C. A. BETTINGTON.

STEAM GENERATOR.

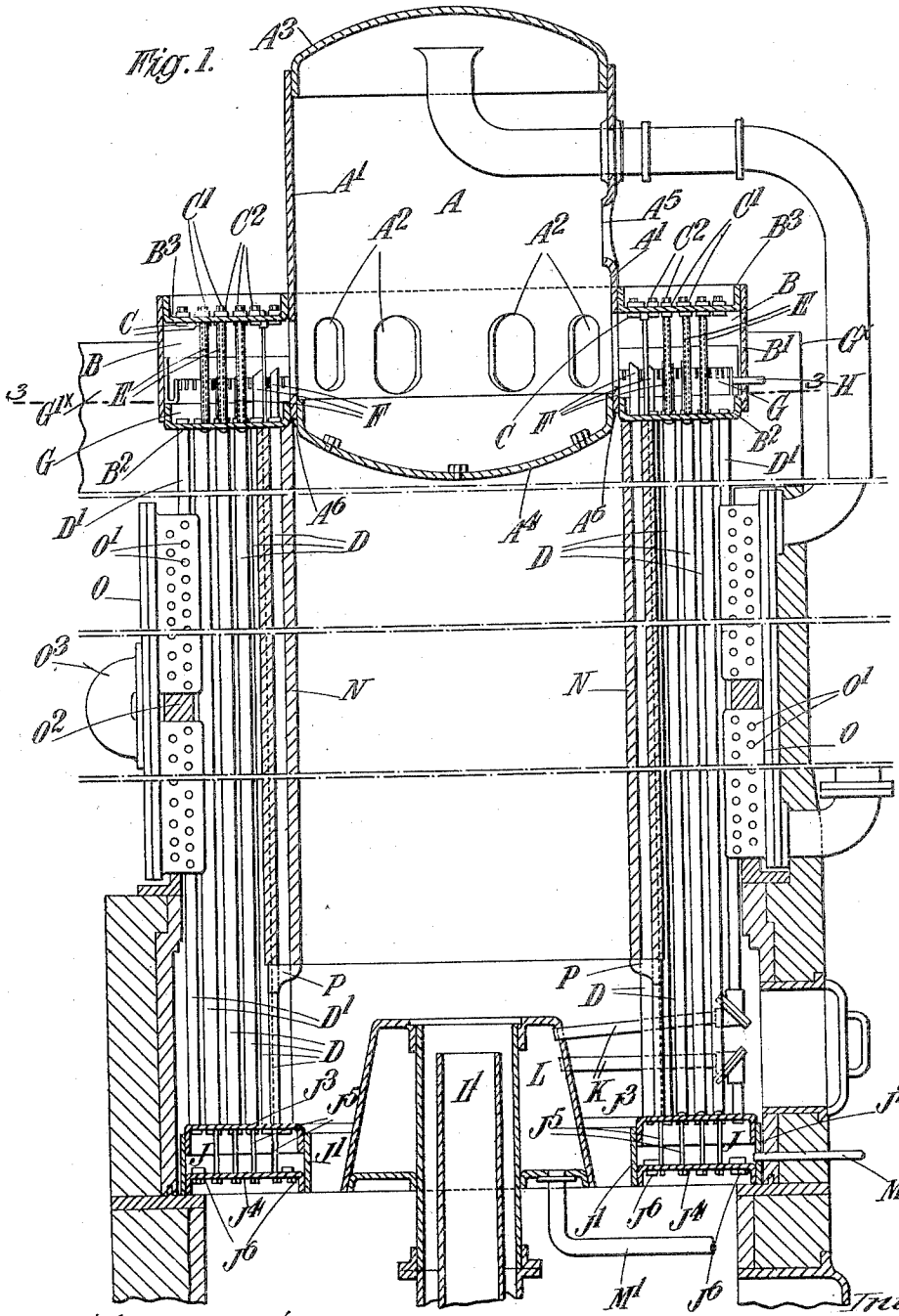
APPLICATION FILED NOV. 15, 1909.

1,068,301.

Patented July 22, 1913.

4 SHEETS—SHEET 1.

Fig. 1.



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4 SHEETS—SHEET 2.

Fig. 2.

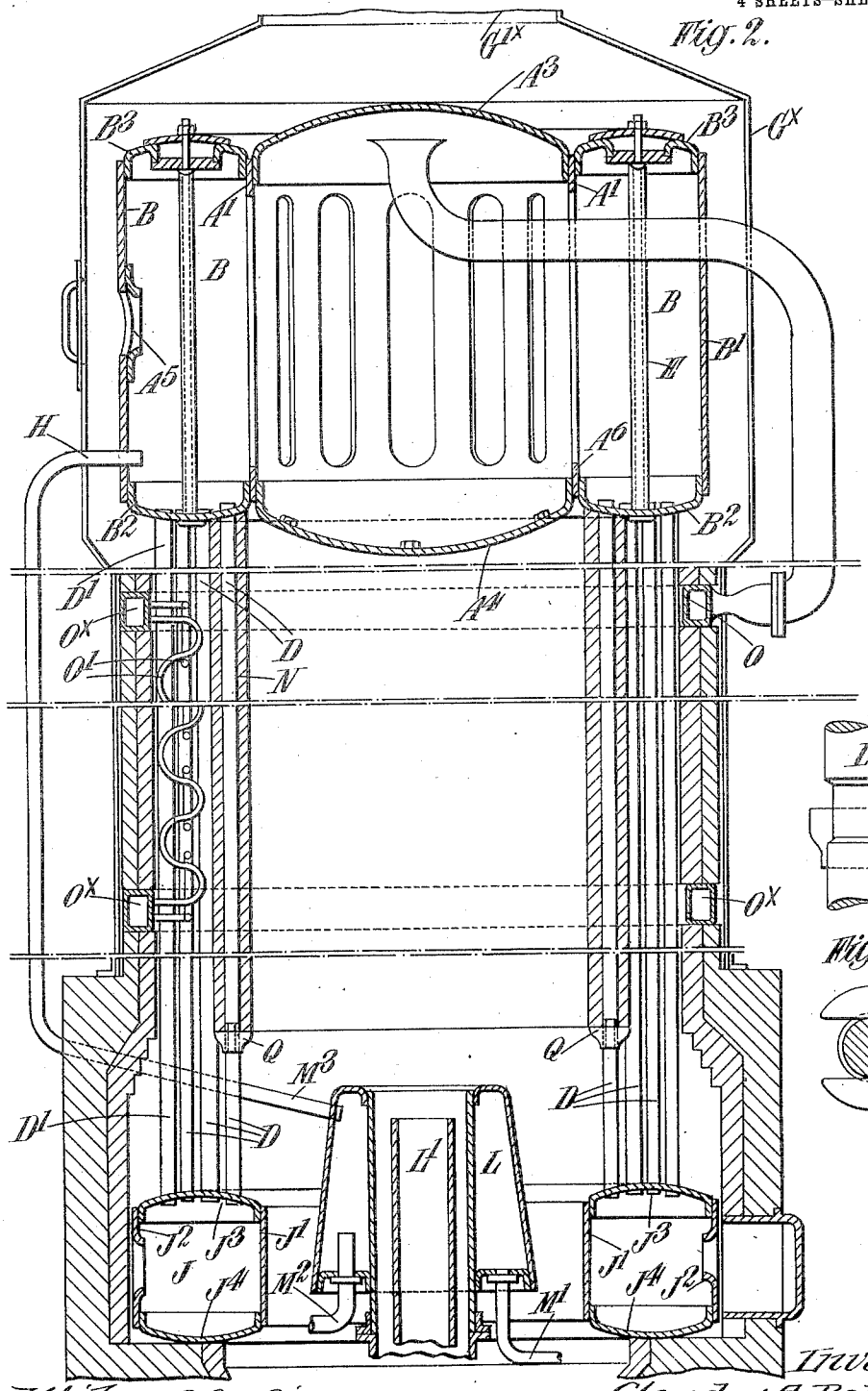


Fig. 11.

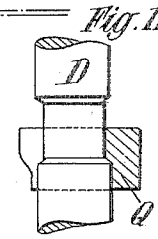
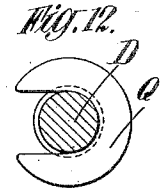


Fig. 12.



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4 SHEETS—SHEET 3.

Fig. 3.

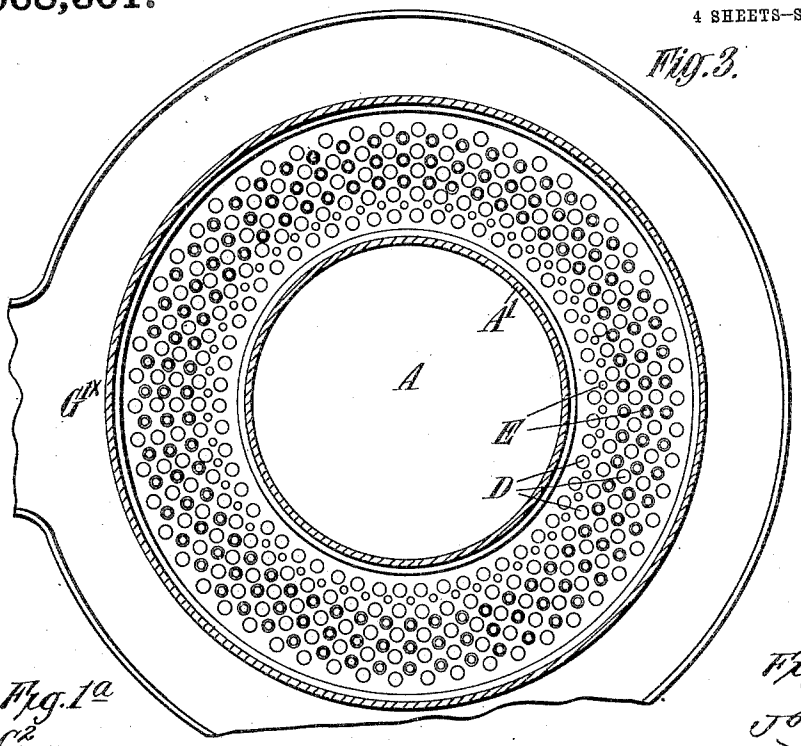


Fig. 1a

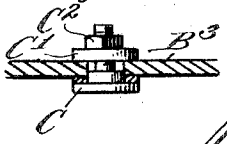


Fig. 1b

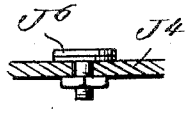
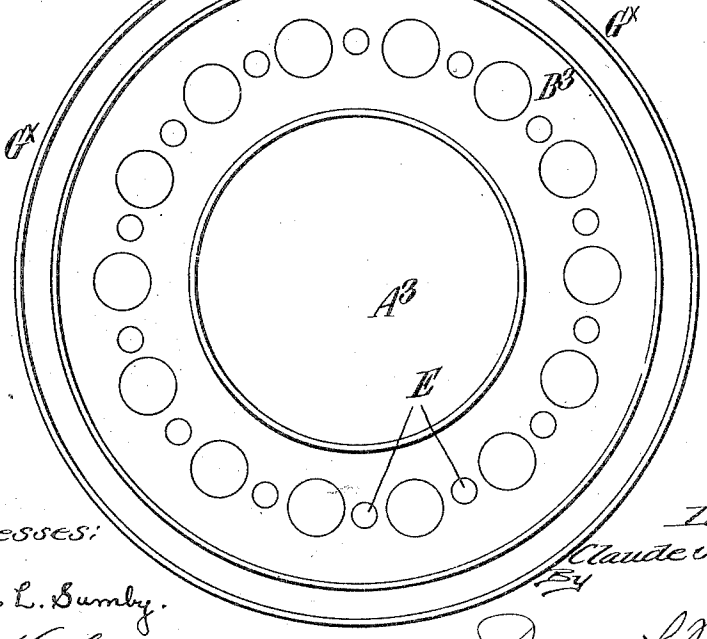


Fig. 4.



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4 SHEETS—SHEET 4.

Fig. 5.

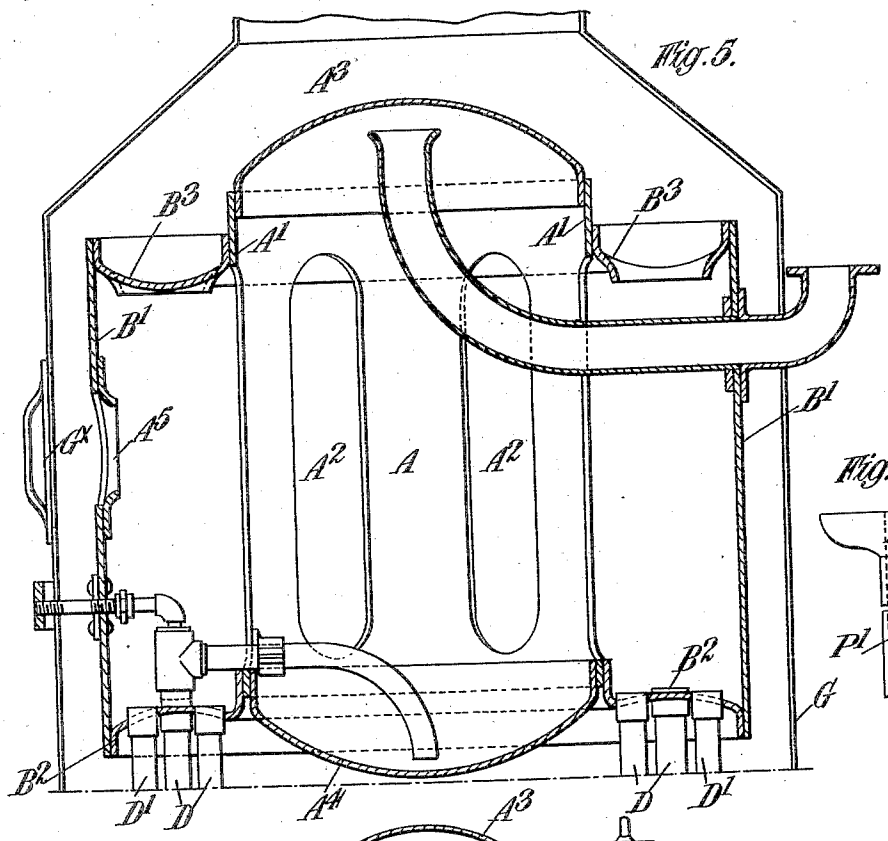


Fig. 7.

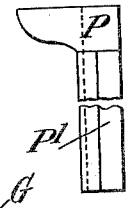


Fig. 9.

Fig. 10.

Fig. 6.

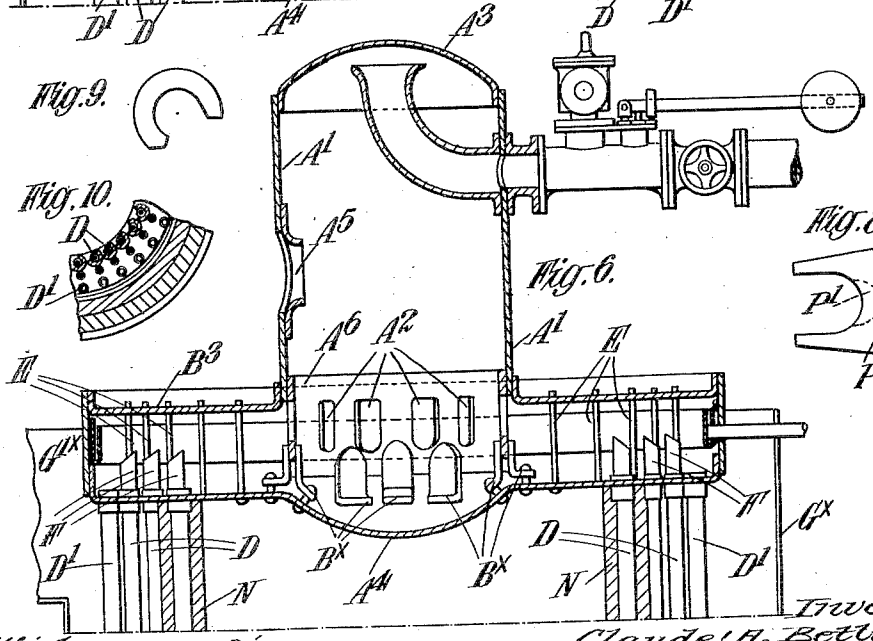
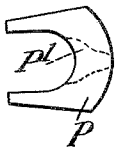


Fig. 8.



Witnesses:

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Inventor

Claude A. Bettington

By James L. Norris Atty

UNITED STATES PATENT OFFICE.

CLAUDE ALBEMARLE BETTINGTON, OF PICCADILLY, LONDON, ENGLAND.

STEAM-GENERATOR.

1,068,301. Specification of Letters Patent. Patented July 22, 1913.

Application filed November 15, 1909. Serial No. 528,151.

To all whom it may concern:

Be it known that I, CLAUDE ALBEMARLE BETTINGTON, a subject of the King of Great Britain, residing at the Junior United Service Club, 11 and 12 Charles street, St. James, and of 14 Half Moon street, Piccadilly, in the county of London, England, have invented certain new and useful Improvements Relating to Steam-Generators, of which the following is a specification.

This invention relates to steam generators and particularly to those of the kind set forth in the specification of my prior British Patent No. 19501 of 1906, in which the tubes are so arranged as to inclose, and assist in forming a combustion chamber. In steam generators of this type it has been proposed to provide a central steam and water drum surrounded by a receiver or header which receives the upper ends of the water tubes, the wall dividing the drum from the header being perforated with a number of small holes for the intercommunication of the steam and water.

The chief object of the present invention is to construct the steam and water drum and the top and bottom receivers or headers, so that they possess greater strength, simplicity and accessibility than heretofore and so that the generator can be manufactured, erected, entered, inspected, cleaned and re-tubed when necessary with greater facility. According to this invention I provide either the said drum or the header surrounding the same with a manhole or the like and construct the wall between the said receiver or header and the drum in such a manner that ready access can be had to the two chambers so that the necessary attention can be given to the whole of the inclosed parts without necessitating the dismantling of the boiler. The dividing wall serves the purpose of stays and enables the end plates of the drum and header to be of less thickness than would otherwise be necessary in order to provide sufficient strength in the absence of staying. It further allows of suitable thicknesses of plate to be used; one at least of which is subjected to a high temperature, but being of ideal form and unweakened, can be made sufficiently strong to resist the pressure while at the same time thin enough to be always efficiently cooled by its contained water—the other, especially where weakened by the necessary tube holes is outside the high temperature zone—can be made of almost any desired thickness to compensate for metal cut away. The seams where necessary are protected and efficiently cooled. The said receiver or header and the drum are preferably composed of end plates and side plates, the side plate of the drum being formed with large apertures and serving as the inner wall of the header. The lower end plates of the drum and header are connected with the plate dividing the said drum from the header, in such a manner as to form a recess which constitutes a dead space so that the joint is not appreciably swept by the hot gases and thus endangered. The header may be provided with an annular trough which may be termed a launder into which the feed water is introduced for the purpose of causing the water to flow in the direction of the down-take or downcomer tubes, and the up-take tubes are provided with prolongations or the like and the down-take tubes are unprovided with said prolongations whereby the contents are discharged into the header approximately at the surface of the contained water, thus as well as reducing the agitation of said water and any tendency to priming which might otherwise occur, causes the water to circulate in a definite path. The outer receiver may be provided with suitable doors through which the tubes may be withdrawn and replaced.

In order that the said invention may be clearly understood and readily carried into effect, I will describe the same more fully with reference to the accompanying drawings, in which:—

Figure 1 is a sectional elevation of a generator showing one constructional form of my improvements. Fig. 1^a and Fig. 1^b are, respectively, enlarged views showing the doors in the upper and lower end plates to permit the insertion, expanding, cleaning or renewing of the tubes. Fig. 2 is a sectional elevation showing a modified constructional form. Fig. 3 is a horizontal sectional view on the line 3—3, Fig. 1. Fig. 4 is a plan of Fig. 2. Figs. 5 and 6 are sectional elevations of modified constructions of headers. Figs. 7 and 8 represent respectively a side elevation and a plan of a detail, and Figs. 9 to 12 are views of other details.

In these figures A is the steam and water drum, B is the concentric receiver or header divided from the said drum by the wall A′ which is provided with large apertures A^2. The drum is provided with dished end

pieces A^3, A^4 riveted or otherwise suitably attached to the said wall A'. The receiver or header B is composed of an outer wall B' and annular end pieces B^2, B^3.

A^5 is a manhole giving access in the example shown in Figs. 1 and 6 to the interior of the drum A, from which access to the receiver or header B is obtained through the aforesaid apertures A^2.

The wall A' is continued by means of the portions A^6 to the lower dished ends A^4 and B^2, thus forming powerful tension stays, capable of supporting the whole pressure on the end A^4 and that of B^2 not taken by the rod stays and outer wall B', the chamber A in effect being nothing more than a cylindrical drum with ends suitably dished and only of sufficient thickness to resist the internal pressure associated with the relatively small diameter drum A while the necessary full diameter of steam and water drum or header is secured as above described. It is obvious that if some such method were not adopted it would be necessary to make the dished ends A^4 and A^3 of such thickness in order to sustain the pressure resulting on the overall diameter especially as the ends are weakened by the holes cut for the tubes D, as to render such constructions impracticable in conjunction with the high temperature to which it is necessarily subjected; on the other hand the tube plate B^2 is relieved of all tensile strain due to the center portion, across its tube holes, and could if further strength was necessary be made of thicker plate, as it does not cover the high temperature zone.

The outer plate B' it will be observed is subjected to the greatest bursting pressure, but not being subjected to any temperature of consequence and further being strengthened by the turned up sides of the end plates B^2 and B^3, it does not introduce any difficulty.

Rod stays E (Figs. 1 and 6) screwed or otherwise fixed into the end plates B^2 and B^3, and which may be hollow, take the pressure on the flat surfaces B^3 and B^4, thus obviating the necessity of curving these surfaces to withstand the tension due to the pressure, and thereby reducing its thickness and simplifying the problem of tube holes and doors.

In order to determine with greater certainty the circulation of the water and free escape of the steam generated in the tubes, continuations F to the tubes D are provided in a similar manner to that heretofore proposed as shown in Figs. 1 and 6. In the present case however only the uptake tubes D are provided with continuations, while the downtake tubes D' are unprovided with them. These continuations, which may consist of the tubes themselves projected through the lower plate B^2 or preferably short lengths of lighter tubing or rolled plates, with more or less open longitudinal seams, provide channels through the body of water in the receiver B, through which the rapidly rising columns of water containing bubbles of steam are carried to the working water level where they more readily separate as desired without appreciably disturbing the said body of water in B which is itself thus continuously augmented while flowing radially to the outer row or rows D' of tubes, which it will be observed are the farthest from the source of heat and are as aforesaid not provided with projecting channels F. Therefore by a well known process of circulation these outer rows of tubes D' receiving the least heat tend to become "downcomers," being further encouraged to do so as hereinafter explained, by the introduction of colder feed water. By this arrangement the liberation of steam is facilitated and a definite path for the circulation of the water is provided.

A circular launder G is arranged just inside the outer wall plate B' and being of comparatively light construction and a loose fit, it may be merely allowed to rest on the outer upturned edge of the plate B^2. The inner side of the said launder may be lower than its outer side, and is preferably provided with slots or apertures around its top edge. This launder receives the colder feed water at one or more points by means of a pipe or pipes H and distributes it through the slots referred to or on overflowing over the edge of the launder to the outer row of tubes, where it mingles with the heated water and passes down to the bottom header J with the water in circulation, whereby the general circulation through the boiler is encouraged and certain impurities deposited in the lower header or mud-drum before evaporation takes place. As one object of the launder is to dissipate any sudden change of temperature of the feed water it is preferable to leave it loose and free to expand or contract or only lightly attached to plate B', which latter is then protected from any great variation of temperature of the feed water by the layer of hot water or steam between itself and the high side of the launder. As this launder is not essential to the operation of the boiler, it may be omitted, especially in cases where hot feed water is to be used.

The stays E—E Figs. 1 and 6 may be made hollow in order to allow of the introduction of cleaning rods or chains to operate brushes scrapers or the like if desired, or a steam jet may be passed through them; all of which methods can be employed to externally clean the tubes if necessary; when not in use the said hollow stays may be temporarily closed with loose plugs or

caps. Also in making the stays hollow I introduce the well known expedient of immediately detecting faulty stays, thereby conducing to further safety.

In order to provide means for inserting, expanding, cleaning or renewing tubes, I provide opposite the tube ends in the end plate B^3, (Fig. 1) a door C of the well known type having a projecting stud and preferably circular in plan and provided with a recess around the edge to take a jointing ring of any suitable material. The said doors are easily passed through the apertures A^2 and placed in position with the stud projecting externally while the cap or dog C′ is adjusted over the stud and secured in position by the nut C^2. The advantages of this arrangement over numerous well known alternatives of providing holes and cleaning doors opposite tube ends, lies firstly in the fact that all the door holes can conveniently be made circular instead of square or elliptical and secondly the fact that the seating of the door is inside, where the addition of pressure tends to tighten the joint. Further it is possible to clean and inspect without the use of special tools or a mirror, the faces on the underside of the plate B^3. Obviously this form of door, which is circular and larger than the aperture it covers is impossible to blow off, but becomes tighter under pressure, and it is therefore quite safe to remove the nut and the cap or dog C′ with the boiler working under full pressure. This fact has an important advantage especially for marine work as by making dog C′ in this form of a cap, preferably with machined faces and resting on a machined seating on the end plate B^3, it is possible in most cases, in the unusual event of the joint between the door C and lower face of the plate B^3 leaking or blowing out, to stop the leak by removing the cap or dog C′ and dropping a disk of suitable jointing material with a hole in the center, over the projecting stud of the said door. On replacing the cap or dog C′ and the nut C^2 an external joint is formed to check the leak on the defective internal joint. The screwed stays E may have their upper ends plain or are formed with square ends in order to allow the use of a wrench or spanner for screwing them home to the end of the thread, thus forming a tight finish, without the necessity of riveting the top ends over, at the same time providing more space for the caps C′, while the lower ends of the said stays, which are subjected to some heat, may without objection be conveniently riveted over; in the case of hollow stays they may be secured by the ends being merely expanded in. The method of joining the end plate A^4 of the drum A and the end plate B^2 of the header B with the portion A^6 of the side plate A′ interposed provides a protected expansion joint between A^4 and B^2. The end plate A^4 being exposed to a very fierce temperature is liable to rapid change, and is therefore preferably kept thin in order to facilitate conduction. The end plate B^2 not being subject to this high temperature can consequently be made as thick as may be desirable to compensate for the material cut away for the tubes. The recess formed by the said joint forms a dead space so that the joint is not appreciably swept by the hot gases and thus endangered. The lower part A^6 of the plate A′ may be made thicker than the upper part of said plate in order to reduce the weight and at the same time compensate for the portions cut away to form the apertures, A^2.

The bottom header J is composed of an inner and outer circumferential plate, J′ and J^2 respectively which together with the top and bottom plates J^3 and J^4 form a closed hollow ring header, the flat ends J^3 and J^4 being further stiffened in the example shown in Figs. 1 and 6 by the rod stays J^5, which may be conveniently made and fitted the same as the stays E before referred to, some or all of which may be made hollow if necessary for the purposes already described. The top plate J^3 is drilled to receive the ends of the tubes D, D′ as shown, while the lower plate is in the example shown in Fig. 1 provided with holes through which the end of the mandrel of a tube expander may be inserted and operated. As it is unnecessary to make the majority of these latter holes larger than is merely required for the said mandrel, it is preferred to make circular holes of considerably smaller diameter than the outside of the tubes, whereby a gain in strength and efficiency is obtained. A method of closing these mandrel holes is used similar to but somewhat simpler than that employed in the top header B hereinbefore described. The doors J^6 have stems which project outwardly through the said holes and owing to the small diameter of the holes the nut can be conveniently made to perform the purpose of the cap or dog in the above mentioned device, while it is still possible to remedy a leak while under pressure by removing the nut and placing on the stem of the door J^6 a suitable washer. In order to place the tube expander, and subsequently the doors J^6 in position it is necessary to provide occasional hand holes. These are preferably made elliptical in form and sufficiently large to allow of the introduction of an expander and a man's arm. These hand holes are closed by elliptical doors and caps or dogs, which doors owing to their elliptical shape can be inserted from the outside. The header J is provided with a suitable blow off pipe M. While the header J is shown in the examples illustrated made up

of separate plates J′, J², J³ and J⁴, the said header can in certain cases be conveniently formed by dishing the plate J³, to form sides sufficiently deep to take the place of the plates J′, J².

In Fig. 1 one of the tubes in the outer row of tubes D′ has a portion removed, the exposed ends being connected by the pipes K through the flanged elbow joints K′ and K² with a water jacketed fuel pipe L in such a manner that water will automatically circulate from the lower header J through the lower pipe K into the jacket and out again together with any steam which may have formed, through the upper of the pipes K to the top header B, and thus protects the fuel pipe against burning. This particular tube would be an "upcomer" and so be provided with projecting channel the same as the inner rows. A blow-off pipe M′ is provided at the lower part of the water jacket. L′ is an inner concentric fuel pipe of a cross sectional area preferably equal to one half the area of annular space formed between the pipes L and L′. The capacity of the inner pipe L′ will thus be one-third of the total capacity when both pipes are in operation, and that of the pipe L′ will be two-thirds of the total capacity. N is a filling of refractory material which may be plastered in position while moist between the tubes D of the innermost row which together with said refractory material form the wall of the combustion chamber. The weight of these columns or lining of fire bricks or refractory material is carried on the brackets P, which are fitted behind the inner tubes, the leg P′ resting on the plate J³. By placing these leg brackets in close contact with the tubes and in such a manner that the said tubes tend to prevent the hottest gases from impinging directly on them, they remain relatively unharmed in an otherwise destructively hot atmosphere, while this arrangement further does not materially interfere with the passage of the same gases through the boiler. The upper ends of the said leg brackets are formed in the shape of a horse shoe (Figs. 7 and 8) and closely envelop the water tubes. Instead of using the supporting bracket P, I may form a support for a bracket Q (Fig. 2) upon which the lining of fire brick is supported.

As shown in Figs. 11 and 12, the tubes, are constricted at one point and the bracket Q is so formed that it fits over this constriction and falls into the position shown where it is retained in place.

A superheater may be arranged around the outer row of tubes. In the arrangement shown in Fig. 1, the header O is vertical and the tubes O′ are horizontal, while in the example shown in Fig. 2 the headers O and O× are horizontal and the tubes O′ arranged substantially vertical. In the former arrangement the header is divided into two chambers which are connected one with the other by means of a pipe O³, thus insuring an equal circulation of the steam through the tubes. Around the top portions of the tubes and the header is arranged a casing G× which forms a smoke box terminating in a flue or stack G′×.

In order to obviate the necessity of using stays in the headers as in Fig. 1 and to provide greater accessibility to the same, the header may be constructed as shown in Figs. 2 and 5 in which the header B is of the same height as the steam drum A, the slots in this case being considerably longer than in the example shown in Figs. 1 and 6. Further by reason of the increased height, the launder and the extensions of the tubes may be omitted, though obviously, if desired, these may be employed. A number of hollow stays E are provided though these are more for the purpose of providing access to the outer portions of the tubes for cleaning purposes, and may obviously be omitted. Through these hollow stays, chain cleaners or the like may be introduced. The upper end plate B³ may be dished as in the example shown in Fig. 2, or approximately flat as in Fig. 5. The said end plate is provided with holes over which suitable doors fit, the said holes being for the purpose of pasing tubes therethrough when desired. The lower header may be similarly constructed with dished ends J³, J⁴ and stays are therefore unnecessary.

The jacketed pipe L may as shown in Fig. 2 be supplied with the feed water by the pipe M², the water passing out at the top of said jacket through the pipe M³ to the inlet pipe H of the header B.

In the modification illustrated in Fig. 6, the lower portion of the drum A forming the dividing wall between the said drum and the header B is made in a separate plate A⁶, and the end plate A⁴ is in one piece covering the drum A and the header B, the said plate A⁴ being supported by means of stringers B× suitably attached to the said plate A⁶. This plate is provided with holes A² to give acess to the header B as in the previous constructions.

The fire bricks surrounding the inner row of tubes are preferably constructed as shown in plan at Fig. 9, this construction being such that when in position as shown in Fig. 10, they are locked in position. As the last brick cannot be placed in position its place has to be taken by mortar or the like which is inserted. The said bricks are so arranged that sufficient of the usual liquid slag formed during the working of the boiler is retained and chilled during working to automatically seal up any cracks or crevices between the tubes and the said bricks.

What I claim and desire to secure by Letters Patent of the United States is:—

1. In a water tube steam generator, the combination with the combustion chamber, independent top and bottom plates of the steam and water drum, independent top and bottom plates of the header surrounding the drum, water tubes in the form of a ring surrounding the combustion chamber and communicating with said header, of a wall forming the outer sides of the drum and the inner sides of the header, the said walls being formed with apertures so that ready access can be had to the drum and header, and an annular trough in said header.

2. In a water tube steam generator, the combination with the combustion chamber, independent top and bottom plates of the steam and water drum, independent top and bottom plates of the header surrounding the drum, water tubes in the form of a ring surrounding the combustion chamber and communicating with said header, of a wall forming the outer sides of the drum and the inner sides of the header, the said walls being formed with apertures so that ready access can be had to the drum and header, and an annular trough in said header, and prolongations on the innermost of the aforesaid tubes.

3. In a water tube steam generator, the combination with the combustion chamber, independent top and bottom plates of the steam and water drum, independent top and bottom plates of the header surrounding the drum, water tubes in the form of a ring surrounding the combustion chamber and communicating with said header, of a wall forming the outer sides of the drum and the inner sides of the header, the said walls being formed with apertures so that ready access can be had to the drum and header, fire bricks covering the inner row of said tubes, and means for supporting said fire bricks.

4. In a water tube steam generator, the combination with the combustion chamber, independent top and bottom plates of the steam and water drum, independent top and bottom plates of the header surrounding the drum, water tubes in the form of a ring surrounding the combustion chamber and communicating with said header, of a wall forming the outer sides of the drum and the inner sides of the header, the said walls being formed with apertures so that ready access can be had to the drum and header, fire brick covering the inner row of said tubes, and brackets for supporting said fire brick.

5. In a water tube steam generator, the combination with the steam and water drum, the header surrounding the same and the water tubes in the form of a ring surrounding the furnace and communicating with said header, of a dividing wall between the said drum and header, said wall being provided with means whereby ready access can be had to the two chambers, fire brick covering the inner row of said tubes, brackets for supporting said fire brick, and top parts of said brackets that partly encircle the tubes.

6. In a water tube steam generator, the combination with the steam and water drum, the header surrounding the same and the water tubes in the form of a ring surrounding the furnace and communicating with said header, of a dividing wall between the said drum and header, said wall being provided with means whereby ready access can be had to the two chambers, a number of fire bricks covering the inner row of tubes, said bricks being so formed as to be locked when in position.

7. In a water tube steam generator, the combination with the steam and water drum, the header surrounding the same and the water tubes in the form of a ring surrounding the furnace and communicating with said header, of a dividing wall between the said drum and header, said wall being provided with means whereby ready access can be had to the two chambers, a number of fire bricks covering the inner row of tubes, and refractory material plastered in position to take the place of the last of the series of fire bricks.

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

CLAUDE ALBEMARLE BETTINGTON.

Witnesses:

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THOS. F. HARGREAVES.