No. 829,871. PATENTED AUG. 28, 1906.

J. LIVINGSTONE.

FURNACE FOR STEAM BOILERS.

APPLICATION FILED SEPT. 15, 1904.

2 SHEETS—SHEET 1.

Fig. 1

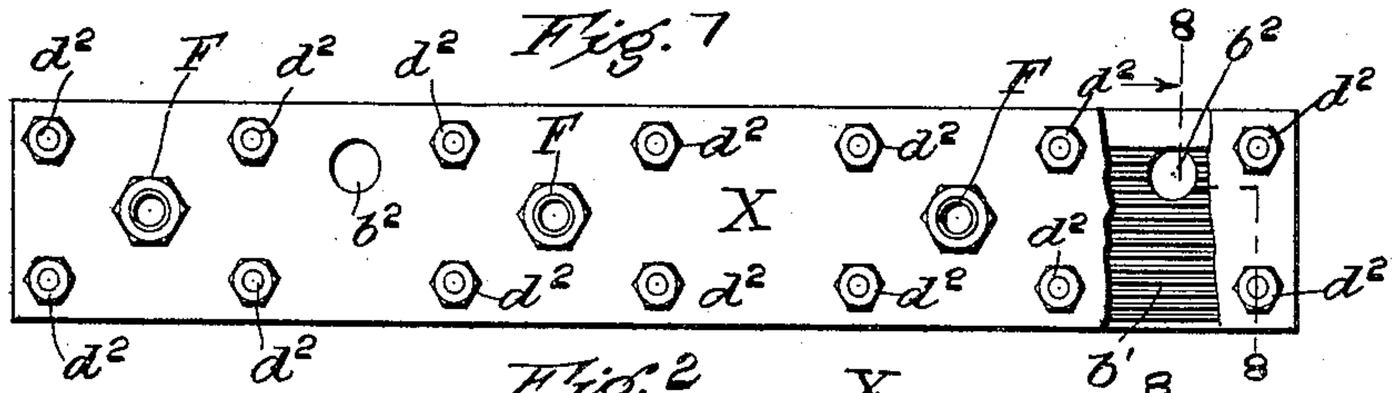


Fig. 2

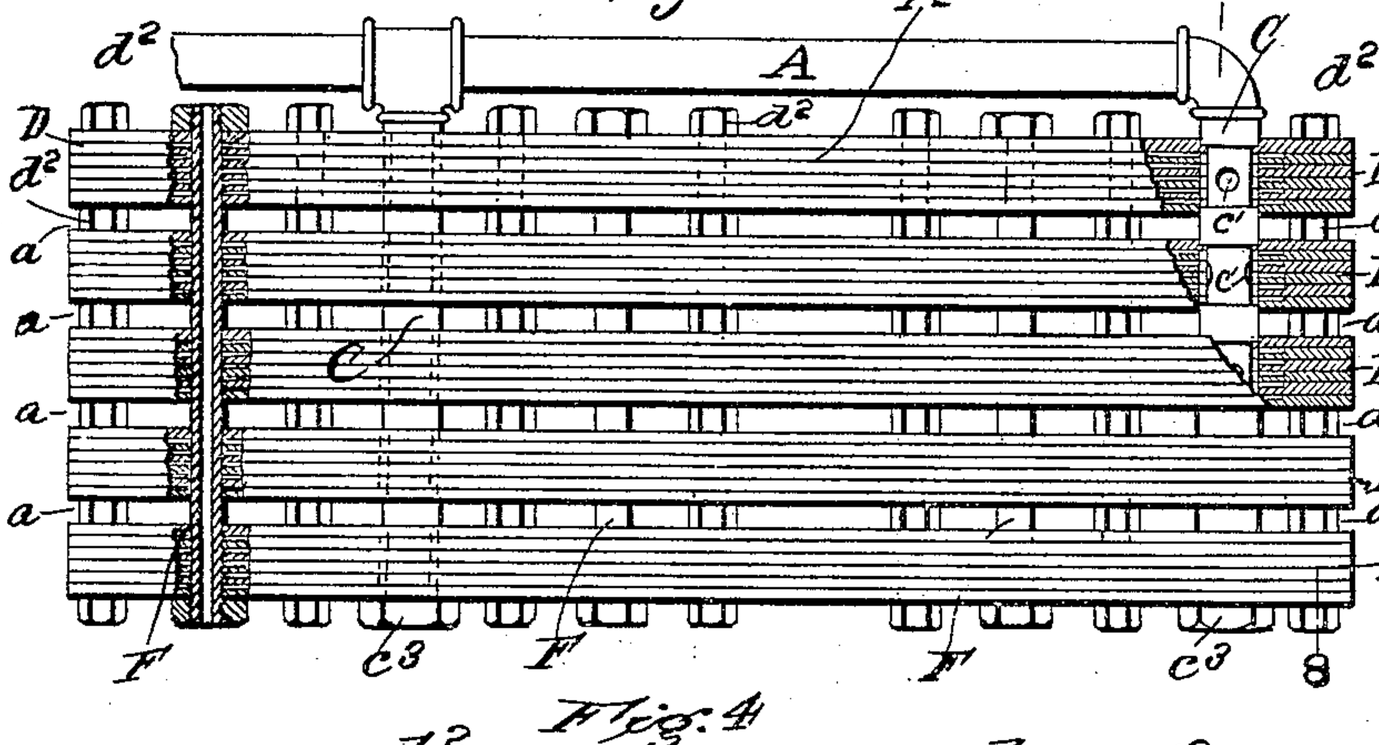


Fig. 3

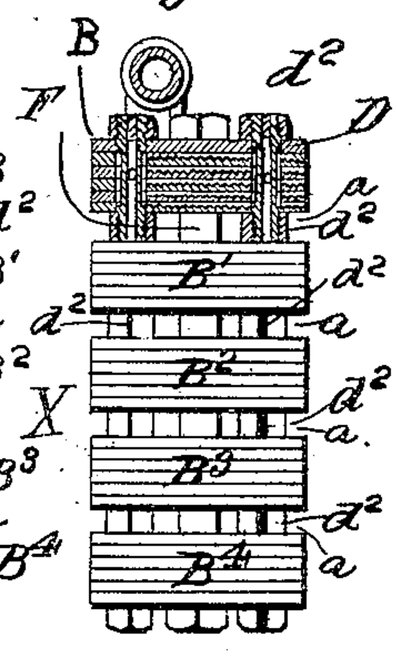


Fig. 4

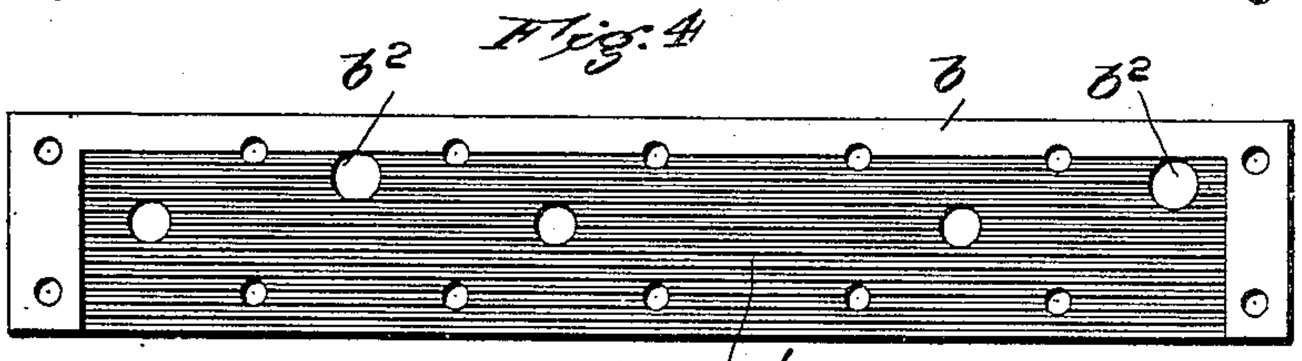


Fig. 6

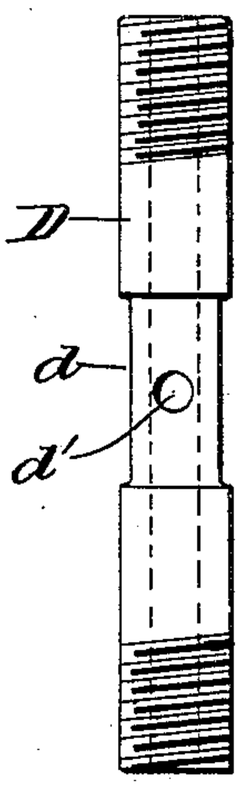


Fig. 5

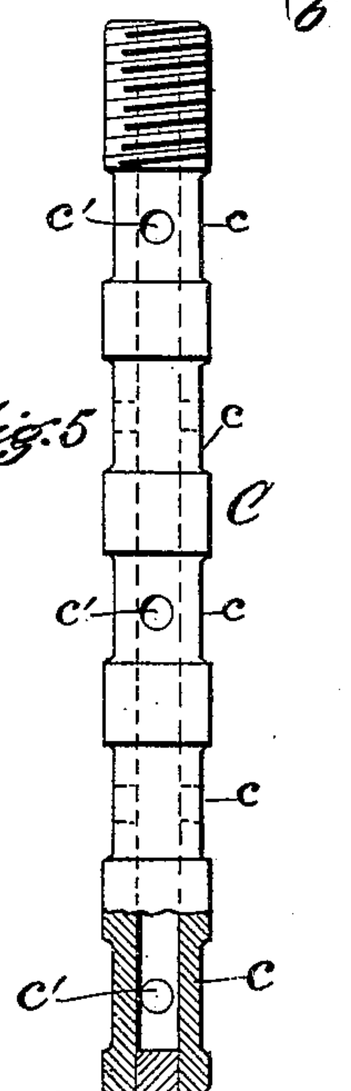
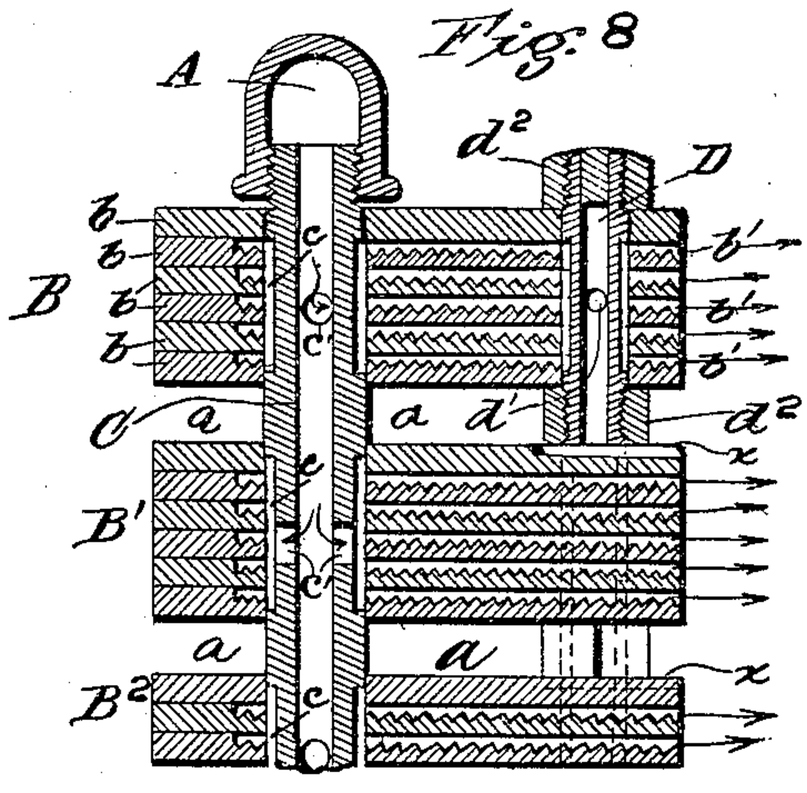


Fig. 8



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2 SHEETS—SHEET 2.

Fig. 9

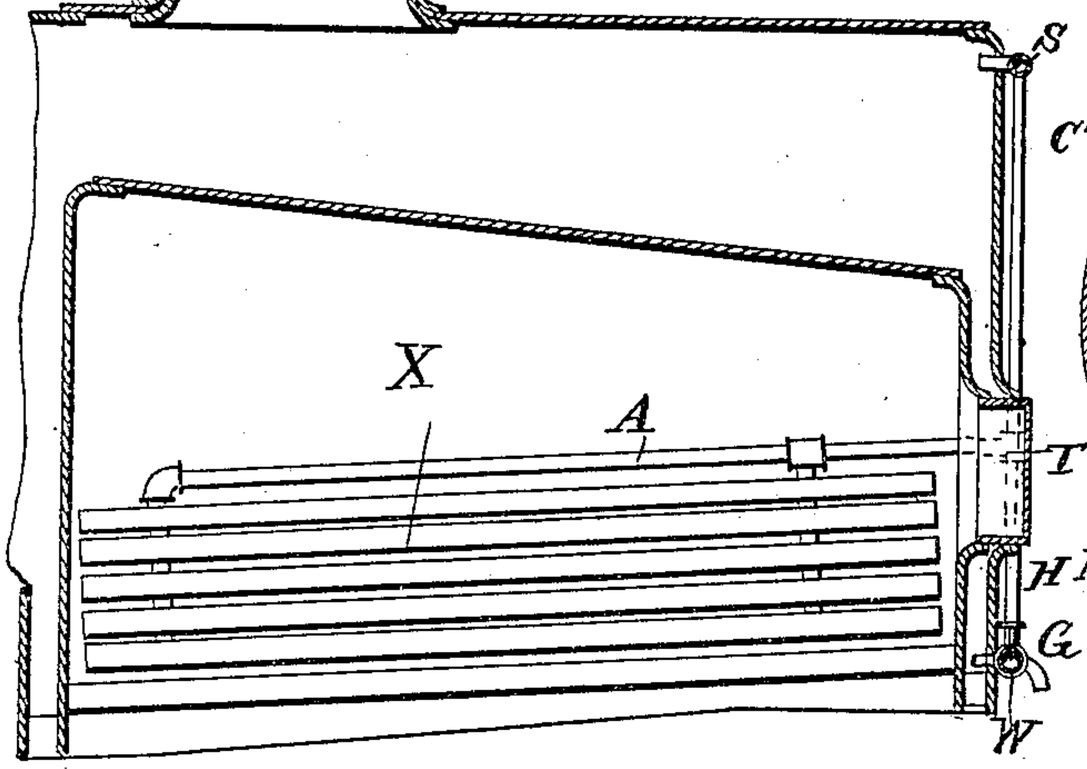

Fig. 10

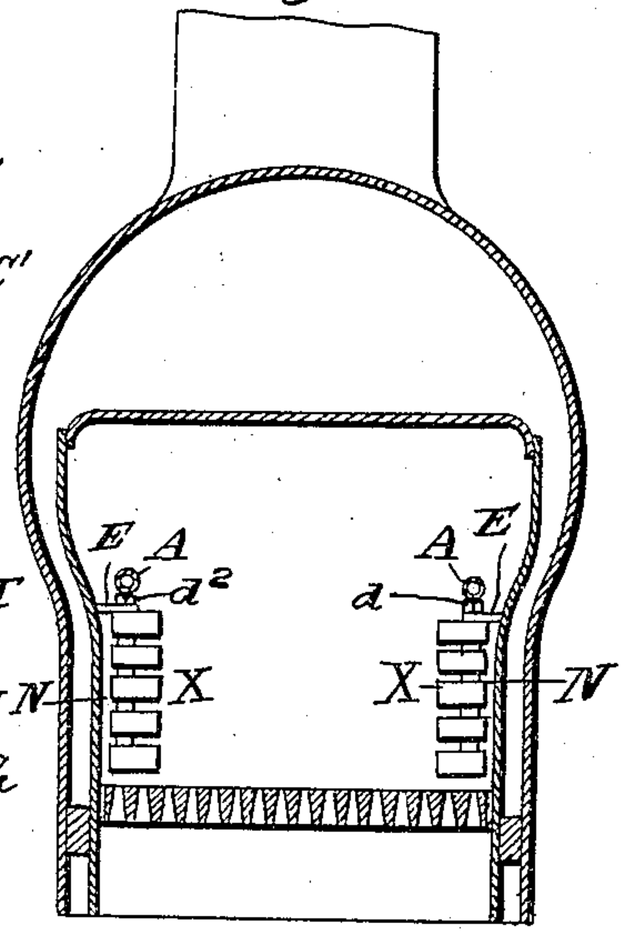

Fig. 11

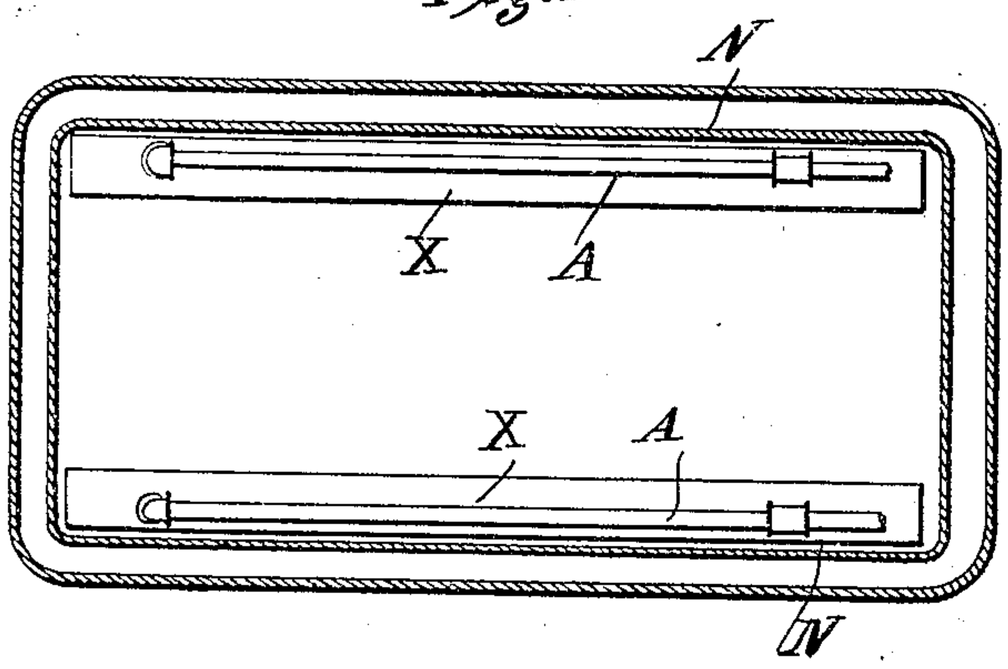

Fig. 12

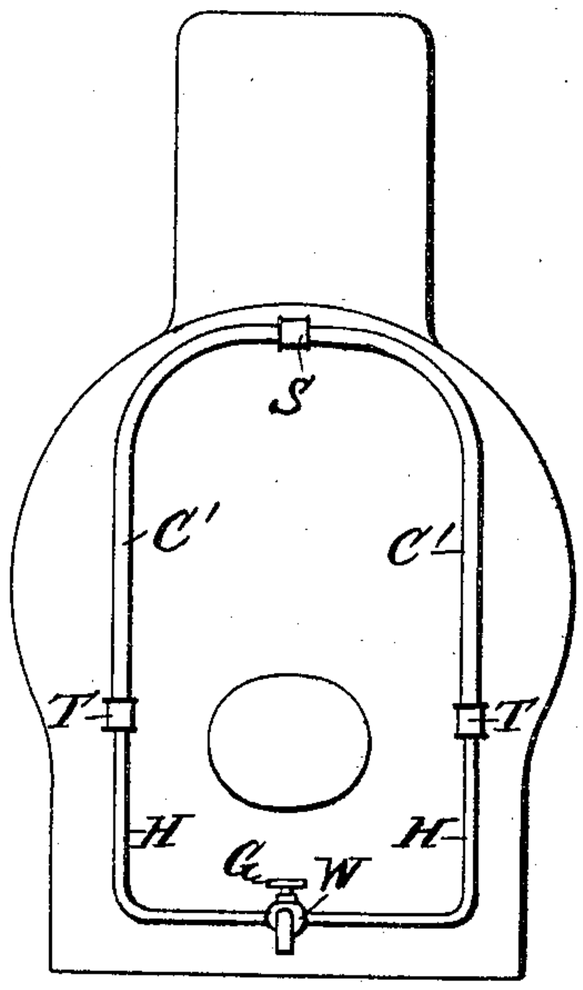

Fig. 7

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UNITED STATES PATENT OFFICE.

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FURNACE FOR STEAM-BOILERS.

No. 829,871. Specification of Letters Patent. Patented Aug. 28, 1906.

Application filed September 15, 1904. Serial No. 224,627.

To all whom it may concern:

Be it known that I, JOHN LIVINGSTONE, a citizen of the Dominion of Canada, residing at Montreal, in the county of Hochelaga and Province of Quebec, Canada, have invented a new and useful Improvement in Furnaces for Steam-Boilers, of which the following is a specification.

My invention is in the nature of a new furnace for steam-boilers, whether used for locomotives, marine engines, or stationary engines. It belongs to that class of furnaces known as "smoke-consumers," whose object is to consume and utilize the portions of the fuel which are ordinarily lost in smoke, combustible gases, and particles of carbon escaping with the draft as cinders. The loss in fuel from the above-named causes is known to be great. The loss from the escaping solid particles of carbon has been estimated to be from ten to twenty per cent., and when the greater loss of carbonic oxid and other unconsumed but combustible gases is taken into account the aggregate loss in fuel is believed to approximate fifty per cent. of the combustible elements. In addition to the money loss, the fouling of the air has been a serious objection, discriminated against by many municipalities, while the risk of fire to barns, grain fields, &c., is also to be taken into consideration. Various attempts have been made to conserve this waste and utilize the lost elements. The introduction of both air and steam into the fire-box by special methods of distribution has long been the chief agency for overcoming the difficulty, but no entirely satisfactory means have been devised which sufficiently commend themselves to secure general adoption. My invention is designed to provide such a means. In principle it comprehends the disassociation of the oxygen and hydrogen of steam in the fire-box and their union with the fuel to produce a water-gas, and in construction it provides novel means by which the steam is so superheated and its contact with the heating-surfaces so prolonged as to insure the disruption of the elements, which elementary gases by their tenuous and expansive character pursue, overtake, and combine with the carbon particles while yet in the fire-box and by quickly forming a water-gas and immediately burning it by the oxygen present reaches the very desirable result aimed at, as hereinafter more fully described.

Figure 1 is a plan view, partly broken away, Fig. 2, a side elevation, partly in section, and Fig. 3 an end view, partly in section, of one of the superheaters of my system by which the steam is superheated and its elementary gases disrupted. Fig. 4 is a plan view of one of the surface-plates of one of the units of the superheater. Fig. 5 is a side view in detail of the steam-pipe connector for the several groups of plates forming the units. Fig. 6 is a side view in detail of a hollow connecting-bolt for connecting the plates shown in Fig. 4 into groups forming laminated units. Fig. 7 is a detail of a baffle-plate. Fig. 8 is an enlarged cross-sectional view taken on line 8 8 of Figs. 1 and 2. Fig. 9 is a vertical longitudinal section, and Fig. 10 a vertical transverse section, through the fire-box of a locomotive, showing my superheater and its accessories in position. Fig. 11 is a horizontal section of the same, and Fig. 12 is an outside end elevation of the boiler and fire-box looking into the fire-door.

In the drawings, Figs. 1, 2, 3, X represents one of my superheaters. This consists of a number of units B B′ B^2 B^3 B^4, which are arranged parallel to each other and are bolted together by long hollow tie-bolts F F, screw-threaded, but open at their upper and lower ends and provided with nuts by which the units are clamped together with air-spaces *a a a* intervening. Each unit consists of a group of parallel iron plates *b* laid flat together so as to form a laminated structure. Each of these plates (except the top one of each unit) is scored with a series of fine parallel grooves adjacent to and communicating with each other, which grooves or scorings *b′* cover the entire surface except at the ends and on one side, where the metal is unscored and smooth and fits steam-tight to the face of the adjacent plate. Each unit has its group of plates clamped together independently of the others by hollow bolts D, whose ends are exteriorly screw-threaded and provided with clamping-nuts d^2 d^2. The spaces left between the plates of each unit by the scorings form shallow superheating spaces into which steam is admitted and in which the steam is superheated to the point of disruption or disassociation of its oxygen and hydrogen and which gases escape laterally from the side slits into the fire-box, the scorings in the plates extending out to the edge of the plates on the sides next to the fire-box and at no

other point, as shown by arrows in Fig. 8. To admit steam to these scored and exceedingly flat or shallow chambers between the plates of the laminated units all of the plates are formed with coinciding holes b^2, and through these holes two (more or less) steam-connectors C, Fig. 5, are extended and secured in transverse relation to the plates by nuts c^3. These connectors are pipes of thick walls, and the tubular chamber of the connector at the bottom is closed either by making the screw-nut c^3 as a cap or by a separate plug or stopper, as shown in Fig. 5.

The outer surfaces of the steam-connectors C are turned down to form annular recesses c whose vertical length is a little less than the vertical thickness of one of the laminated units B, and each recess lies in the plane of a unit or group of plates. A hole c' establishes communication between the interior of the connector-pipe C and the annular space c, lying in the plane of the group of plates, and this annular space is in direct communication with the little shallow chambers formed by the scorings in the plates, as seen in Fig. 8. The tops of the connectors C communicate with and receive steam from a horizontal steam-pipe A through suitable couplings, so that steam from this pipe may pass down the connectors C and through the holes c' into the annular recesses c and thence into the flat and scored-out spaces between the plates of each unit or group of plates. The hollow individual clamping-bolts D of each unit are also turned down exteriorly to form annular recesses d, and this recess by means of hole d' communicates with the interior of the hollow bolt. The upper end of the hollow bolts D of the upper unit and the lower end of the hollow bolt of the lowest unit are closed, but where these hollow bolts terminate between the groups of plates the ends are open, and between the nuts d^2 and the adjacent face of the adjacent unit the plates are scored for a small space, as seen at x, Fig. 8, so that the steam or gases may issue from the center of the bolt and into the spaces between the face of the nut and the abutting face of the next unit, the purpose of which will be explained further along.

It will be remembered that steam is admitted to the scored chambers between the plates from the connector C, and the steam after being superheated and disrupted escapes laterally into the fire-box. As these scored chambers are, however, in open communication with the annular spaces of the hollow bolts D, a part of the steam or gases will pass from these scorings into the hollow bolts D and will issue through the inner ends of the bolt between the nuts and the adjacent faces of the next unit at the points x. This is to blow out the grit and ash between the units, and it is especially desirable at the inner row of bolts next to the fire-box, as seen in Fig. 8, so as to keep the air-spaces a between the units clean and free from obstruction. The superheaters X, as thus described, are arranged one on each side of the fire-box, as seen in Figs. 9, 10, and 11. A shallow vertical space N is left between the superheaters and the water-legs of the boiler, as seen in Fig. 10, and this space is in open communication with the air from below the grate. This air-space is closed at the top of each superheater by a baffle-plate E. (Shown in detail in Fig. 7.) This baffle-plate E is provided with holes e e, which are caught and held by an extension of the top bolts D of the upper unit and is held firmly by its nuts d^2. The steam-pipe A of each superheater connects by a coupling T with an external branched pipe C', which at S is tapped into the steam-space of the boiler. The couplings T also connect these steam-pipes with branched pipe H, which at W, Fig. 9, is tapped into the water-space of the boiler and is provided with a cut-off valve and discharge-cock G, as seen in Fig. 12.

In commencing the act of firing up to make steam there is danger that the iron or steel of the superheater will burn if not protected with water or steam behind the metal. The connection with the water-space of the boiler is accordingly opened to allow an upflow by the pipe H to pass the connection T into pipe A and connector C, where as it receives the heat it diffuses as vapor through holes c', recesses c, and scorings b'. A small part of the vapor finds the shallow scorings at x, partly protecting the edges of the flat plates, exposed to the radiant heat of the fire and the steam preventing the lodgment of grit in spaces a between the groups of plates. The water connection alone may be continued in service and the impurities in the water be expelled at G when desired; but after a pressure is seen at the gage the steam connection is the better one to have in service in the appliance, as an inflow of water may hinder the attainment of the highest quality of superheated steam which has a temperature above the constant for vaporous steam. Therefore, with the water connection shut off, the steam passes thence down pipe C' to A and thence enters C, and passes through holes c' and fills the turned-down annular spaces c, then unable to get out other-ways, the lower end of C being plugged, the steam forces its way through scorings b', issuing laterally in thin sheets of gas into the fire-box. A small portion surrounds the bolts D and passes into the hollow center at d', then out at the base below the nuts d^2, and into the shallow scorings x, where it blows away particles or grit, which might otherwise lodge in the spaces a, and incidentally it aids the other channels in protecting the iron or steel from burning. The main portion of the steam passes in the scorings b' into the fire-box and with the ap-

pliance in the furnace set back, but in convenient position to obtain for the metal a dark-red heat, the steam is converted from the vaporous quality of steam to the superheated steam, which has the properties of a gas, and as such it passes through the minute outlets in close contact with the red-hot metal, where it becomes decomposed in part, the constituent gases, hydrogen and oxygen, of the steam and the superheated steam going out of the minute outlets to the fire-bed, converting the fuel into water-gas with free oxygen from the air-spaces N and *a* to perfect its combustion. At this stage under the mechanical and physical action of the superheated steam and the physical influences of the disassociated constituents of the steam the fire is in condition for perfect combustion by natural union with the proper combining weights of oxygen. Experience under ordinary conditions has shown that the combining weights cannot be assured through the grate alone for the volatile matter in the coal passes to the chimney or smoke-stack before the volatile hydrocarbons receive the required oxygen at the required temperature for their union, and carbonic oxid is at all stages of burning in process of formation with loss of heat. An excess or insufficiency of air produces these conditions of imperfect combustion, and no one can measure the required combining weights of oxygen for the varying conditions of the fire. The fire only is the true judge of the weight of oxygen it needs, and as burning progresses the fire tends to create a vacuum, and the vacuum induces the required flow of air from convenient contiguous sources, but not in excess volume. With, therefore, the fire in the essential condition for the perfect union of the combustibles with oxygen the induction of the air up through space N is diverted by the baffle-plate E from being dissipated in the upper part of the furnace, but is induced by the vacuum created by the burning on the grate to pass through the spaces *a* between the units of the superheater and over the fire-bed, as required, but not in cooling volumes. The oxygen unites with the forming carbonic oxid, converting the carbonic oxid into carbonic acid, and the two-thirds of the heat lost in formation of the carbonic oxid is recovered to the furnace in the formation of the carbonic acid.

In firing, the volatile portions of the coal, in ordinary conditions, as soon as they touch the red coal fly away to the chimney, and in the process of burning the solid fuel, sparks and cinders, for the most part coked coal, are in motion in the upper part of the furnace and on the way to the chimney unburned, the passing cinders in a locomotive becoming entrapped in the smoke-box to the extent of a large percentage of the coal put into the fire-box, while in the upper part of the furnace the soot formed by the disassociation of the hydrocarbons passes out of the stack or chimney in clouds of smoke. It is to insure the burning of the volatile matter and the soot, cinders, and sparks in the furnace that the steam is decomposed in the scorings of the laminated superheaters so as to obtain the hydrogen from the steam. Its other constituent, oxygen, may at first be taken up by the iron until the surfaces take on a coating of black oxid of iron, after which it will pass into the furnace and recombines with the carbon or hydrogen. Hydrogen performs an important service, as it is a gas of the highest diffusiveness and has a strong affinity for both oxygen and carbon. In its diffusiveness it pursues and overtakes the volatile portion of the fuel and also the soot, cinders, and sparks. The air passing up N and through spaces *a*, increased by the air through the hollow tie-bolts F, together with the soot, cinders, and sparks as they rush on their way to the chimney, all meet the hydrogen from the minute lateral outlets, and the hydrogen, soot, cinders, and sparks are all consumed in the fire-box without escaping to the chimney.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. A steam-boiler furnace having a fire-box provided with one or more superheating units, each composed of parallel plates arranged in laminated relation to form shallow steam-spaces between them and one or more steam connector-pipes extending through said plates and opening into said shallow spaces.

2. A steam-boiler furnace having a fire-box provided with one or more superheating units, each composed of parallel plates arranged in laminated relation to form shallow steam-spaces between them opening along one edge and closed around the other three edges and one or more steam connector-pipes extending through said plates and opening into said shallow spaces.

3. A steam-boiler furnace having a fire-box provided with one or more superheating units, each composed of parallel plates with scorings or grooves and arranged in laminated relation and forming shallow steam-spaces extending out to one side and opening into the fire-box but stopping short of the other side and the two ends, and one or more steam connector-pipes extending through said plates and opening into said shallow spaces.

4. A steam-boiler furnace having a fire-box provided with one or more steam-superheaters, each composed of parallel plates arranged in laminated relation and connected together in groups with air-spaces between the groups, the parallel plates of the groups being formed with shallow steam-spaces between them extending out to one edge of the plates and opening into the fire-box and one or more

steam connector-pipes extending through said plates and opening into said shallow spaces.

5. A steam-boiler furnace having a fire-box provided with steam-superheaters arranged on each side of the fire-box, but set a little distance away from the walls of the fire-box, said superheaters being formed of parallel plates connected together in groups with air-spaces between the groups opening into the space behind the superheaters, the parallel plates of each group being formed with shallow steam-spaces between them extending out to one side and opening into the fire-box and closed on the other side, and one or more steam connector-pipes extending through said plates and opening into said shallow spaces.

6. A steam-boiler furnace having a fire-box provided with steam-superheaters arranged on each side of the fire-box but at a little distance away from the walls of the fire-box, a baffle-plate closing the opening between the top of each superheater and the wall of the fire-box, said superheaters being formed of parallel plates connected together in groups with air-spaces between the groups opening into the air-space behind the superheaters, the parallel plates of each group being formed with shallow steam-spaces between them extending out to the side next to the fire-box and opening into the same and closed on the other side, and one or more steam connector-pipes extending through said plates and opening into said shallow spaces.

7. A steam-boiler furnace having a fire-box provided with one or more steam-superheaters formed of parallel plates with shallow steam-spaces between them opening into the fire-box, one or more steam connector-pipes extending through the plates and opening into said shallow spaces and an external pipe connecting said steam-pipe to the boiler at a point in the steam-space of the boiler and also at a point in the water-space and a valve for controlling the flow of water or steam to the superheater.

8. A steam-superheater for the fire-box of a steam-boiler consisting of parallel plates arranged in laminated relation with shallow steam-spaces between the plates opening into the fire-box, bolts for connecting the plates together in groups, tie-bolts for connecting the groups of plates together with alternating air-spaces between the groups, and one or more steam connector-pipes extending through the groups of plates and opening into the shallow steam-spaces between the plates.

9. A steam-superheater for the fire-box of a steam-boiler consisting of parallel plates arranged in laminated relation with shallow steam-spaces between the plates opening into the fire-box, hollow bolts for connecting the plates together in groups, hollow tie-bolts for connecting the groups of plates together with alternating air-spaces between the groups, and one or more steam connector-pipes extending through the groups of plates and opening into the shallow steam-spaces between the plates.

10. A steam-superheater comprising a series of connected parallel metal plates arranged in laminated relation with shallow intervening spaces opening on one side and a steam-pipe passing through said plates and formed with an annular recess in the plane of the plates, said recess having an open communication with the interior of the pipe and also with the shallow spaces between the plates.

11. A steam-superheater comprising a series of connected parallel metal plates arranged in laminated relation with shallow intervening spaces opening on one side, a steam-pipe passing through said plates, and formed with an annular recess in the plane of the plates, said recess having an open communication with the interior of the pipe and also with the shallow spaces between the plates, hollow bolts connecting the plates together in groups, said hollow bolts also being formed with an annular recess in the plane of the plates in open communication with the interior of the bolt and also the spaces between the plates.

12. A steam-superheater comprising a series of connected parallel metal plates arranged in laminated relation with shallow intervening spaces opening on one side and provided with a steam-inlet to the shallow spaces, a hollow bolt having an annular recess in the plane of the plates in open communication with the interior of the bolt and the shallow spaces, nuts on the ends of the bolt clamping the plates in groups, the adjacent face of the plate of the next group being scored opposite the abutting nuts of the first-named group to permit steam from the interior of the hollow bolts to blow out grit from the spaces between the groups of plates.

13. A boiler-furnace having a fire-box with a superheater device constructed of parallel plates arranged in laminated relation with shallow spaces between them opening into the fire-box to form a water-gas apparatus located directly in and operated by the heat of the furnace charge and a steam-pipe connecting the same to the boiler as set forth.

In testimony whereof I have signed my name in the presence of two subscribing witnesses.

JOHN LIVINGSTONE.

Witnesses:
HUGH RUSSEL,
CHAS. E. STANLEY.