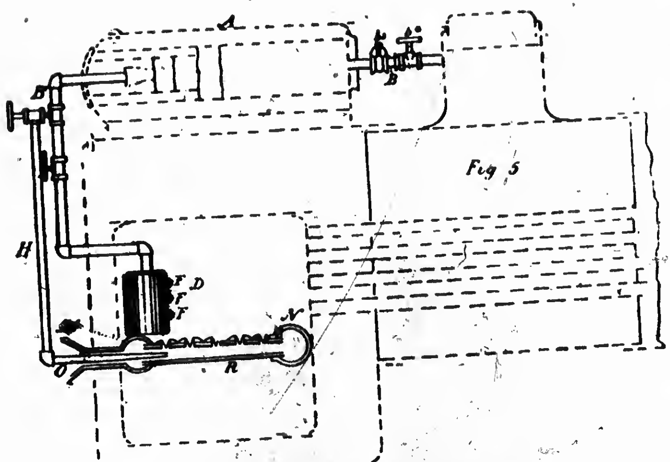

Fig 6

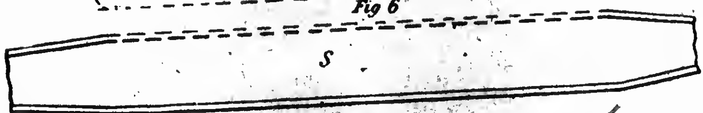

Fig 7

Figure 5 is a longitudinal section of a furnace, showing my apparatus the same as in figure 1, except the extension of the movable pipe "H" to connect with hollow grate bars, with a sectional view of the hollow headers marked "M" "N" across the front and rear end of the furnace, and one hollow straight furnace bar marked "R" across the furnace longitudinally, with the ends open, terminating in "M" "N".

Figure 6 is a sectional view of a round hollow grate bar, with the ends slightly tapered to enter easily, and wedge into headers "M" "N".

Figure 7 is a sectional view of headers "M" "N", which rest across the front and rear of the furnace in a boiler, the inlet holes from the header in the front of the furnace to the inlet holes in the header in the rear of the furnace, made mathematically true in line and size each to the other.

"A" in figures 1 and 2 is a vessel that may be of any shape to suit the space or place available, made of boiler plate, or cast iron or other suitable material of strength to resist internal pressure equal to that in the same boiler to which it is attached, or of which it may be a part, and in it may be stored scrap zinc, or zinc strips or pieces of zinc, finely divided particles of iron and metal filings, turnings and small pieces of scrap metal.

"B" is a steam pipe from the boiler, entering "A" and passing through it, the portion inside of "A" is surrounded by one or more tubes, tunnels or pipes "b^1" "b^2", of iron or brass or other suitable metal, with holes in the said portion of "B" inside of "A", and in the surrounding pipes "b^1" "b^2", as seen in figure 1, exposed for reference to the perforations and woven linings hereafter referred to around "b^1" "b^2".

The said portion of "B" and the surrounding pipes "b^1" "b^2" may be each encased in close fitting sleeves made of fine woven wire cloth, or the sleeves may be made of flannel, cotton, canvas or other suitable woven material. The sleeves may be made fast to the said portion of the pipe "B", and the sleeves for each of the said pipes "b^1" "b^2" may be made fast by sewing each sleeve, according to its size or pipe, to each respective pipe, with fine wire of brass or other metal, through the holes in the said portion of the pipe "B" and through the holes in the surrounding pipes "b^1" "b^2" within the vessel "A," as seen in figure 1.

Between "A" and the boiler the pipe "B" is fitted with a check valve "b^3" and a shut-off valve "b^4", for disuse of the invention when for any cause necessary to use the boiler without the device, but the check valve is more especially to prevent gases entering the boiler.

"C" is a pipe connected to "A", by which oil may be put into the vessel "A", by hand or by any mechanical device; a glass gauge may be used to show the level of oil in the vessel "A", and a hand hole, with secure joint may be in any part of the said vessel "A" to remove sediment or refuse matter.

"D" (see figures 1 and 4) represents superheaters of any desired shape or form, according to the room space and shape of the space available. I prefer the cylindrical form, of a size corresponding to the available room space in the furnace, they may be about seven to ten inches in diameter, placed in the preferred part, the part preferred being on each side of the door at the front inside, standing on end, resting upon the floor of the furnace, and passing up through the grate bars, or standing upon the grate bars, (see Figure 2) or supported by any suitable means, and of such height as may be suitable for the furnace. "D" "D" may be made of steel, cast iron or suitable metal. I prefer a fire-resisting quality of cast iron, which may be protected by a coating, or by any suitable means. I prefer the use of the metal without any coating or cover, and the superheaters, "D," must be of sufficient strength to withstand pressure at least equal to that in the boiler.

Inside the casings of "D" "D" there may be tubes, "E" E," of iron, or steel, or brass, or bronze, or other suitable material, that may pass through the upper end to the bottom of the inside (see Figure 3). The bottoms of the casings of "D" "D" and the tubes, "E" "E," are closed and steam tight.

The inner tubes, "E" "E," may be about one-third of the diameter of the outer shells, "D" "D," and have a number of small holes, which may be in parallel rows, drilled through the sides of each, about half an inch apart (see Figure 3).

Around "E" "E," and close-fitted thereto, may be sleeves of fine-woven brass wire-cloth, sewed to said tubes, "E" "E," with brass wire stitched through the holes in "E" "E" to the sleeves in which "E" "E" are encased, and within "E" "E" is also a lining of fine woven brass wire cloth, also stitched to "E" "E" with brass wire through the holes in "E" "E" (see Figure 3).

From the inner linings in the tubes "E" "E," but not passing through the said linings (see Figure 3), there may be one or more (see Figure 1) small tubes or nozzles, "F" "F" "F," "F" "F," "F" made to project through from the linings (see Figure 3) within "E" "E." through "E" 'E" and outer linings of "E" "E," and through the superheaters, "D" "D," on the circle, or in angles one to the other, exposing to the fire short, blunt or semi-circular points "F" "F" "F" (see Figure 1 for each superheater).

The opening in the inner end of each of the nozzles or tubes, "F" "F" "F," "F" "F," "F," for about half an inch or less, may be one sixty-fourth of an inch in diameter, or less, increased by tapering the hole in each nozzle toward the outer or semi-circular end, say to the extent of about three thirty-seconds of an inch in diameter at the furnace end or point (see Figure 3), for the purpose of blowing through any grit or sediment

that may pass to the nozzles, "F" "F" "F," "F" "F" "F," as seen in the sectional view of upper "F," Figure 3. Instead of nozzles there may be holes, which may be made to taper through "D," like those in the nozzles.

The nozzles or tubes "F" "F" "F," "F" "F" "F" in superheaters "D" "D" are made to project, as stated, by being screwed through the casing of "D" "D" and "E" "E" (see Figure 3) or they may be made to screw through "D" "D" (see Figure 4) without the combination therein, as seen in Figure 3.

Within the spaces (see Figure 3) between the brass woven wire cloth lining to "E" "E" and the casings, "D" "D," there are placed loosely, small pieces of metal and iron or steel, iron filings, iron turnings from iron turning lathes, and scrap metals in small particles.

The holes or nozzles, "F" "F" "F," "F" "F" "F," in each of the superheaters, "D" "D" (see Figure 2), are placed one above the other (see Figure 3), the lowest being about ten inches above the grate bars, so as to be a little above the level of the top of the fuel when coal is used, and I place the others each about four inches above the other, but they may be on the circle of "D," or at angles thereon, one to the other.

The holes in superheaters or nozzles, "F" "F" "F," "F" "F" "F," are adjusted to point diagonally across the furnace, but the particular angle is not essential, neither is the height at which they are placed, as both may be varied to suit conditions required by the shape and size of the furnace or kind of fuel used.

"B[1]" is a continuation of steam pipe "B," which may have a check valve and a shut-off valve (see Figure 1) rom the boiler through "A," and connecting "A" with the inner tubes, "E" "E" (see Figures 1, 2, 3). By means of it steam is conveyed into superheaters, "D" "D" (see Figure 2).

"H" is a movable pipe so arranged that when necessary it may be used to increase the draught above the fire bed, or to prevent any excess of volume in the gases escaping through the door (see Figure 1), or it may be extended to aid in creating a draught current through hollow grate bars in the furnace.

The headers "M" "N," may be made from any metal. I prefer to make them from a fire-resisting quality of cast iron, free from blow holes, with the ends closed, the inlet holes limited to the number of hollow furnace grate bars, the metal not less than one-half inch in thickness.

The hollow grate bars, "R," may be all of a uniform size, and may be about two inches for the outside diameter, with the metal, of the same fire-resisting material, about one-half inch thick. I prefer the centre tube, as seen in Figure 5, to be of a greater size than the other tubes, and I prefer, as seen in said figure, each tube on each side of the centre tube to be less in gradually lessening sizes to a size not less than one and one-half inches outside diameter, with same thickness of metal in each for the two tubes nearest the furnace sides of the boiler.

The hollow grate bars may be made to fit, and be wedged to fit closely into the inlet openings or holes in "M" "N."

Through the front of the furnace, by a mouse-hole opening or aperture, and through the front header, "M," to the hollow grate bar as in Figure 5, or as I prefer, to the unperforated bar in the centre, connection is made with the atmosphere for the admission of atmospheric air to circulate through the hollow grate bars and headers.

Into the opening at the furnace front of the boiler, through header "M," a small jet pipe, "O," of not more than half the diameter of the opening, may be carried through the shell of the boiler front, through header "M," to a point just entering the centre tube, "R."

The headers and or hollow grate bars, other than the centre bar, connected as aforesaid with the atmosphere and inlet jet, may be perforated on the top with very small holes, or they may have a large number of small plugs of suitable material, with minute perforations.

The operation of the device is as follows :—

After steam has been raised to a pressure in the boiler it is passed through the pipe "B" to the vessel "A" (see Figure 1), and from "A," by the pipe "B¹," to the tubes "E" "E," within and to the superheaters, "D" "D" (see Figures 1 and 2), the steam carrying in its course its units of heat, acting on and acted upon by the heated metal, or iron turnings, filings or pieces of iron and steel in "A" in the spaces in the superheaters between the linings of "E" "E" and the casings of "D" "D," and upon the superheaters, "D" "D," and therein becoming superheated in contact with the iron, particles of iron and metal, is decomposed into its component parts, and expelled by pressure through the holes or nozzles, "F" "F" "F," "F" "F" "F," into the furnace above the fire-bed in the form of combustible gas, energized by the heat and pressure, accelerating motion amongst the particles in motion in the furnace, and uniting by affinity with the carbon of the solid fuel, for perfect combustion in the union of all the particles of combustion.

Air may be admitted through the centre grate bar for exit through the small perforations in the other bars into the furnace bed in contact with the burning coal, and when desirable for greater efficiency, the current and pressure of air through the hollow grate bars may be accelerated by an oil vapour-saturated steam jet "O," from "H," through the centre hollow grate bar.

When desirable, always by preference at low temperatures, and preferable as increasing efficiency at all temperatures, the vessel "A" is partially filled with oil, by preference, crude petroleum, which, acted upon by the heat from the steam passing through "B," gives off a vapour, thinned by filtration through the sleeve linings on the pipes, "b^1" "b^2," that in smallest measure saturates the steam from the boiler, overcoming and counteracting the aqueous properties of the steam at low temperatures increasing the gases in the furnace and aiding combustion.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. Vessel "A," with woven sleeve lined tubes, tunnels or pipes therein.

2. Superheaters, "D" "D," with woven metal sleeve linings outside and inside of "E" "E," in superheaters "D" "D."

3. The superheaters, "D" "D," with and without the combination therein, with tapering holes or nozzles, as substantially described (see Figure 4).

4. The use of zinc strips, shavings or pieces of metal, and iron filings, turnings or small pieces in the boiler, in vessel "A," and in the superheaters, "D" "D," or in either of them, to prevent the formation of the precipitated lime salts that interfere in making steam, and to split or decompose the steam within the heated superheaters, "D" "D," into hydrogen and oxygen.

5. The nozzles, "F" "F" "F," or holes, in each of the superheaters, "D," for the purpose herein stated, as part of said invention, to aid combustion.

6. The use of steam in combination with metal and metal particles, to aid combustion, producing gases substantially as described.

7. The use of steam, in combination with metal, metal particles and hydrocarbons, to aid combustion.

8. The hollow headers, in combination with the centre and hollow grate bars, for the admission of air, its circulation through the other hollow grate bars, its expansion and expulsion through the upper part of the bars into the furnace.

9. The hollow headers, in combination with the centre grate bar, and connection with inlet jet of steam, to accelerate motion amongst the particles of the inflowing air, for the decomposition of the jet of steam, its utilization as a gas to aid combustion by its exit into the furnace

10. The hollow headers, in combination with centre hollow grate bar, and other perforated hollow grate bars, for the conveyance of air above the fire-bed.

11. The hollow grate bars and headers in combination with steam jet.

12. The several parts of the described invention as one united whole, for the purposes following :—

To aid combustion in furnaces of every kind, with special reference more especially to land and marine boilers of all kinds.

To aid in the decomposition of the steam into its component parts, for use in its superheated, energized and gaseous state to aid combustion.

To give to the furnace aid by a purer and more oxygen than acquired by the ordinary atmospheric draught by way of furnace bars to support combustion.

To accelerate motion amongst the moving particles of combustion in a furnace, aiding combustion.

To aid in creating the requisite density of furnace air for combustion in the furnace.

To maintain steam at highest pressures, and make steam economically, with the least measure of labour in firing and stoking.

To make combustion perfect by accelerated motion, by the required density of furnace air, by decomposition of the fuel, and by natural union of the gases of combustion.

To reduce the quantity of fuel ordinarily required, by the combustion of the whole in heat making.

To remove cause for smoke, grit, sparks or flame from chimneys and smoke stacks, all being seized upon and consumed by natural union in the furnace.

To reduce the solid residue in the combustion of fuel

To reduce the continuous labour required ordinarily in firing and stoking, by effective natural union of the gaseous elements combining in the furnace.

To prevent the formation of the precipitated lime salts in superheaters and boilers, that interfere with the making of steam, and affect combustion.

The inventor does not pretend to burn steam, the steam that he carries from the boiler or from an exhaust is saturated with hydrocarbon vapours to counteract its aqueous properties, and to aid in enriching the gases.

The saturated steam is, in the superheaters, brought into contact with metal, iron and iron particles at a red heat. It is there decomposed or split into its constituent elements, hydrogen and oxygen, ejected by pressure diagonally in small imperceptible streams, right and left, across the furnace, above the fire-bed. In its passage over the furnace it liberates a rich, carburetted gas from the fuel, and raises the temperature of the furnace more rapidly than possible by any other process of firing.

The atoms or molecules of the gases of combustion, usually moving in a straight line in and with the current or draught of atmospheric air, are, in and with the oxygen of the air, deflected diagonally and irritated by deflectional interference with the straight line current, moving with great velocity, attracting and repelling one another by impact upon the sides of the furnace until thoroughly intermixed, combined and consumed, the nitrogen, or non-combustible particles only, passing through the smoke-stack.

The perfect union of the gases by this mode of uniting with the air is due to the hydrogen ejected from the superheaters, that gas having a refractive power greater than any other gas, six times greater than air, and four times greater in diffusive power than oxygen; uniting with all, it raises the temperature, and having a great affinity for carbon in the presence of oxygen, it becomes a racer after the atoms of carbon, checked in their progress to the smoke-stack by the deflected movements of the gaseous atoms that are drawn into union, with evolution of heat, instead of being passed off as smoke and soot, to the annoyance of the vicinage.

The conditions of perfect combustion may be had in most furnaces without the use of hollow grate bars. The heating of air is in some respects a disadvantage, for in so doing it becomes rarefied and less dense, a condition not always favorable to combustion, a requisite weight of air being necessary to perfect union; but as in the supply of air ordinarily through the grate bars, a large part of the oxygen of the air supplied is lost in its passage through the fuel, the ejection of the air from a large number of jets, through plugs or through raised portions, of the bars, or from the headers, into the carbon flame above the fire-bed will aid in the intimate intermixture and union of thc gases in the furnace; in also the pressure of volume by the aid of the steam jet, counteracted as to its aqueous properties by saturation in hydrocarbon vapours, the density is partially preserved by the pressure of the atoms of successive volumes of air held in the hydrogen atmosphere of the furnace during combustion. The air entering thus into the furnace at a warmer temperature than the outer air, acts as a corrective when too little or too much air is supplied to the furnace, the heated air parting more quickly with its oxygen than the cold air; the lighter constituent, nitrogen, passing to the chimney, the heavier constituent, oxygen, uniting more readily with the carbon in the fuel by reason of the heat; carbon requiring a higher temperature for ignition than the other constituents of coal. Thus, by this process of firing, nature assisted, assists the Stoker, the temperature is made higher in the furnace, and made higher as far as the gaseous flames extend through the flues of a boiler, with the temperature lower beyond, where no act of union or combustion is in progress, nor uncombined highly-heated gases, uncombined or unburnt particles, pass, as now, in the firing of the largest number of boilers in use, with a loss of 30 to 50 per cent. of fuel thrust as a nuisance into the outer air.

These results have been demonstrated in a twelve horse-power boiler and Engine (see Figure 1), used for experimental purposes.

Experiments have demonstrated a combustion so thorough that the writer and others have been able to sit upon a ladder within two feet of, and facing the smoke-stack of such a boiler burning bituminous coal therein, to hold sheets of cream white paper over the smoke-stack without soiling, to sit in the teeth of a high wind, with face immediately on a line and level with the smoke-stack, and to hold their heads over the middle of the top of the smoke-stack about twelve inches above it, without having cause to move by reason of either grit, sparks, smoke or soot; there was neither. Only a slight vapour from the smoke-stack moistened the air.

These and other experiments are an earnest of what may be accomplished in the way of comfort and clean firing by regard to nature's laws, and by adoption of the patented "Improvements in Means for Assuring Perfect Combustion," the comforts and economical results being as near as possible illustrated by comparisons, figures 8 and 9, a steamer, with and without the improvements, rushing through the water; in the one, figure 8, it is seen belching forth great volumes of smoke, and in the other, figure 9, with the Improvement, sending up only a clean white vapour. The same results shown in figures 10 and 11, for a locomotive; the discomforts of travelling, by reason of smoke, shown in figure 10, while in figure 11 only a clean white vapour is seen coming from the smoke-stack of a locomotive, in and upon which the patented improvements are supposed to be.

Like illustrations apply to stationary boilers, and like results may be obtained by adopting in and upon them, the "Improvements in Means for Assuring Perfect Combustion."

THE FIRES IMPROVEMENT CO.

BUFFALO, N.Y.
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Figure 8, an every day sight to travellers by steamer, smoke in large masses from two funnels, making the rear half of the deck of the steamer Saratoga an uncomfortable part in which to either sit or promenade.

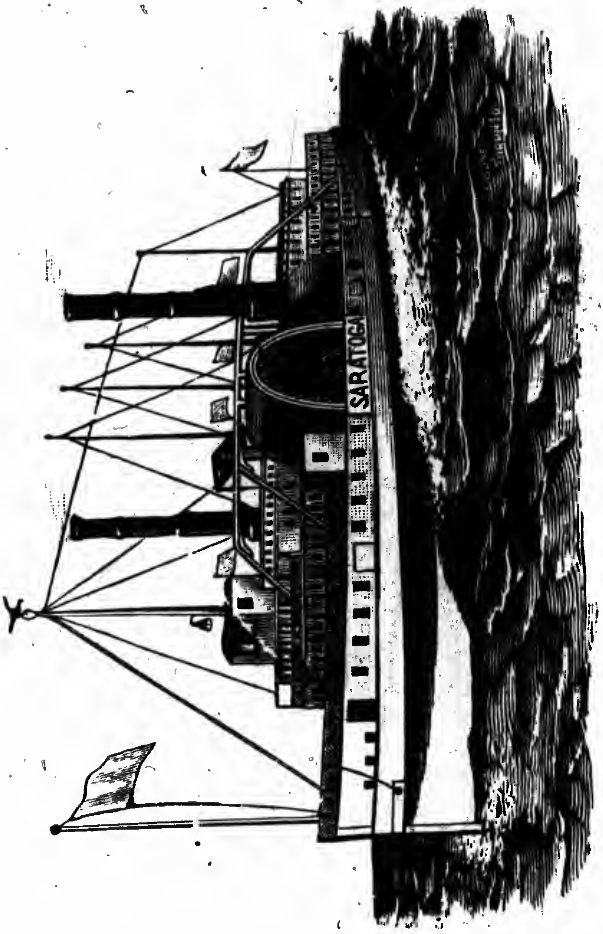

Figure 9, a rare sight, the steamer Saratoga, as steamers should be seen, rushing through the water without making the deck uncomfortable to promenaders. This may be accomplished by adopting the "Improvements in Means for Assuring Perfect Combustion."

Figure 10, an ordinary sight, a train in motion, with smoke extending from the smoke-stack to the discomfort of passengers on the train.

Figure 11, as trains may be run by the perfect combustion of the fuel, by adopting the "Improvements in Means for Assuring Perfect Combustion."