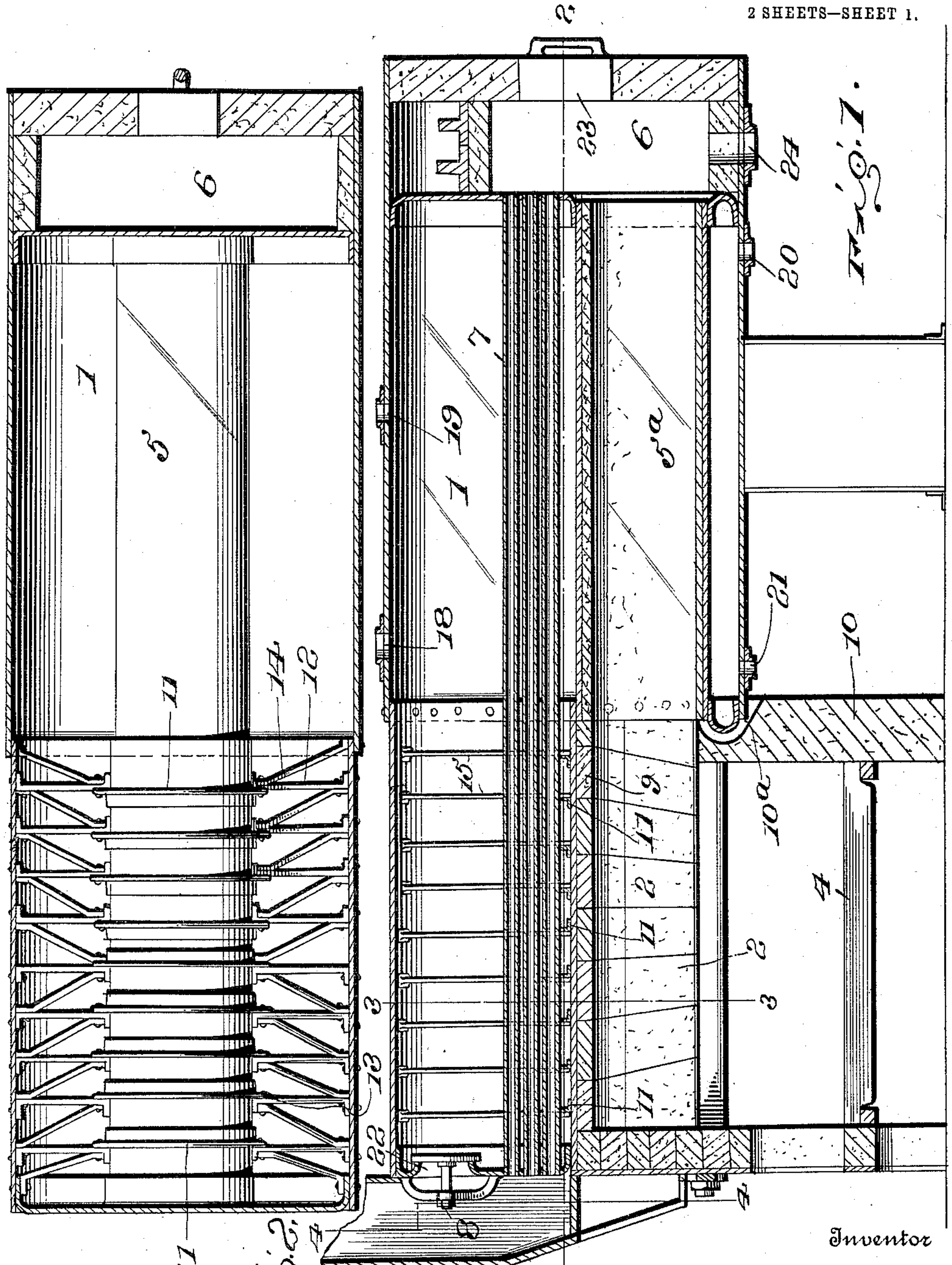
J. M. CAMERON.

STEAM BOILER.

APPLICATION FILED APR. 19, 1911.

1,018,873. Patented Feb. 27, 1912.

2 SHEETS—SHEET 1.



Witnesses

W. N. Woodson

Cora M. Handy

Inventor

J. M. Cameron

By

Victor J. Evans, Attorneys

COLUMBIA PLANOGRAPH CO., WASHINGTON, D. C.

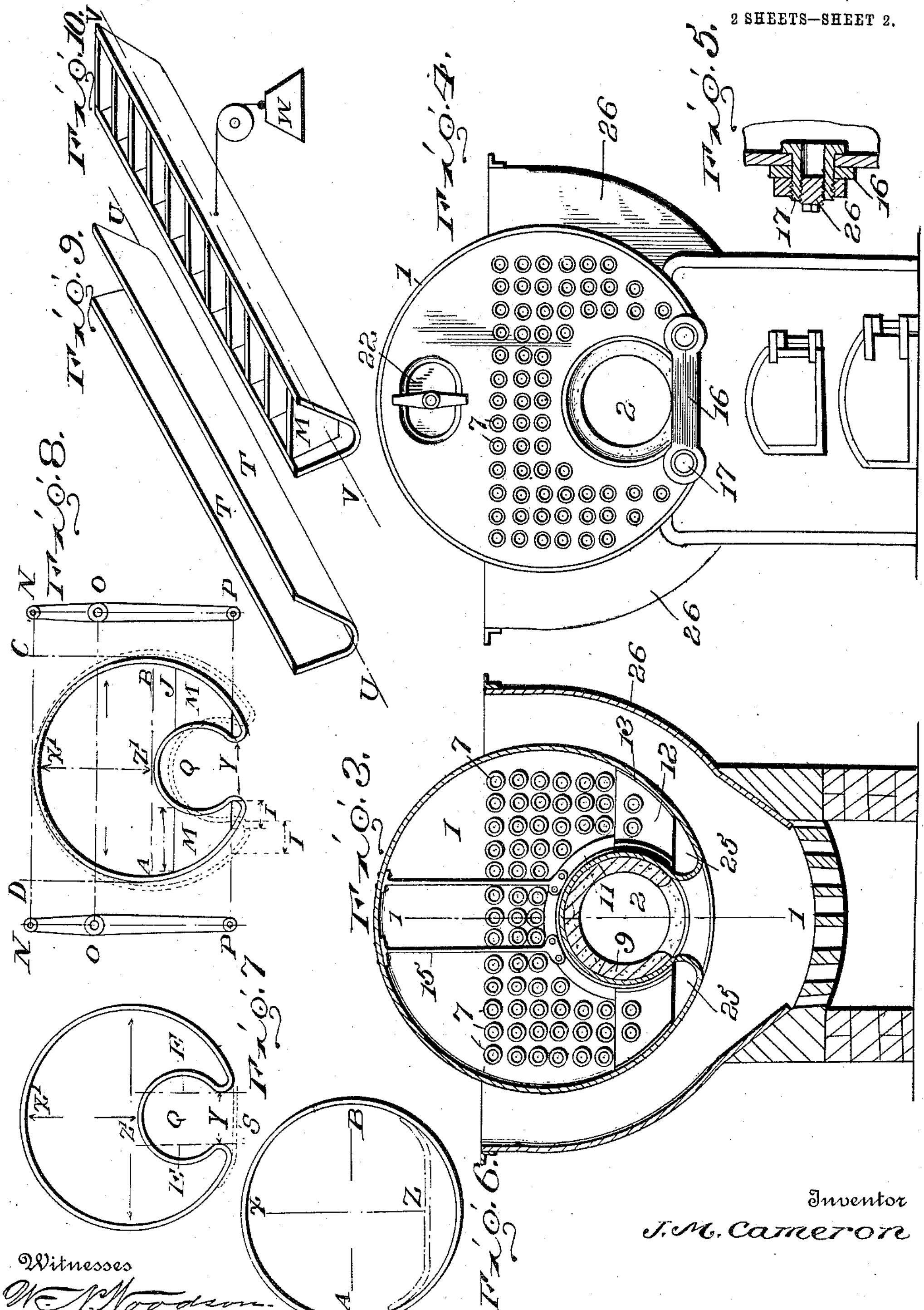
J. M. CAMERON.

STEAM BOILER.

APPLICATION FILED APR. 19, 1911.

1,018,873. Patented Feb. 27, 1912.

2 SHEETS—SHEET 2.



Inventor

J. M. Cameron

Witnesses

W. N. Woodson

Cora M. Handy

By Victor J. Evans, Attorneys

COLUMBIA PLANOGRAPH CO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

JOHN M. CAMERON, OF JOHNSON CITY, TENNESSEE.

STEAM-BOILER.

1,018,873. Specification of Letters Patent. Patented Feb. 27, 1912.

Application filed April 19, 1911. Serial No. 622,150.

To all whom it may concern:

Be it known that I, JOHN M. CAMERON, citizen of the United States, residing at Johnson City, in the county of Washington and State of Tennessee, have invented certain new and useful Improvements in Steam-Boilers, of which the following is a specification.

My invention relates to steam boilers and particularly to "fire tube" boilers of the type illustrated and described in Patent No. 914,647, granted to William J. Ellis on the 9th day of March, 1909. Boilers of this type are crescent shaped in section above the fire box, and nearly inclose a central flue, by which the products of combustion are carried back to a combustion chamber. From the combustion chamber the products of combustion are carried through the boiler by means of return tubes opening into a smoke box at the front end of the boiler from which extends an uptake. Coal is supplied to a hopper or reservoir on each side of the boiler shell and falls to the grate by gravity. The flue is formed by the reëntrantly curved bottom of the boiler.

In designing a boiler to meet present day requirements, it is necessary that strength be provided to carry with safety the pressure desired; that the boiler be proof against explosion; that the parts be so arranged that the internal surface can be examined by sight and be accessible for the removal of mud, scale and other accumulations, that repairs can be made to the tubes, rivets, braces, etc., without disturbing the setting, that the several parts of the boiler be free to expand and contract with changes of temperature without buckling the boiler shell or flue and without undue shearing strain on the rivets, and that the free and natural circulation or movement of the water within the boiler be unobstructed by braces, stay bolts, plates, etc., crossing the line of flow.

The crescent shaped type of boiler referred to above does not meet the requirements above set forth, for the reason that pressure within the boiler tends to expand the legs of the boiler or cusps of the crescent so that they spread, and the primary object of my invention is to eliminate this defect by providing a system of internal bracing which, while giving the boiler a maximum of strength, does not act to obstruct the natural movement of the water in the boiler, this internal bracing acting to reinforce the boiler against vertical stresses as well as lateral stresses, and preventing any deformation of the boiler under strain.

A further object of the invention is to so arrange and construct the tie plates, tie bars and other members acting to brace the boiler, that the legs of the boiler may be easily cleaned and the condition of the inner surface at the bottom of these legs may be easily observed.

Other objects will appear in the course of the following description.

My invention is illustrated in the accompanying drawings wherein:

Figure 1 is a longitudinal vertical section on the line 1—1 of Fig. 3. Fig. 2 is a longitudinal horizontal section on the line 2—2 of Fig. 1. Fig. 3 is a transverse vertical section on the line 3—3 of Fig. 1. Fig. 4 is an end view of the boiler and furnace. Fig. 5 is a detail sectional view of one of the bolts and nuts 17 for holding the tie bar 16 in place. Fig. 6 is a diagrammatic sectional view of a circular boiler. Fig. 7 is a diagrammatic sectional view of a crescent shaped boiler. Fig. 8 is a diagrammatic sectional view of a crescent shaped boiler showing the forces acting on the boiler and showing in dotted lines the position taken by the different elements of the boiler under pressure. Fig. 9 is a perspective view of a U-shaped element. Fig. 10 is a perspective view of a like U-shaped element strengthened by transverse tie plates.

Corresponding and like parts are referred to in the following description and indicated in all the views of the accompanying drawings by the same reference characters.

In order to illustrate the action of my internal bracing, I will refer first to the diagrams, Figs. 6 to 10. In Fig. 6 there is illustrated in full lines a cylindrical boiler shell which offers a maximum of resistance to either external or internal uniform pressure. Such a shell as this requires no bracing, but if the lower portion of the boiler be flattened or formed as shown by the dotted lines in Fig. 6, pressure within the shell will force the flat bottom Z down until the whole periphery is a true circle. This circle will have a diameter less than the original diameter of the shell and in pressing down bottom Z, the sides A and B will be forced in against the pressure, in the direction shown by the arrows. Inasmuch then as the pressure on the sides A and B acts to keep the bottom Z flat and under tension, and the pressure vertically downward acts to force the portion Z out of its flat position, it follows that a suspension brace from the point X to Z in order to support the flattened portion Z against strain would require a strength equal to the difference between the strength of the two opposing forces. Where a crescent shaped boiler is to be braced, however, an entirely different solution is required. The boiler shell at X′ might be connected to the top of flue Q at the point Z′ by a suspension brace of unlimited strength, and unless the gap Y be bridged by a tie bar S, the boiler shell will be forced to assume a form different from that shown. The internal pressure on every square inch of surface in a boiler having the shape of that shown in Fig. 7 acts to widen the gap between the two legs of the boiler and cause a change of form which is detrimental to the safety of the boiler. The flue passage Q in the bottom of the boiler in this type of boiler extends the full length of the furnace, and tie rods S can be placed only at each end of this opening. It is necessary then to provide means whereby the pressure acting to force the boiler shell out of normal correct shape shall be resisted throughout that part directly over the fire.

In Fig. 8 a boiler shell is shown having the same form as that in Fig. 7, but having tie plates M securely riveted to the boiler shell and to the flue. The horizontal force acting to widen the gap Y between the two legs of the boiler may be symbolized by the levers N, O, P. Each of the levers N, O, P is a lever of the third class with a fulcrum at N. The power at O combines with the downward pressure on a surface equal to the horizontal diameter of the boiler shell, multiplied by the length of the inverted flue, to force the boiler shell to a shape shown by the dotted lines in Fig. 8. This will be understood better with the following explanation. Assume that the curved surface of the boiler shell from the point X′ to the point E is of infinite strength against bending. Assume that the halves of the shell are hinged together as at X and that the lower part of the shell is connected to the inverted flue Q as shown forming the cusps of the crescent. Assume that the inverted flue has infinite strength against bending and that it is formed in two sections hinged together at the point Z′. Now consider the pressure within the boiler as acting as a downward force only. This pressure will act on a horizontal plane having a width equal to the diameter of the boiler, and a length equal to the length of the inverted flue, or the length of the boiler. As both the upper part of boiler shell and the upper part of the inverted flue are considered as being hinged at the points X′ and Z′, it will be clear that the pressure within the boiler over the whole area mentioned acts to widen the gap Y′ by pushing upward against the top of the boiler shell, and pushing downward against the inverted flue and the lower portion of the boiler shell. Now to prevent the inverted flue from being forced down, suspension braces are put in. These suspension braces and the boiler shell act against any downwardly acting pressure.

In considering the pressure acting horizontally, and remembering that it is assumed that the curved boiler shell and the inverted flue have infinite strength, it is clear that the internal pressure at E—E acting to force the boiler shell out is neutralized by the internal pressure acting to force the inverted flue in, so that the pressure within the cusps of the crescent-shaped shell does not tend to widen the gap Y. This, however, is not the case with the pressure above the inverted flue.

To make the action of the pressure above the inverted flue clearer, we will assume that the boiler is rectangular in form, this rectangle being bounded by the line N—N, the lines A—B and the lines C—D. Each side of the boiler will present a plane having a vertical distance X′—Z′, and a length equal to that of the inverted flue, and on the surface of this plane the pressure will act uniformly in a horizontal direction. Inasmuch as the top of the plane is securely fastened to the upper sheet of the boiler, we have the leverage as shown in Fig. 8, in which the lever N O P represents the vertical distance from X′ to the cusps of the crescent. The pressure acting horizontally against the vertical plane C—B or D—A is assumed to be concentrated on a line through the center of this plane as at O, and the force tending to widen the gap Y will be the pressure on the plane C—B for instance multipled by the distance N—O and divided by the distance N—P.

Assuming that the boiler has been allowed to take the form shown in the dotted lines in Fig. 8, a comparison of the distances I in the unexpanded boiler with the distances I in the expanded boiler will show that the lower part of the plate M has been under compressive strain, while the upper part of the plate M has been placed under tensile strain, the last being shown by a comparison of the distances I between the expanded and unexpanded boiler. The change in shape of plate M, however, is so slight in comparison with the movement of the flue and lower part of the boiler shell, that these plates in themselves have but little value in preventing the widening of gap Y by the force of pressure within the boiler. Supporting rods from X′ to Z′ will also not prevent the widening of the gap Y, as has been before explained.

Keeping in mind that the force within the boiler is acting in two directions to change the shape of the shell, namely, vertically as indicated by the arrows X′, Z′, and horizontally as indicated by the arrows on line O—O, it is evident that strength to withstand these forces might be had by stay bolts or tie rods radially placed from the flue to the boiler shell, but in a high pressure boiler the number of such rods or stays would have to be so great that little room would be left for the boiler tubes, and the tubes instead of being placed in horizontal and vertical rows, as required by good practice, in order that all parts of the boiler may be examined and cleaned would have to be placed irregularly in staggered relation, and as the stay bolts or rods would cross the line of direction of the natural flow of the water at every conceivable angle, they would greatly retard the water circulation and thus reduce the efficiency of the boiler. The simplest means for preventing the widening of gap Y between the two cusps of the crescent shaped boiler is a tie bar or its equivalent disposed at each end of the gap Y, this tie bar being indicated by the letter S in the diagram Fig. 7.

We will now assume that the boiler shell is supported by members S as well as tied together thereby, and we will assume that the pressure acting downwardly on a horizontal plane extending through the center of the boiler to be considered as concentrated at E—E. Fig. 9 is a diagram illustrating the action of the trough shaped bottom of a boiler leg. We will consider this trough shaped portion illustrated in Fig. 9 as a beam uniformly loaded throughout its length, the sides T—T being unsupported. The neutral axis of the beam is on the line U—U. The bottom of the trough being under tension and the upper part of the side plates T being under compressive strain, the plates T which are relatively thin and are relatively of great length will easily bend under strain, and the distance from the bottom, or that part of the plate which is under tensile strain, to the neutral axis being small, the strength of the member illustrated in Fig. 9 is proportionately low. In Fig. 10 I show the same trough shaped member having the sides T—T, but fitted with the tie plates M previously referred to and illustrated in Fig. 8. These tie plates being securely riveted to the sides T—T transform the relatively weak beam shown in Fig. 9 into a beam of great strength as illustrated in Fig. 10, the tie plates preventing any bending of the sides T—T when under compressive strain. The neutral axis is raised by the tie plates to line V—V, and as the strength of the element considered as a beam varies with the distance of the neutral axis from the bottom of the beam, it is clear that the tie plates M have great value as a strengthening means when the structure is considered as a beam uniformly loaded. It will be seen then that by providing the cusps of the crescent or the lower ends of the water legs with the transversely extending tie plates M as in Fig. 8, I secure great strength for the boiler when considered as a beam uniformly loaded, and that if the upper surface of the flue Q be secured to the roof of the boiler by suspension rods parallel to the line X′, Z′, these, in conjunction with the plates M and the plates forming the boiler shell and flue, will give any required strength to carry pressure acting vertically. We now come to a consideration of the force acting to widen the gap Y through the levers N, O, P. We will assume that the legs of the boiler are tied by the tie member S and will consider the boiler as rigidly supported at each end. Referring again to Fig. 10, we will assume that the element shown therein is acted upon by the weight W and that the element is now required to carry a uniformly distributed load acting in a horizontal plane as indicated by the pull of the weight W. Under these circumstances, the element may be considered as a bridge truss rigidly secured at each end. The tie plates M will now form struts and by adding diagonal braces or trusses between the tie plates, as illustrated in Fig. 2, any desired strength is secured.

A boiler of the form shown in Fig. 7 without the tie bar S and without internal bracing of any kind will sustain a low internal pressure per square inch. If the tie plates M are fitted in place in the legs of the boiler, the strength of the boiler will be increased and a higher pressure may be safely allowed. If the top of the flue Q be supported by rods attached to the roof or crown of the boiler, the strength is again increased, allowing a further increase of pressure in the boiler. By adding the tie bar S, the strength of the boiler is again greatly increased and by fitting diagonal braces between the plates M, a strength and stiffness is secured that will carry any reasonable pressure.

In Figs. 1, 2, 3 and 4, I show a boiler of the type before referred to which is internally braced in accordance with the principles before stated. The boiler 1 is crescent shaped in cross section. The space between the cusps of the crescent forming a U-shaped flue 2 open at its bottom into a furnace 3 which extends the entire length of the flue 2. At the rear of the furnace the inverted open bottomed flue 2 becomes cylindrical as at 5 and extends rearward through the boiler to a combustion chamber 6 formed upon or attached to the rear end of the boiler. The products of combustion pass from the combustion chamber 6 through return tubes 7 to a smoke box 8 located at the front end of the boiler. The inverted open bottomed flue 2, the cylindrical continuation 5 thereof and the combustion chamber 6 are each lined with fire tile 9 to protect the plates and rivets from intense heat and to assist in securing a more perfect combustion of fuel than would be possible were the hot gases allowed to come in contact with the relatively cool surface of the shell before the combustion was completed. In order to supply air for perfect combustion, I provide an air inlet 10^a in the bridge wall 10, but the particular manner whereby cold air is applied to the combustion chamber does not form any part of the present invention and therefore need not be particularly described.

In order to secure the boiler strength necessary to carry a high pressure, that portion of the boiler shell which forms the U-shaped flue 2 is strengthened against collapsing under pressure by angle irons 11. These are each arcuate in form and are closely riveted to the plate forming the bottom of the boiler and the wall of the flue 2, and extend over half of the flue circumference. Extending between the boiler shell and the angle iron stiffeners are the tie plates 12 which correspond to the plates M in Fig. 8. The ends of these tie plates are flanged as at 13 and the plates are securely riveted in a plane perpendicular to the axis of the boiler. As shown in Fig. 3, these plates 12 are located in the cusps of the crescent shaped boiler but do not extend down to the extremities of the cusps.

Securely riveted to the plates 12 are the diagonal braces 14, the outer ends of these braces being riveted to the next adjacent tie plate 12. These diagonal braces act as trusses resisting any lateral strain. Suspension rods 15 are attached at their upper ends to the boiler shell as illustrated in Fig. 3, and at their lower ends are attached to the angle iron stiffeners 11. These suspension rods 15 act to prevent the flattening of the flue sheet in a manner previously described. The boiler shell proper, that portion of the boiler shell which forms the flue sheet, the angle iron stiffeners 11, the tie plates 12 and the suspension rods 15 are intended to carry with safety any pressure desired; the whole construction being considered as a beam uniformly loaded. In order to secure strength to resist lateral pressure, the pressure acting horizontally, the diagonal braces 14 are used, and the cusps of the crescent shaped boiler are additionally prevented from expansion by means of a tie bar 16 held in place by bolts 17, the rear end of the flue 2 being securely riveted to the cylindrical flue 5 and to the boiler shell.

The boiler is provided with a steam outlet 18, safety valve outlet 19, blow-off outlet 20, clean-out plug 21 and manhole 22. The combustion chamber is provided with an opening closed by a plug 23 and the combustion chamber is formed with a clean-out opening 24. The boiler may be supported in any convenient manner over any ordinary type of furnace and I have not attempted to show any detailed construction for the furnace but show the doors thereof.

It is to be particularly noted that the tie plates 12 do not extend to the bottom of the boiler. It is at this point that the fierce heat of the furnace impinges against the boiler, and it is most important that there be no obstruction to the free passage of the water over the plate at this point. The rapid transmission of heat causes a swift flow of the water and prevents the deposit of mud, sediment or scale at these points. As the boiler is inclined toward the rear end in setting, the mud and other foreign material is carried to the rear where a blow-off connection 20 is provided. The space between the tie plates 12 permits the free vertical circulation of water.

In order that the condition of the boiler sheet may be observed particularly at the points 25, I prefer to secure the tie bar 16 to the boiler head by large removable bolts 17. Each of these bolts is tubular as illustrated in the detailed view, Fig. 5, and the tubular bolt is fitted with a plug 26 which can be removed, allowing a pipe or hose to be inserted for washing out the boiler. By holding a light in the clean-out opening 21 and looking through the tubular bolt 17, the condition of the internal surface can be seen. If necessary to clean the internal surface of the boiler sheet with scrapers, the tie bar 16 and the bolts 17 are removed and the cleaning can then be readily accomplished by the openings provided for the bolts. Inasmuch as the only portion of the boiler liable to be damaged by heat is the plate surface at 25, and as all the bracing and strengthening plates are above the points 25, it follows that while a rupture might occur at 25, an explosion due to weakening of the plates over the furnace is impossible.

While I do not wish to limit myself to any particular method or manner of heating this boiler, it may be stated that with this type of boiler the boiler is set within a U-shaped casing designated 26 in the drawing which forms a coal hopper. This casing has the same length as the fire box and delivers the coal onto the grate bars 4. The coal is coked as it passes downward through the legs of the hopper 26 and burns upon the grate bars immediately beneath the opening of the flue 2. I have not illustrated any means for feeding the coal, regulating the draft etc. as my invention does not relate to this portion of the apparatus but to the means for internally strengthening the boiler itself.

What I claim is:

1. A boiler crescent shaped in cross section and having a reëntrant bottom forming an inverted U-shaped flue, and tie plates between the reëntrant bottom and the outer shell of the boiler.

2. A boiler crescent shaped in cross section to form opposed longitudinally extending water legs and having a reëntrant bottom forming an inverted U-shaped flue, and tie plates extending perpendicularly to the axis of the boiler and disposed in the water legs, the lower edges of said tie plates being above the lower ends of the water legs, said tie plates being attached at their outer ends to the exterior shell of the boiler and at their inner ends to the bottom of the boiler forming the flue.

3. A boiler crescent shaped in cross section to form opposed longitudinally extending water legs and having a reëntrant bottom forming an inverted U-shaped flue, tie plates extending perpendicularly to the axis of the boiler and attached at one end to the reëntrant bottom and at the other end to the exterior boiler shell, and diagonal braces extending between said tie plates.

4. A boiler crescent shaped in cross section to form opposed longitudinally extending water legs, said boiler having a reëntrant bottom forming an inverted U-shaped flue, a tie bar located at one end of the boiler and connecting the extremities of the water legs, and a plurality of tie bars attached to the bottom of the boiler and extending upward and attached to the top or crown of the boiler.

5. A boiler crescent shaped in cross section to form opposed longitudinally extending water legs, said boiler having a reëntrant bottom forming an inverted U-shaped flue, tie plates disposed in the water legs and extending between the reëntrant bottom and the exterior boiler shell, tie bars depending from the crown of the boiler shell and connected to the reëntrant bottom, and a transversely extending tie bar disposed at one end of the boiler and extending between the water legs thereof for holding said water legs from spreading.

6. A boiler crescent shaped in cross section to form opposed longitudinally extending water legs and having a reëntrant bottom forming an inverted U-shaped flue, tie plates disposed in the lower portions of the water legs and extending perpendicularly to the axis of the boiler, said tie plates being attached at their opposite ends to the reëntrant bottom and to the exterior boiler shell, diagonally arranged braces attached at opposite ends to adjacent tie plates and extending between the same, a plurality of vertically disposed tie rods, each attached at its upper end to the crown of the boiler and at its lower end to the reëntrant bottom thereof, a transversely extending tie bar located at one end of the boiler and connecting the lower ends of the water legs.

7. A boiler crescent shaped in cross section to form opposed longitudinally extending water legs, said boiler having a reëntrant bottom forming an inverted U-shaped flue, a plurality of transversely extending angle irons attached to the inner face of the reëntrant bottom, a plurality of tie rods attached at their upper ends to the crown of the boiler and at their lower ends attached to the angle irons, and tie plates disposed near the ends of the legs of the boiler and extending perpendicularly to the axis of the boiler, said tie plates being connected at their inner ends to the angle irons and at their outer ends to the outer shell of the boiler.

8. A boiler crescent shaped in cross section to form opposed longitudinally extending water legs, a tie bar extending between the lower ends of the water legs, and tubular bolts passing through the tie bar and into the boiler at the lower ends of said legs, the tubular bolts being closed by removable plugs.

In testimony whereof, I affix my signature in presence of two witnesses.

JOHN M. CAMERON. [L. S.]

Witnesses:

THOS. O. COX,

A. F. HOSS.