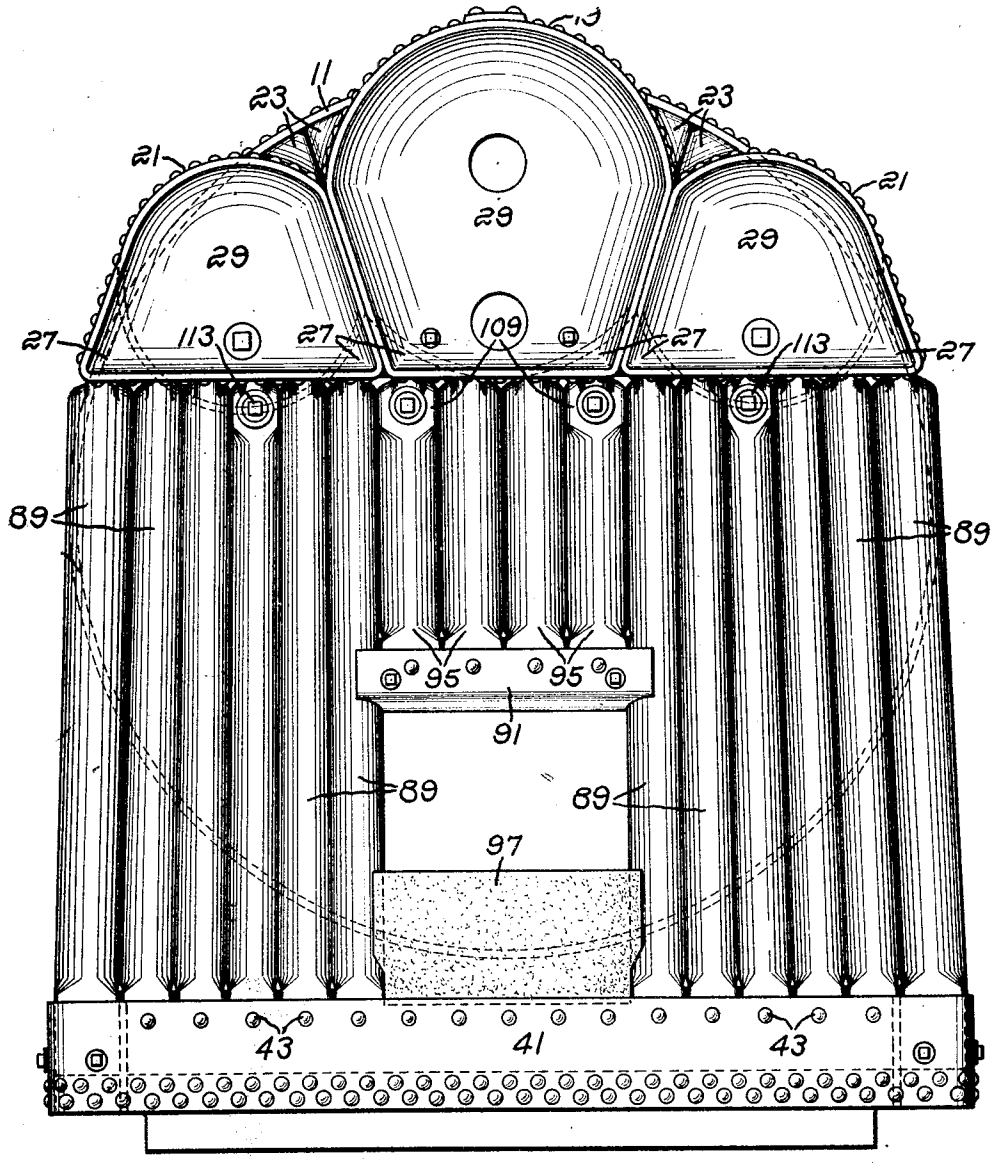
April 9, 1929. J. M. McCLELLON 1,708,229

BOILER

Filed Feb. 19, 1919 4 Sheets-Sheet 1

Fig. 1.



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Filed Feb. 19, 1919 4 Sheets-Sheet 2

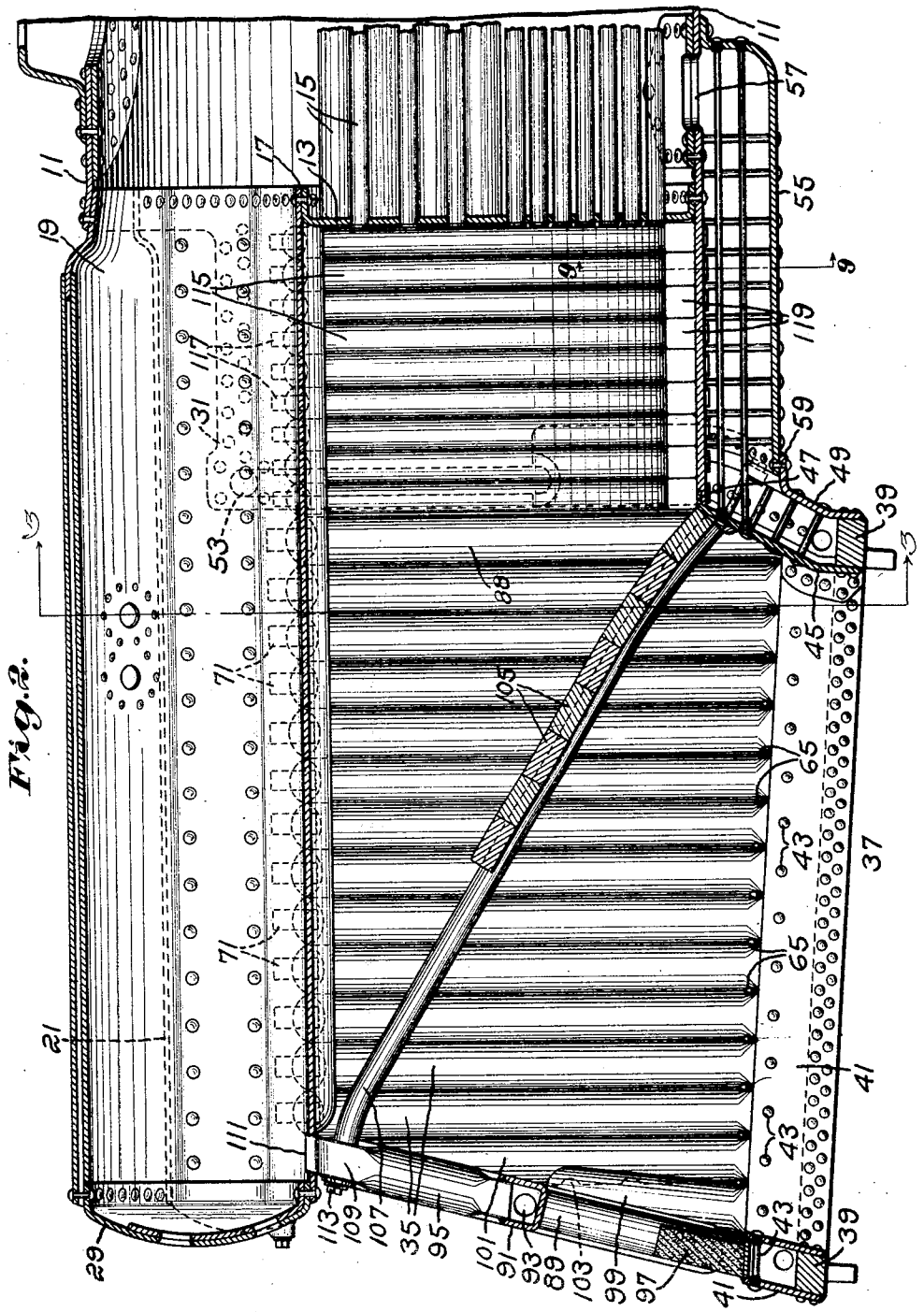

Fig. 2.

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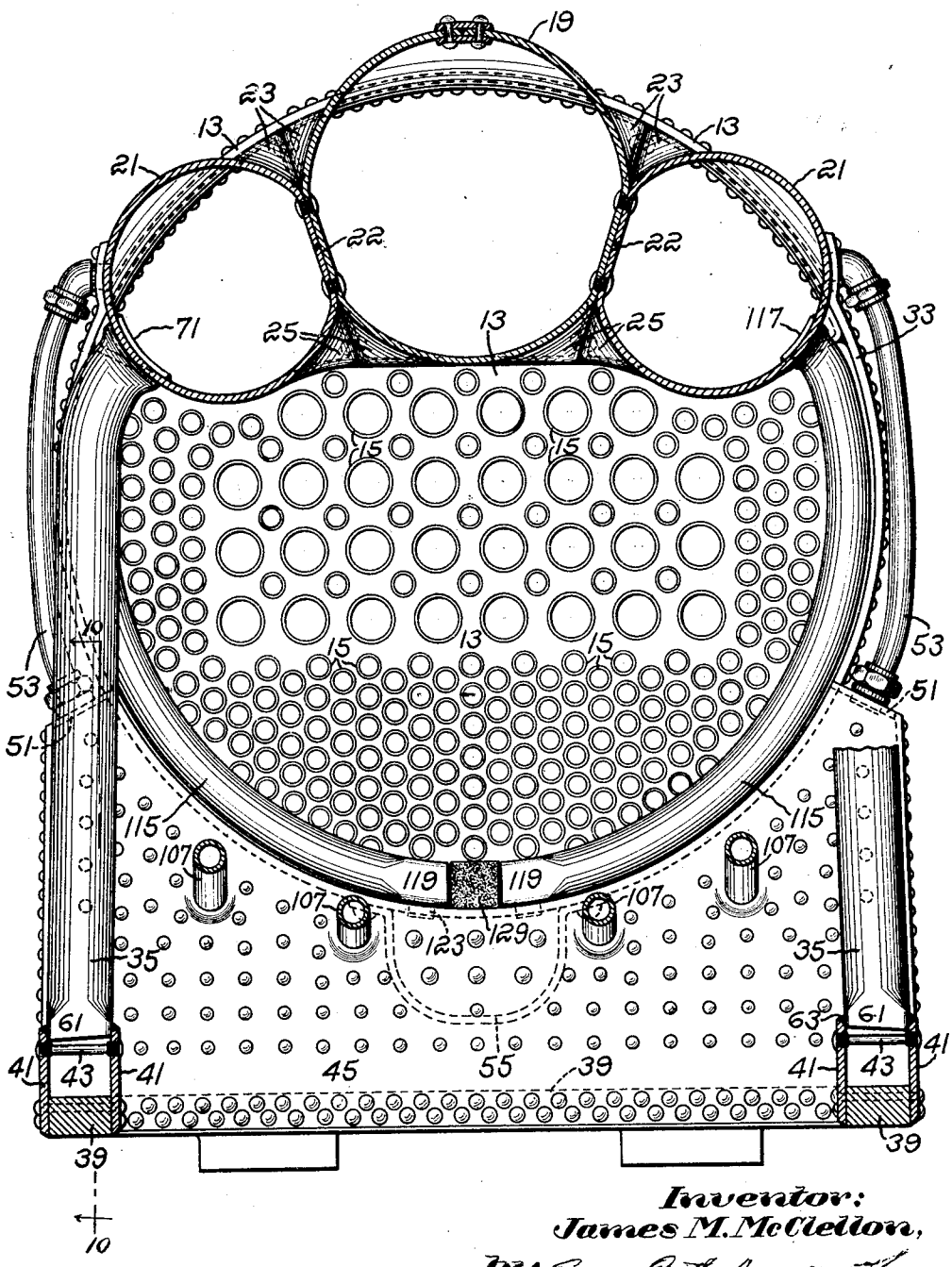
Fig. 3.



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BOILER

Filed Feb. 19, 1919 4 Sheets-Sheet 4

Fig. 4.

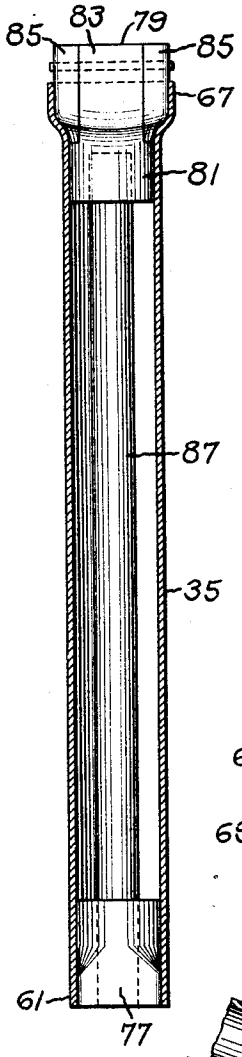


Fig. 7.

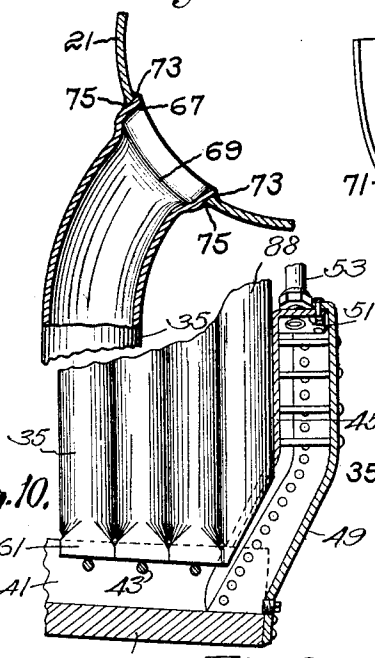


Fig. 8.

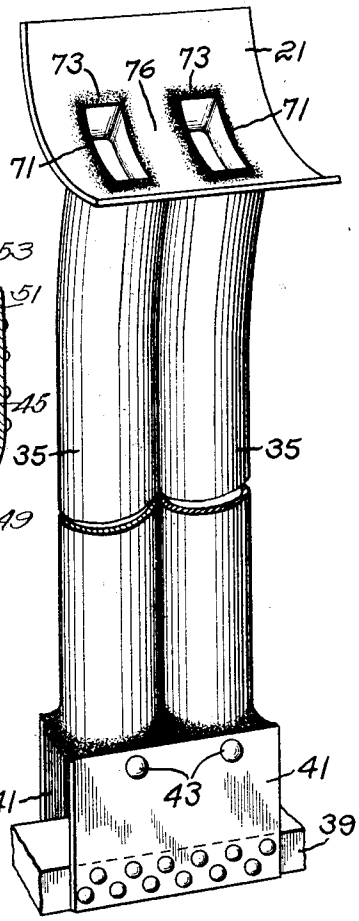


Fig. 10.

Fig. 5.

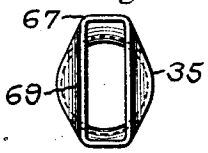


Fig. 6.

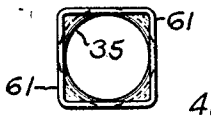
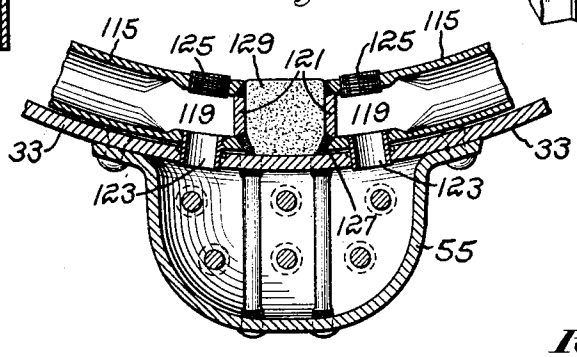


Fig. 9.



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Patented Apr. 9, 1929. 1,708,229

UNITED STATES PATENT OFFICE.

JAMES M. McCLELLON, OF EVERETT, MASSACHUSETTS; HAROLD B. McCLELLON ADMINISTRATOR OF SAID JAMES M. McCLELLON, DECEASED.

BOILER.

Application filed February 19, 1919. Serial No. 277,968.

This invention relates to steam generators and in its more specific aspect to steam generators or boilers for use on locomotives. I herein show as an example of my invention a locomotive boiler embodying in its construction a barrel, fire box and combustion chamber, and for convenience in describing my invention I shall refer specifically to locomotive boilers. This application constitutes a continuation in part of my earlier copending applications Serial No. 2,565, filed Jan. 6, 1915, Serial No. 101,610, filed June 3, 1916, Serial No. 122,754, filed Sept. 28, 1916, Serial No. 134,897, filed Dec. 4, 1916, and Serial No. 175,088, filed June 16, 1917, and generic claims covering the subject matter of invention disclosed in said applications and also exemplified by the particular structure here described are herein presented.

My invention will best be understood by reference to the following description of the illustrative embodiment thereof taken in connection with the accompanying drawings wherein:—

Figure 1 is a rear end elevation of the fire box;

Fig. 2 is a central longitudinal section showing portions of the fire box, combustion chamber and barrel;

Fig. 3 is a section, on an enlarged scale, on line 3—3 of Fig. 2;

Fig. 4 is a vertical diametrical section through a fire box tube illustrating the manner of shaping it;

Figs. 5 and 6 are end views of the top and bottom of such tube;

Fig. 7 is a detail, partly in section, showing a fire box tube and a portion of the crown to which it is connected;

Fig. 8 is a perspective detail of a pair of fire box tubes and fragments of the foundation chamber and crown;

Fig. 9 is a section on an enlarged scale on line 9—9 of Fig. 2; and

Fig. 10 is a longitudinal section through the throat chamber and part of the foundation chamber substantially on the plane of the line 10—10 of Fig. 3.

Referring in detail to the illustrative embodiment of my invention shown in the accompanying drawings by way of example, the general construction may perhaps be most clearly understood from Fig. 2 wherein I show a barrel 11 which, with exceptions which will be readily understood as the description proceeds, may be of the type customary in locomotive boilers. Within this barrel and closing the lower portion thereof is a flue sheet 13 which in the present case is spaced inwardly from the rear end of the barrel for some distance to provide a combustion chamber, as hereinafter described. Flues 15 open through the flue sheet and extend forwardly through the barrel in well known manner.

The upper edge of the flue sheet 13 may be provided with a flange 17 adapted to fit the lower portion of a suitable crown chamber forming a part of the fire box and to be riveted thereto, as shown. While the crown chamber may take various forms, I prefer to construct it, as shown in Fig. 3, of a number of substantially cylindrical drums of inherent pressure-resisting form; and I have herein shown a central drum 19 and smaller lateral drums 21. The sides of the several drums may be somewhat flattened, as at 22, and secured together, the central drum 19 fitting between the others in the manner of a keystone.

The forward ends of the drums are open and are received by the opposed open end of the barrel, and I prefer to have these drums fit the same and completely close the upper segment of the barrel above the flue sheet 13 which itself is disposed wholly below the crown. To facilitate this, the end portions of the drums may be somewhat distorted from true cylindrical form, providing extruded portions 23, Figs. 1 and 3, having flat sides so that the ends of the drums fit together block-like to form, collectively, a segmental structure adapted to fit the open end of the barrel 13 and which may be riveted thereto. Preferably also, the drums are provided with similar extruded portions 25 (Fig. 3) at the lower portions of the forward ends, providing a substantially straight-edged marginal portion against which the flange 17 of the flue sheet may fit. In other words, in the preferred construction shown, the main body of the crown is formed of substantially cylindrical and therefore inherently pressure-resisting parts, as shown in Fig. 3. It

will be understood, of course, that the pressures on the flattened portions 22 are balanced. The forward end of the assembly, however, is in form a segment of the circle formed by the end of the barrel.

The rear ends of the drums, as best shown in Fig. 1, may also be provided with similar extruded portions 27 at the bottom side thereof, providing a substantially straight-edged portion to which the tubes forming the rear wall of the fire box may be connected. The rear ends of the drums may be closed by suitable heads 29 conveniently dished, as shown in Fig. 2, to resist pressure.

Herein the upper portion of the barrel is cut away, as indicated at 31 in Fig. 2, to receive the crown drums and this forms a segmental extension 33 of the barrel shell extending along the sides of the drums which may be riveted thereto. The barrel and the fire box, including the crown, are thus joined in a sort of splice joint considerably increasing the strength and rigidity of the boiler as a whole and also providing a space within the end of the barrel and rearward of the tube sheet, bounded by the segmental extension 33 of the barrel and the forward portion of the crown, providing for a combustion chamber hereinafter to be described.

The walls of the fire box are formed of comparatively thin-walled, water-receiving tubes of inherent pressure-resisting form. In other words, the tubes are, at least throughout the major portion of their length, cylindrical, thus offering a large heating surface to the fire while providing a structure of great strength as regards internal pressure. The various details of construction which I shall hereinafter describe are designed to permit tubes to be used in the most advantageous manner to provide unbroken, smooth-surfaced, water-containing walls for the fire box, not subject to burning out and corrosion and formed to facilitate a regular circulation of water in one direction from the barrel through the tubes to the crown chamber.

I shall first describe the construction of the side walls of the fire box proper, after which the construction of the rear wall and of the water-containing wall of the combustion chamber, as herein shown, will be more readily understood.

The side walls of the combustion chamber as stated, comprise (see Fig. 2) a number of thin-walled tubes 35 having cylindrical body portions set substantially in contact side by side and extending substantially vertically between the crown drums 21 and a bottom chamber 37 which supplies water to the tubes.

I have herein disclosed a bottom chamber 37 as formed of a cast steel mud ring 39 to which are secured plates 41 forming an open-topped, channel-shaped chamber in which may be braced at the open side by stays 43. Conveniently the mud ring 39 may be made of a greater width than is customary in standard boilers built of sheets, so that the bottom chamber 37 may be of generous size to supply plenty of water to the lower ends of the tubes 35.

To carry water from the barrel to the bottom chamber 37, the latter opens into a throat chamber the bottom of which may be formed by the forward transverse portion of the mud ring 39. A throat sheet 45 extends between the inner plates 41 upwardly from the rear side of the mud ring and overlaps and is riveted to a reduced edge portion 47 of the barrel 11. I prefer to make the sheet 45 overlap the barrel, as thus the fire plays on the face of the relatively thin sheet 45 the opposite face of which is cooled by water, whereas if the barrel shell lay on top the projecting end portion of this comparatively heavy plate, lying rearwardly of the rivets and not in direct contact with water, would be subject to the heat of the fire playing on the edge thereof and might well be "fire-cracked". Cooperating with the sheet 45 to form the throat chamber is a sheet 49 secured to the forward side of the transverse portion of the mud ring, the two sheets extending upwardly along the sides of the barrel, as indicated in Fig. 3, and secured together at the sides, the transverse form of the throat chamber approximating the form of the lower portion of the fire box, as indicated in Fig. 3. As shown at the right hand side in that figure, closures 51 may be welded in place between the sheets and to prevent trapping of steam in the corners thus formed, pipes 53 may connect these upper portions of the throat chamber with the crown drums.

Water is supplied to the throat chamber through a passage formed by a sheet 55 marginally secured to the under side of the barrel, as shown best in Fig. 9, and having a closed end (Fig. 2) extending forwardly of the flue sheet 13 and overlying an opening 57 in the barrel, and an open end embraced by a flange 59 of the sheet 49 and thus communicating with the throat chamber. The throat chamber and passage 55 are suitably stayed, as shown. It may be noted in passing that the stays just referred to are practically the only ones necessary in my improved type of boiler; and it will be noted that these are substantially all out of the zones of highest heat and less subject to damage than the multitudinous stays customary in a standard boiler, many of which are subject to the highest heat. For example, the stays of the passage 55 are exterior of the barrel and their inner ends are protected by the water-containing tubes of the combustion chamber, as hereinafter to be

described. The stays of the throat sheet and the stays 41 of the foundation chamber are not in the regions of greatest temperature.

It being assumed that the passage 55 and the bottom chamber 37 have been made of such proportions as to assure an ample supply of water being drawn rearwardly from the barrel, the next problem is to permit the water to pass from the bottom chamber through the tubes without hindrance and also to provide a substantial connection between the bottom chamber and tubes in a construction which will provide an adequate water-containing, retaining wall for the fire within the fire box and will not be subject to undue corrosion or to rupture. Herein the ends of the tubes are received by and completely close the open upper side of the foundation chamber and this may be effected by providing the wall of tubes with a flat-sided marginal portion on which the side plates 41 may lap and be secured. In the present instance I attain this by the construction best shown in Figs. 3 and 6. As there indicated, while retaining the cylindrical, pressure-resisting form of the body portions of the tubes, which permits me to make them both thin and strong, I distort the lower ends by pressing them out square, as shown at 61, the side of the square being equal to the diameter of the cylindrical body portion 35. When a series of these tubes is set side by side, with the cylindrical body portions in contact, the flat sides of the portions 61 will fit together in the manner of blocks, as illustrated in Fig. 3, and form an uninterrupted marginal portion for the wall which in itself will have flat sides formed by the aligning flat sides of the squared end portions 61. This flat-sided marginal portion of the wall is adapted to be received between the channel flanges 41 formed by the side plates of the bottom chamber and completely to close the open side of this chamber. The plates 41 are secured to the flat-sided marginal portions referred to by lines of welding 63 (Fig. 3).

To seal the joint between abutting squared end portions of the tubes, I may somewhat depress the meeting faces, for example by driving a suitable tool between the same, to form a recess, as indicated at 65 in Fig. 2, which recess is thereafter filled up by metal welded into place.

Hitherto one of the major difficulties of constructing locomotive fire boxes with water-tube walls, a difficulty illustrated by my own efforts as shown by my various patents in this line, has been the joining of the tubes to the bottom chamber with a view to providing a connection of adequate strength without undesirable breaks in the wall and one which would permit the passage of sufficient water without throttling it or checking its head by successive constrictions and enlargements of the passageway. The construction herein admirably meets all conditions. It will be noted that the main portion of the wall is composed of tubes of cylindrical, that is, of inherently pressure-resisting form which are set side by side and preferably in contact. At the same time there are no interstices at the margin of the wall where it joins the bottom chamber, which interstices would have to be plugged up, but the fire box wall to and including the bottom chamber where exposed to the fire is composed of the thin walls of the tubes backed by water and substantially in contact one with another to form an unbroken container for the fire. The structure is, furthermore, particularly adapted to construction by the use of the welding process, and by utilizing such process I do away with all projecting stay heads, rivets and the like which would invite incrustation and which would be likely to be burned off. It will furthermore be noted that the opening from the bottom chamber to the tube is uninterrupted and is substantially as large as the bottom chamber itself. It follows that no impediment is placed upon the upward passage of water through the tubes but that the circulation through the fire box is facilitated throughout.

I shall next describe the manner in which the upper ends of the tubes 35 are connected to the crown drums to communicate therewith. Herein problems similar to those encountered where the tubes join the bottom chamber are found, which problems are also intimately bound up with the former ones since, for example, the provision for ample communication between the tubes and the bottom chamber would be, comparatively speaking, of minor importance were the passage of water to be checked at the tops of the tubes.

As best shown in Fig. 7, the end portions of the tubes may be inwardly bent somewhat, so that the ends of the tube wall are presented substantially perpendicular to the wall of the drum 21. To secure the tube to the wall, the end thereof is preferably drawn out of shape, in the manner best shown in Fig. 5, not to the square form 61 of the bottom end of the tube, but to an oblong and preferably rectangular form, shown at 67 in Fig. 5, the longer dimension of the oblong being transverse to the wall formed by the totality of the tubes 35 and transverse to the longitudinal axis of the drum 21 with which the tubes communicate, as best shown in Fig. 8. The effective area of the oblong opening thus provided is, of course, somewhat smaller than the area of the circular cross section of the tube. As it is impracticable for reasons which will appear to utilize the end of the tube in its original circular form, I may so proportion

the rectangle as to obtain the necessary opening while retaining certain advantages hereinafter to be referred to. The distorted end portions 67 of the tubes 35 may merge into the tubes along a curved line 69 (Fig. 7) corresponding to the curvature of the drum 21; and the ends are inserted through suitably formed rectangular openings 71 in the drum and may be trimmed off, as indicated in Fig. 7, to the curvature of the interior of the drum. The portions 67 are united to the drum wall by interior lines of welding 73 and, if desired, by exterior lines 75, the lines of welding 73 providing a pressure-resisting joint between the tubes and the drum wall. The structure not only adapts itself to the use of welding but in its preferred and most efficient form is possible only in a welded structure since, for example, the rectangular tube end could not be expanded or beaded over or conveniently connected in any simple manner.

By the provision of the oblong openings 71 in the drum wall, the longer dimensions of which are transverse to the axis thereof, I provide for a communicating passage between each tube 35 and the drum which is as nearly as practicable the full size of the tube; and by connecting the tubes in the manner just described this passage is not in any way obstructed. At the same time, as shown best in Fig. 8, there intervenes between adjacent openings a body of metal 76 of substantial width and strength; and in virtue of the manner of connection described, this body is not weakened by any holes or openings giving rise to narrow necks of metal likely to rupture.

Since the body portions of the tubes are set side by side in contact in the fire box wall, they could not be carried up into the crown drum side by side because a zone of the crown drum would be completely cut away. If the tubes were tapered or reduced in diameter, as has been attempted, the tapering, in so far as it provided for sufficient space between the openings in the crown drum to provide adequate strength, would equally contract and choke down the tube, obstructing proper circulation in the boiler. By elongating the openings transversely of the axis of the tube, as described, a comparatively thin-walled drum 21 may be used, with obvious advantage, while retaining ample strength between the openings 73 which, moreover, are of large area, approximating the cross-sectional area of the tubes 35 themselves. The connection herein described necessitates a slight opening between adjacent tubes where they join the crown drum which, however, is negligible as contrasted with the simplicity of the structure.

It will be noted that the connection of the parts is most convenient, since a man can readily enter the crown drum 21, the interior of which is not obstructed by any stays or braces whatever, and apply the welding 73 around the margins of the tubes, which welding not only holds them in position but forms an absolutely water-tight connection.

The constructions of the ends of the side wall tubes, herein described, besides their functional cooperation already referred to, are such as to facilitate formation of the tubes which may readily be effected in the manner illustrated in Fig. 4. The straight cylindrical tube, before being bent in the manner indicated in Fig. 7, may have its ends formed by means of a die or form 77 corresponding to the internal form of the lower end of the tube, as shown in Fig. 6, and another collapsible form 79 having a cylindrical base portion 81 from which rises a central portion 83 to which are detachably secured side pieces 85, the parts 83 and 85 having the general formation of the upper end of the tube, as shown in Fig. 5. The two forms may be held in alignment by a rod 87 sliding in the form 77. To shape the tube 35, it is placed with its end portions fitting over the cylindrical portion 81 of the upper form and the cylindrical upper portion of the lower form, and the two are then pressed toward each other. This serves to press out the lower end of the tube to the form shown in Fig. 6, and the upper end of the tube is pressed outwardly at the shorter sides of the oblong shown in Fig. 5, at the same time drawing inwardly at the longer sides which extend transversely in Fig. 4. In this action the metal itself is little strained, the change being principally one of shape. By a single operation, which may be performed on the tube when cold, it is thus formed ready for bending with the exception of pressing down the sides of the oblong extension at 69 to fit the shoulder of the die, thus adapting it to the shape of the crown drum. The pin securing the portions 83 and 85 of the upper collapsible die 79 may then be withdrawn and the tube freed, ready for bending.

As seen in Fig. 2, certain of the side wall tubes 88 adjacent the forward end of the fire box will align with the throat chamber rather than with the foundation chamber 37. These may be connected to the crown in the manner already described for the side wall tubes 35. Their lower ends are preferably bevelled to conform to the inclination of the throat sheet 45 and enter suitable apertures in the same to the margin of which they are welded.

The rear wall of the fire box, as shown in Fig. 1, may be formed of tubes 89 substantially similar to the tubes 35. To provide a larger grate surface it is desirable to permit a certain upward taper of the wall, as illustrated in Fig. 1, and therefore the

tubes themselves may be slightly tapered. It is also unnecessary to bend the same, as the tubes 35 are bent in the manner indicated in Fig. 7. The extrusion of portions of the crown drums at 27 provides a substantially continuous, flat-sided portion in which the oblong necks of the tubes may be entered and secured in the same manner that the side wall tubes 35 are secured to the sides of the drums. Similar advantages in providing ample space between the openings in the drums are found in the case of the rear wall tubes.

To provide an opening for a fire door, I do not use tubes extending from the bottom chamber to the crown at the middle portion of the rear wall, but at a suitable height for the upper edge of the door opening I insert a channel 91 (Figs. 1 and 2) marginally welded to two laterally placed tubes 89, which tubes may have openings 93 (Fig. 2) cut in the wall thereof providing communication with said channel. Short tubes 95, secured to the crown drum 19 in the same manner as the longer tubes 89 are secured to the crown drums 21, are provided, which tubes may have lower squared portions formed in the manner illustrated in Fig. 6 and similar to the lower ends of the other tubes, which portions are fitted into the channel 91 in the same manner as the other tubes are fitted into the bottom chamber. In the present instance I have shown the space between the bottom chamber and the lower edge of the door opening as filled with fire brick or tile 97.

Preferably, the rear wall of the fire box slopes forwardly from bottom to top, as illustrated in Fig. 2. To complete the inclosure, a suitable number of blind-ended tubes of appropriate length, as for example 99 and 101 shown in Fig. 2, may be provided, these tubes fitting the bottom chamber in the same manner as the other tubes. Suitable openings 103 through the contacting walls of adjacent tubes provide communication between these blind-ended tubes and adjacent tubes which reach directly to the crown.

I have herein (see Fig. 2) shown a baffle wall 105 of tile, supported on arch tubes 107 opening at one end through the throat sheet 45 and at the other end expanded into certain tubes of the rear wall. To facilitate the connection of the arch tubes 107, the portions of the tubes with which they connect may be squared, as indicated at 109, below the oblong necks 111. At the outside rear wall of the fire box opposite the ends of the arch tubes, plugs 113 may be inserted in the flattened surfaces to facilitate cleaning of the arch tubes. To permit the expansion of the ends of the arch tubes and the insertion of the plugs, the front and rear flattened faces may be suitably reinforced, either by slightly upsetting the tube or by welding on extra metal marginally of the openings.

The boiler here inllustrated also embodies in its construction a combustion chamber including water tubes housed within the segmental extension 33 of the barrel. As seen in Fig. 3, these tubes 115 are curved to the form of the interior of the barrel. The upper end portions are provided with oblong necks 117 similar to the portions 67 of the tubes 35, illustrated in Fig. 5, and are entered through the wall of the crown drum in analogous manner, as will be clearly understood by Fig. 2. The body portions of the tubes conform to the contour of the extension 33 of the barrel shell, but are preferably slightly spaced therefrom to permit free movement in expansion and contraction. The lower ends 119 of the tubes are presented in opposition adjacent the lower median line of the barrel and means are provided whereby they may be placed in communication with the water passage 55 beneath the barrel shell, one suitable manner of effecting the purpose being best illustrated in Fig. 9. Preferably, the ends 119 are squared, as shown, to fit together block-like and give a flat-sided marginal portion which will rest firmly on the inside of the barrel. Closures 121 may be welded in the ends of the tubes which are thus blind-ended, and to provide communication with the chamber 55 nipples 123 are welded into the lowermost squared side of the tube and pass through the barrel shell extension 33 and open to the passage 55. Suitable plugs 125 are provided in the opposite flattened sides, opposing the nipples, to facilitate cleaning. The welding securing the closures 121 in place may be extended at the lower side at 127 to secure the ends of the tube to the barrel shell, which will relieve the nipples 123 of strain through expansion or contraction.

It might be considered that the adoption of the construction just described tends to stultify the statements made concerning the importance of the manner in which the ends of the side wall tubes 35 are connected to adjacent parts. The conditions in the case of the combustion chamber tubes are, however, markedly different since the barrel shell 33 is much heavier than it would be desirable to make the crown drums and consequently the round openings can be placed much closer together without undue weakening. Moreover, the combustion chamber tubes are not subjected to the racking strain to which the side wall tubes are subjected in the travel of the locomotive, since they are housed by and supported by the heavy barrel shell and by the three crown drums fitting together in the manner of an arch and securely fastened to the barrel shell by the so-called splice joint, illustrated in Fig. 2.

Conveniently, the lower ends 119 of the combustion chamber tubes are somewhat spaced, as shown, which will facilitate replacement of sections. The space between them may be filled with tile 129, the purpose being chiefly to prevent deposit, since the extension 33 of the barrel shell beneath the space is cooled by the water in the passage 55.

Through the features of construction described and their joint and cooperative effect, I provide a locomotive boiler having many advantages over the present standard type wherein the fire box is formed of spaced sheets secured by stay bolts and rivets, and having many of the advantages claimed for the best types of stationary and marine water-tube boilers.

The most striking advantage of a locomotive fire box constructed as described consists in the practically complete elimination of stayed surfaces which are in every way undesirable, being not only unsatisfactory as a construction initially but demanding an excessive amount of repair on account of failure of stay bolts which are loosened or broken by the expansion and contraction of the parts and the pounding strains caused by the travel of the locomotive. I herein provide, in place of flat surfaces which must necessarily be stayed, small strong parts which may be made of thin material of high thermal efficiency but of such form as to be of great strength without reinforcement by stays. In the event of damage to any of the parts, they may easily be repaired or replaced without interfering with the remaining parts, and it will be noted that in the construction described all are very accessible and a workman can readily have access to where they are joined together and can make a quick and workmanlike job of the repair.

While providing a conveniently assembled and conveniently repaired structure, I at the same time form a fire box wherein the water-containing walls are practically uninterrupted and wherein all the parts in contact with the fire are of thin material and backed by water. Furthermore, the joints between the various parts where exposed to the fire are not such as to be damaged thereby or, on the other hand, to be corroded by water at the other side of the fire-enclosing metal, which in either event might cause leakage. On the contrary, separate parts are practically entirely eliminated and projecting portions reduced to a minimum, so that the fire box presents within and without smooth regular surfaces readily cleaned and affording little opportunity for the lodgement of dirt.

Besides these features, which relate more particularly to the building and upkeep of the structure, I obtain the important functional advantage of providing a regular and steady circulation of water in the boiler which increases the steam-generating efficiency and at the same time lengthens the life of the boiler since the parts are kept at a practically constant temperature. The water in the fire box is divided by the wall tubes into comparatively small columns, and a half of the perimeter of these columns is directly subjected to the heat of the fire with only a thin wall of metal intervening. The column of water is thus readily heated and can rise as a unit toward the crown. The column, moreover, is not so large as to introduce conflicting currents, causing priming by motion of steam up through a descending column of water; but since an ample intake is provided at the lower ends of the tubes and an ample exit at the upper ends, a continuous and steady motion of a practically uniformly heated stream of water is provided for.

In order to obtain a proper rigidity of construction while keeping the walls of the water tubes of sufficient thinness to provide efficient heating surfaces, the tubes should be of fair size. While I do not wish to be limited to any particular dimensions, I believe that for the present type of locomotive a tube about 6″ in diameter and of about 3/16″ wall is suitable and that this diameter of tube is practically the maximum which can advantageously be used. Very small tubes would not have sufficient strength to withstand the racking strains which the structure would encounter in use, unless the walls thereof were made unduly thick, in which case they would be inefficient and likely to clog up; but by using a comparatively large tube the necessary structural strength is obtained and the walls may be made thin so as to obtain high absorbing efficiency. At the same time the tubes are not of such size as to permit the travel of relatively warmer and cooler currents of water in opposite directions therein, but the column of water is permitted to move upwardly as a unit. This is facilitated not only by the thin wall of the tube but by the fact that such a large proportion of its surface is exposed at the interior of the fire box. A marked increase in the size of the tubes, besides unduly encroaching upon the grate space, would tend to form too large passages in which the warmer water would travel upwardly on the inside of the fire box and cooler water downwardly at the outside. In fact, I have some reason to believe that even with a 6″ tube the slight reduction in area of the upper end thereof, caused by its distortion from a circular to a rectangular form, as shown in Fig. 5, is not without advantage. By this I mean not without advantage apart from the question of preserving the strength of the crown drum and permit-

ting that drum to be made of thin metal. The slightly restricted outlet tends to prevent any downward current of cooler water from being set up in the side wall tubes, while at the same time the reduction is not sufficient to throttle down and choke the upward passage of water, as would be the case if the tube were uniformly reduced or necked down to a circular form.

Referring to Fig. 2, the water is delivered from the barrel through the opening 57 and passes rearwardly through the passage 55 to the foundation chamber which, as already stated, may be of comparatively generous size to permit an ample supply of water to the tubes of the fire box wall. The water moves thence in a regular determined direction of circulation upwardly through the tubes, without any interference to the rising currents, and since the tubes divide the water into comparatively small streams, there is no tendency for the development therein of reverse currents of cooler water from the crown; but on the contrary the water, after having disengaged the steam therefrom in the crown, will pass in a regular circulating flow to the barrel and thence back through the foundation chamber and up through the fire box tubes in the manner already described. From the foundation chamber the water is delivered to the tubes through the squared ends shown in Fig. 6. The intake ends of the tubes provided by these squared portions present an area practically as large as the plan area of the foundation chamber itself and fully as large as the combined cross sections of the tubes. There can thus be no question of supplying the tubes with ample water to permit an upward circulation therethrough and the head of the column is not diminished or throttled down in any way. The delivery openings 71, shown in Fig. 8, are also large and the column is thus not held back in such a way that priming might ensue, but passes readily to the crown drums. Having passed upwardly through the tubes, the water and steam find in the crown drum an ample water space with a large surface from which the steam can be disengaged at a high temperature and without foaming. The communication of this crown with the barrel is such that the water level and the pressure on the water are equalized.

The regular circulation of water made possible by the combination of parts described provides for most efficient heating and for liberation of the steam in a dry state. In the ordinary or standard boiler having side legs, the circulation is retarded since there are currents of steam and water moving upwardly and other currents of cooler water descending within the same water space, these currents struggling and scrubbing against each other and being continually shifted in direction by the stay bolts. The motion of the water through the fire box is thus slackened and retarded so that the heat of the fire is not abstracted with desirable rapidity and the steam disengaged in the crown is highly saturated. These objections are overcome in the present case, since the chamber at the lower end of the side walls is sufficiently large to supply water to the tubes; and the upper delivery ends of the tubes, while not so small as to check the circulation, are only of a sufficient area to be entirely filled with the ascending currents of mingled steam and water, thus assuring a predetermined positive circulation in one direction. By this circulation a rapid movement is effected which utilizes the heat of the fire most effectively, so that it is exhausted from the stack at relatively low temperature and dry and highly efficient steam is disengaged in the crown.

Having described in detail the illustrative embodiment of my invention shown in the accompanying drawings, the principles exemplified thereby in what I now consider the most desirable, although not immutable, form I shall attempt to define in the following claims:—

1. A boiler firebox comprising in combination a longitudinal chamber and a longitudinal water-containing wall comprising a plurality of tubes having cylindrical body portions set closely together side by side, the ends of the tubes being shortened longitudinally and extended transversely to provide elongated, spaced discharage portions of capacity approaching that of the tube body, said portions entering correspondingly shaped openings in the chamber wall and secured therein.

2. As an element for boiler construction, a thin walled, cylindrical tube having an end portion extended across one diameter and inbent across a conjugate diameter to provide a neck portion of substantially rectangular section.

3. In a boiler, in combination, a barrel, a flue sheet therein, the shell of the barrel extending rearwardly beyond the flue sheet to provide a combustion chamber, water tubes housed in the barrel shell and lining the walls of said chamber, a plate secured to the bottom of said barrel and co-operating with the shell thereof to provide a chamber communicating with said barrel forwardly of the flue sheet and means providing for communication through the barrel shell between the interior of the latter chamber and said tubes.

4. In a boiler, a barrel, a firebox having water-containing spaces, a bottom chamber extending from said barrel and in communication with the same and with the water-containing spaces of said firebox, and a com-

bustion chamber between the barrel and firebox having walls comprising tubes having opposed blind ends overlying said bottom chamber and openings through the sides of said tube ends affording communication with the bottom chamber.

5. In a boiler, a barrel, a firebox having water-containing spaces, a bottom chamber extending from said barrel and in communication with the same and with the water-containing spaces of said firebox, and a combustion chamber between the barrel and firebox having walls comprising tubes having opposed blind ends having flattened sides fitted to the upper wall of said bottom chamber and openings through said sides and said wall affording communication with the bottom chamber.

6. In a boiler, a barrel, the lower portion thereof being rearwardly extended, means cooperating with the extending portion to form a bottom chamber of which said portion forms the upper wall, a crown chamber secured to said barrel, means cooperating therewith to form a firebox, and a combustion chamber between said firebox and barrel having walls comprising tubes extending from said crown chamber and having blind ends overlying the extended portion of the barrel, there being openings through said portion and the lateral walls of said tubes providing communication between said tubes and the bottom chamber.

7. In a boiler a barrel and a throat chamber comprising a front sheet secured to the under part of the barrel shell and a rear sheet having its edge extending over the rear edge of the shell, overlapping and secured to the interior surface of the same whereby the edge of the shell is protected from the fire.

8. In a boiler, a barrel and a firebox, there being an inclined throat sheet extending between said barrel and firebox, walls for said firebox comprising a plurality of upright tubes, certain of said tubes engaging said sheet and having their ends beveled to conform to the inclination thereof and welded thereto, and apertures in said sheet permitting communication between said tubes and the space beneath said sheet.

9. In a boiler, a barrel and a firebox, there being an inclined throat sheet extending between said barrel and firebox, walls for said firebox comprising a plurality of upright tubes, certain of said tubes engaging said sheet and having their ends beveled to conform to the inclination thereof, said sheet having apertures therein corresponding to the section of said tubes, the margin of said apertures and the extremities of the tube walls being welded together.

10. A boiler comprising a barrel, a crown chamber opening into the upper portion of the barrel, a transverse throat chamber opening into the lower portion thereof, firebox walls comprising hollow sections opening at one end to the crown chamber and at the other in communication with said throat chamber and exteriorly disposed pipes extending between the upper lateral portions of said throat chamber and the crown chamber to permit the escape of steam from the throat chamber.

In testimony whereof, I have signed my name to this specification.

JAMES M. McCLELLON.