No. 620,807. Patented Mar. 7, 1899.

# W. M. SMITH.

## STEAM GENERATOR.

(Application filed Dec. 21, 1897.

(No Model.) 4 Sheets—Sheet 1.

Fig. 2.

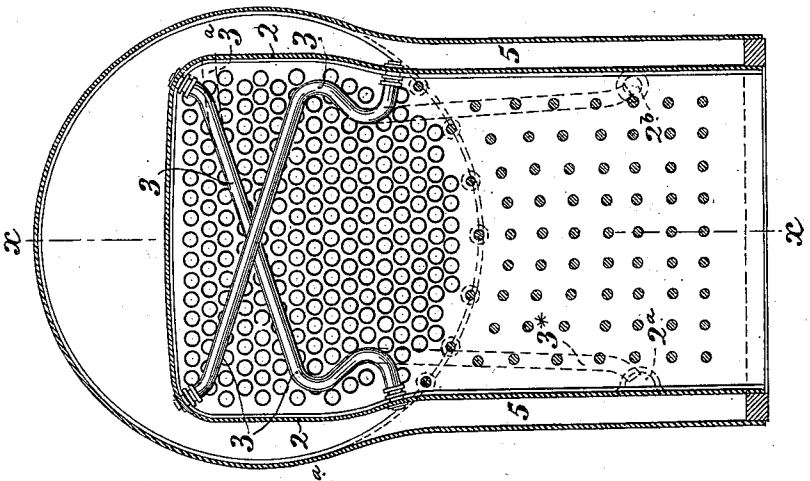
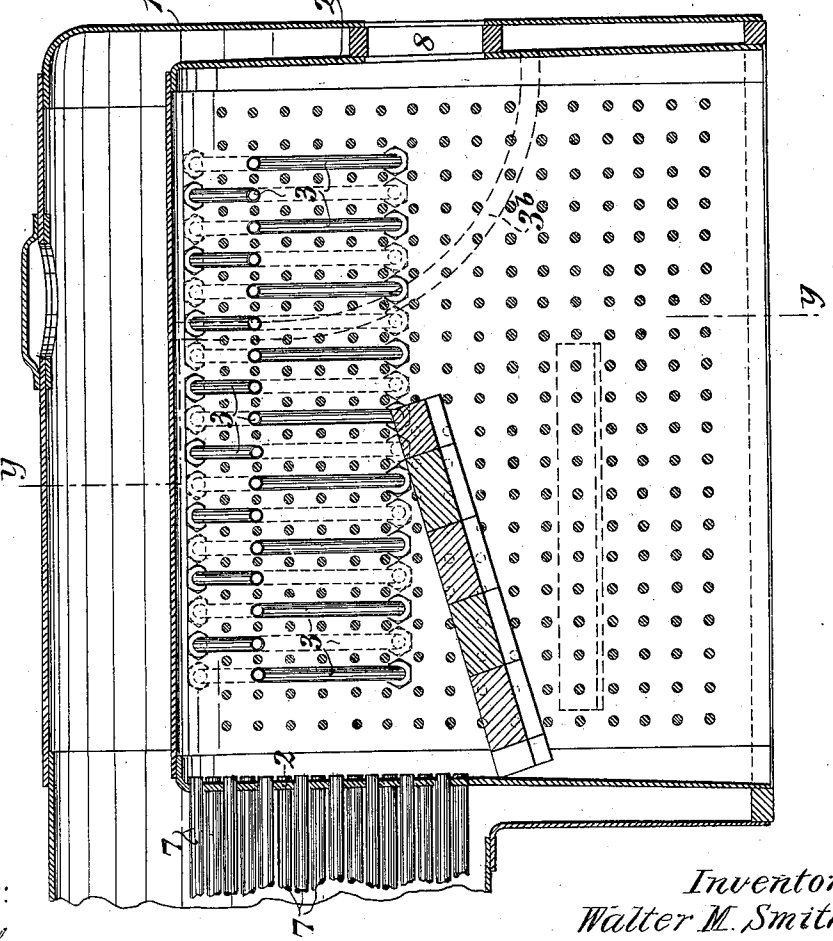



Fig. 1.




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# W. M. SMITH.

## STEAM GENERATOR.

(Application filed Dec. 21, 1897.)

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*Fig. 3.*

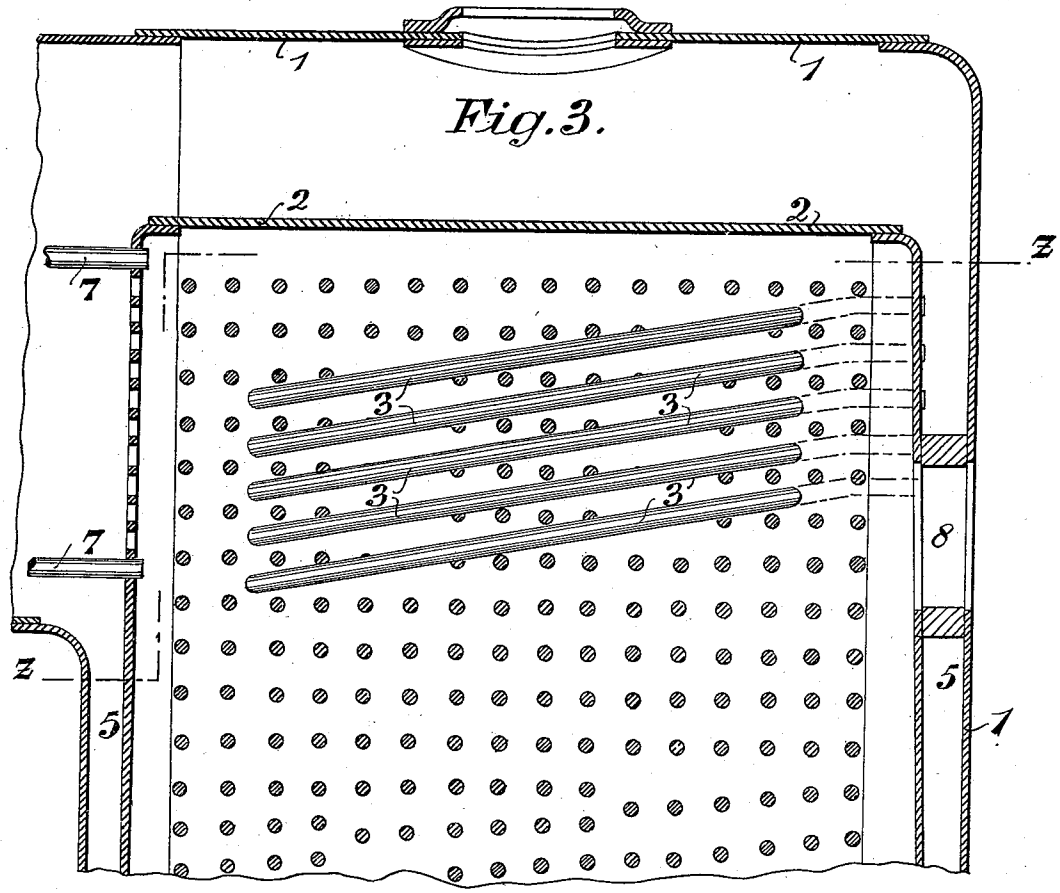
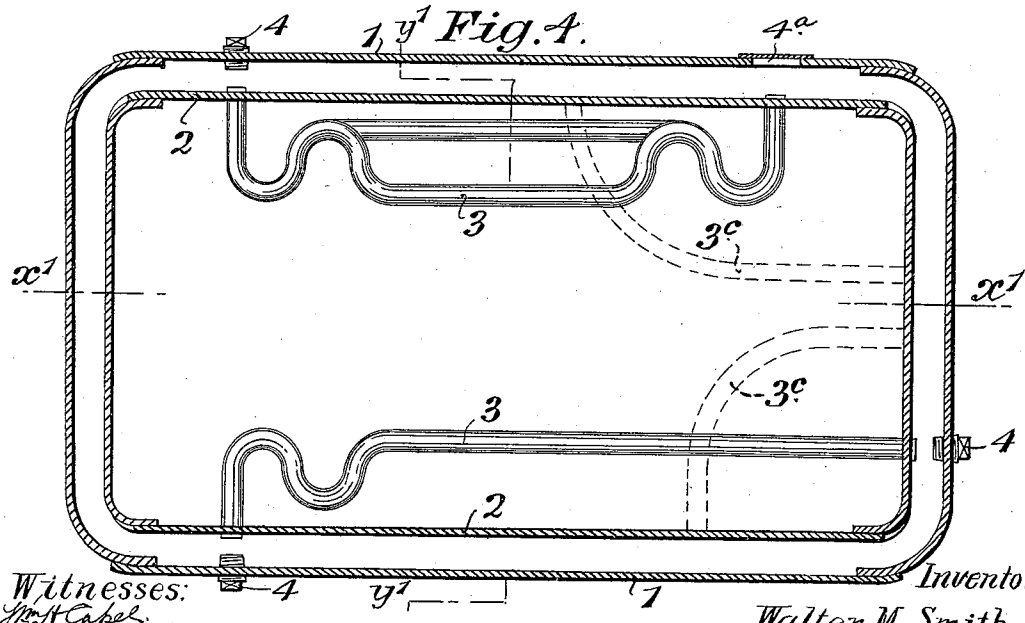



*Fig. 4.*




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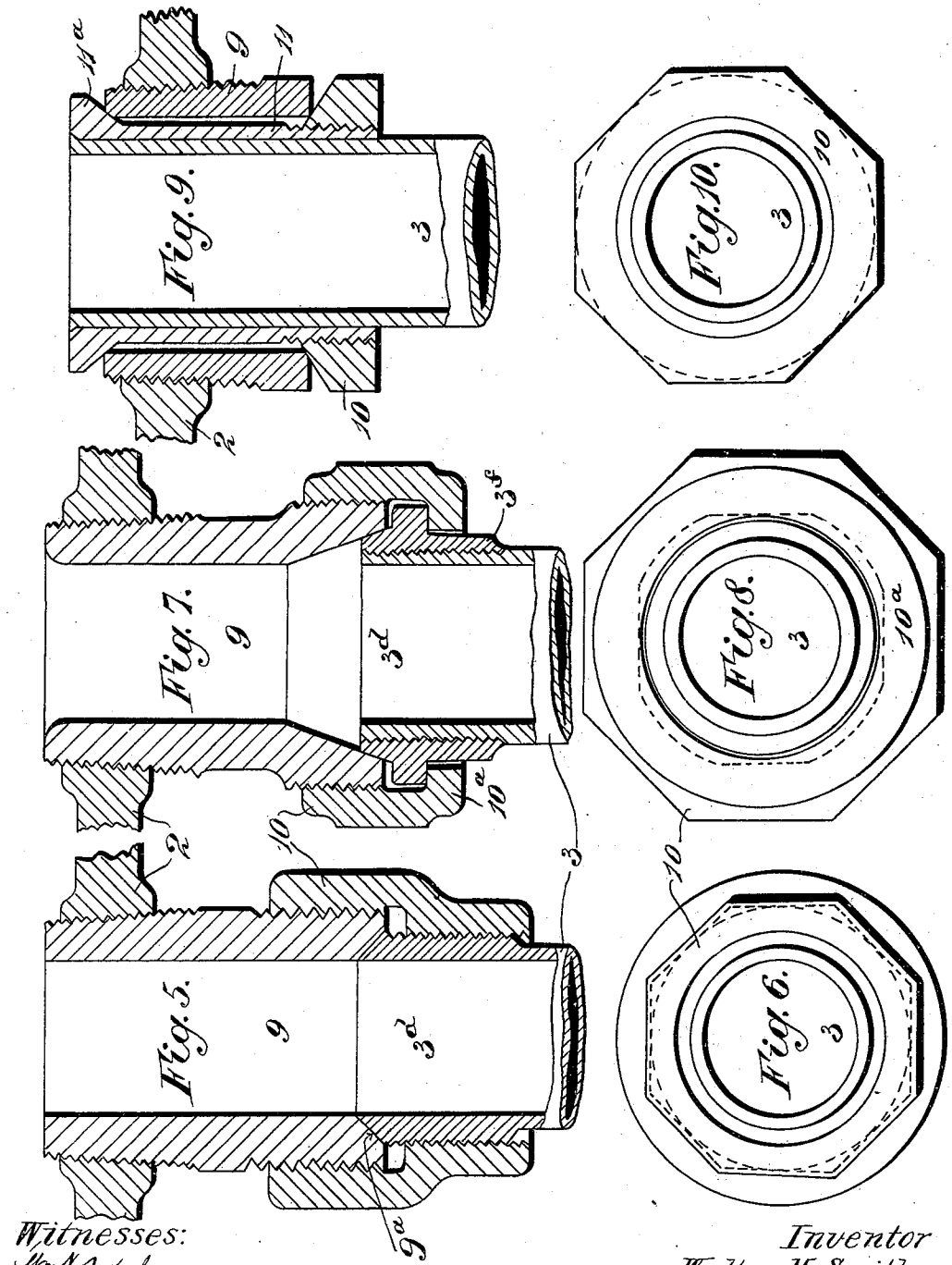
No. 620,807. Patented Mar. 7, 1899.

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## STEAM GENERATOR.

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(No Model.) 4 Sheets—Sheet 3.




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No. 620,807. Patented Mar. 7, 1899.

W. M. SMITH.

STEAM GENERATOR.

(Application filed Dec. 21, 1897.)

(No Model.) 4 Sheets—Sheet 4.

Fig.11.

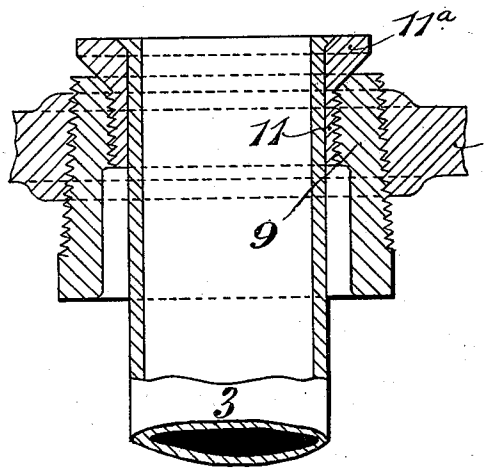



Fig.13.

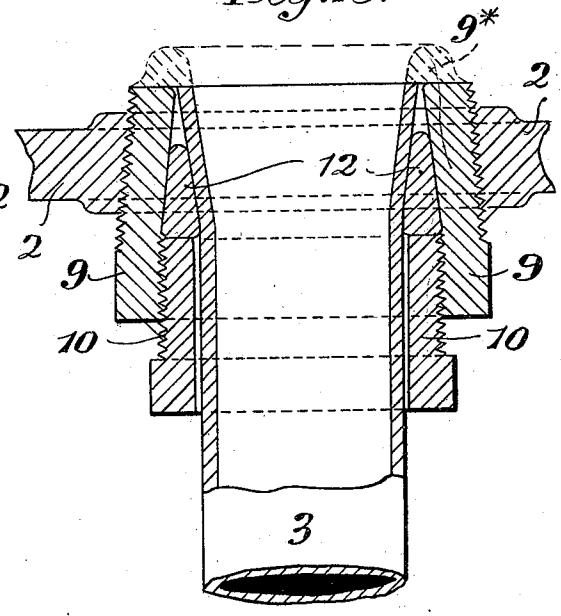



Fig.12.

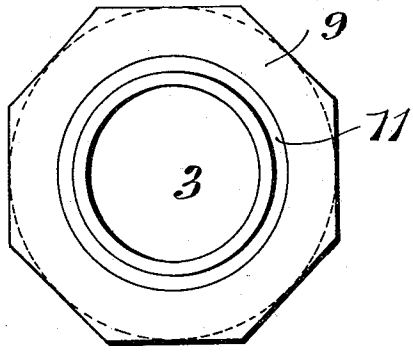
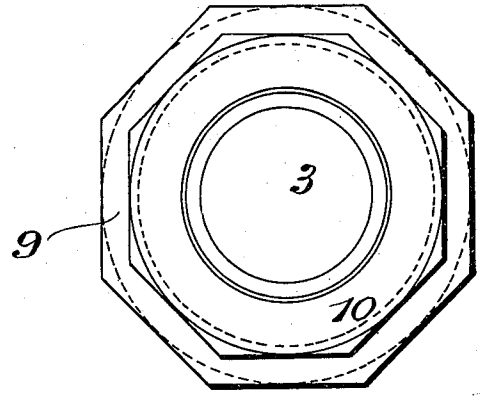



Fig.14.




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# UNITED STATES PATENT OFFICE.

WALTER MACKERSIE SMITH, OF NEWCASTLE-UPON-TYNE, ENGLAND.

## STEAM-GENERATOR.

SPECIFICATION forming part of Letters Patent No. 620,807, dated March 7, 1899.

Application filed December 21, 1897. Serial No. 662,877. (No model.)

*To all whom it may concern:*

Be it known that I, WALTER MACKERSIE SMITH, a subject of the Queen of Great Britain and Ireland, residing at Jesmond, Newcastle-upon-Tyne, in the county of Northumberland, England, have invented Improvements in Steam-Generators, of which the following is a specification.

This invention has reference to improvements in steam-generators of the locomotive type. According thereto the fire-box of such a steam-generator is provided with water-tubes arranged to connect the water-space at one point with that at another, so as to obtain increased heating-surface and better water circulation. The water-tubes are preferably curved and may connect points on the same side, opposite sides, sides and rear end, or sides and rear end with the roof of the fire-box. They may be connected to the fire-box shell by coupling devices or unions, so as to be removable from the interior of the fire-box through the fire-door opening, or they may be inserted through holes in the inner and outer shells of the fire-box and be fixed in the inner shell by expanding, the holes in the outer shell being provided with movable closures for gaining ready access to the tube ends.

In the accompanying illustrative drawings, Figure 1 is a longitudinal section on the line $x\ x$ of Fig. 2; and Fig. 2 is a transverse section on the line $y\ y$ of Fig. 1, showing the fire-box portion of a steam-generator of the locomotive type with one arrangement of water-tubes having their ends connected to the inner walls of the fire-box by coupling devices according to this invention. Figs. 3 and 4 show a fire-box with modified arrangements of water-tubes according to this invention, Fig. 3 being a central longitudinal section on the line $x'\ x'$ of Fig. 4, and Fig. 4 being a sectional plan on the line $z\ z$ of Fig. 3. Fig. 5 is a central longitudinal section; and Fig. 6, an end view showing, to a larger scale than Figs. 1 to 4, inclusive, a tube end with coupling device for connecting the same to the shell of the fire-box. Figs. 7 and 8, Figs. 9 and 10, Figs. 11 and 12, and Figs. 13 and 14 are similar views to Figs. 5 and 6, showing modified arrangements of coupling devices.

Referring to Figs. 1 and 2 of the drawings, 1 is the outer shell of the fire-box, 2 the inner shell of the fire-box, and 3 curved water-tubes arranged within the fire-box. These tubes in the example now being described are located in vertical planes and extend from the sides of the inner shell of the fire-box to the opposite top corner thereof, so as to connect the water-space between the inner and outer shell with that above the crown of the fire-box. They are shown S-shaped at one end to allow for expansion and contraction and are arranged to cross each other at or near the center line of the fire-box, being spaced at suitable distances apart to allow flame and hot gas to pass around and between them.

I do not confine myself to any particular shape of the tubes, nor do I limit myself to any particular point in the sides or crown of the fire-box at which to insert the tubes. They may be continued down near to the bottom of the fire-box, as shown by dotted lines at 3* in Fig. 2. In this case the plate forming the inner shell 2 may be bulged inward, as shown at $2^a$, so as to form projections in which the lower ends of the tubes 3* can be secured, or a suitable junction-pipe, such as $2^b$, may be fixed at its ends to the adjacent side of the fire-box, and to it the lower ends of the tubes 3* can be fixed. The number of tubes shown in Fig. 1 is seventeen, nine being connected to one side of the fire-box and eight to the other side. The number and also the size of the tubes can, however, be varied so as to provide the amount of extra heating-surface required.

The water-tubes 3 are shown in Fig. 3 as inclined to the horizontal, the angle being such as to cause free circulation of the water in the tubes and the water-space 5 between the inner and outer shells 1 and 2. The tubes at the upper part of Fig. 4 are shown as connected to different parts of the same side plate of the inner fire-box shell 2. The tube 3 at the lower part of Fig. 4 is shown as fixed at one end to one side of the inner fire-box shell and at the other end to the rear end plate $2^a$ of the said inner fire-box shell. Fig. 3 shows in dotted lines the rearward ends of a number of tubes so continued to the end plate $2^a$. The tubes may also be arranged to cross from one side of the fire-box to the other side, as

indicated in dotted lines at $3^a$ in Fig. 2. They may also be arranged to connect the rear end wall $2^a$ to the roof of the fire-box, as indicated by dotted lines at $3^b$ in Fig. 1. The points where the ends of the tubes are connected to the plate or plates forming the inner shell of the fire-box may be arranged nearer to or farther from the longitudinal center line $x'$ $x'$ or transverse center line $y'$ $y'$ of the fire-box, as indicated, for example, by the pipes $3^c$. (Shown in dotted lines in Fig. 4.)

The shape of the tubes as seen in plan may be variously modified, as indicated in Fig. 4, which shows several different shapes the tubes may assume; but they are preferably so arranged as to interfere as little as possible with free access to the boiler-tubes. The tubes may be so bent that they can be placed in position by being passed through suitable holes in the inner and outer shells, the ends of the tubes being suitably fixed in the holes in the inner shell—as, for example, by expanding them by a tube-expander inserted from the outside of the fire-box through the holes in the outer shell 1. Fig. 4 shows the tube ends thus fixed by expanding them in the shell 2 of the fire-box. In this case the holes in the outer shell 1, through which the tubes are inserted, are made larger than those in the inner shell and are fitted with removable closures, such as screw-plugs 4 or covers or doors $4^a$, which admit of ready access being gained to the tubes for the purpose of examining, cleaning, and removing them and for further tightening up their ends in the inner shell 2 when desired.

Instead of fixing the ends of the water-tubes by expanding them in holes in the walls and crown of the fire-box, as hereinbefore described, I prefer to connect them to the fire-box by couplings or unions, which enable the tubes to be readily detached and removed when necessary through the fire-door opening 8. In this case the removable closures 4 $4^a$ are dispensed with.

Figs. 5 and 6 show one form of coupling suitable for this purpose. It comprises a hollow screw plug or nipple 9, (hereinafter called a "plug,") which is screwed tightly into a thickened part of the fire-box shell 2 and projects into the fire-box, and a nut 10, which is screwed onto the inwardly-projecting end of the plug and also onto the thickened adjacent end $3^d$ of the water-tube 3. The screwed part of the plug projecting into the fire-box is made larger in diameter than the screwed part of the tube 3, and the pitch of the screw-thread thereon is also made greater than that on the tube. The two screw-threads on the nut are made the one to fit the plug and the other to fit the tube. To fix the tube end in place, the nut is run back onto the tube, which is placed in position, after which the nut 10 is run forward onto the plug and screwed up tight. As the screw-thread on the latter is coarser than that on the tube end, the conical end of the tube is drawn tightly into or against a conical seat $9^a$ on the plug, thus forming a steam-tight joint. By screwing back the nut the tube end can be readily detached.

Figs. 7 and 8 show a modification in which the tube end is provided with a collar $3^e$, by which its coned end is forced into close contact with the coned end of the plug 9 by the flange $10^a$ of the coupling-nut 10. The collar is preferably formed on a sleeve $3^f$, screwed tightly onto the tube end.

In the arrangement shown in Figs. 9 and 10 the tube end has fixed to it in a fluid-tight manner an externally-screw-threaded sleeve 11, having a coned end $11^a$, which is fixed in place by passing it through the hole in the fire-box plate 2 when the plug 9 is removed, then screwing the said plug through the hole until it bears in a water-tight manner against the coned end $11^a$ of the sleeve, and finally screwing the nut 10 on the sleeve until it bears in a steam-tight manner against the plug.

Figs. 11 and 12 show a modification somewhat like that illustrated in Figs. 9 and 10, except that the plug 9 screws onto the sleeve 11, which is made shorter and is unprovided with a nut.

Figs. 13 and 14 show another modification, in which the tube end is outwardly flared or coned and the interior of the plug 9 is inwardly coned, and a ferrule or ring 12, coned externally and internally to fit the plug and tube end, respectively, is forced into close contact with each of them, so as to make a steam-tight joint with both and hold the tube end in place by a forcing-nut 10, screwed into the plug 9. The outer end of the plug may be formed, as shown in dotted lines, to serve as an abutment for the tube end.

With each arrangement the tube end is released by simply screwing back the nut 10 in Figs. 5 to 8, inclusive, and Figs. 13 and 14, the nut 10 and plug 9 in Figs. 9 and 10, and the plug 9 in Figs. 11 and 12.

I am aware that the tube-plate in the fire-box of a locomotive-boiler has heretofore been connected to the rear end wall $2^a$ of the fire-box by rearwardly and upwardly inclined water-tubes, upon which the brick arch has sometimes been placed; also, that the said tube plate has been provided with a rearwardly and upwardly inclined water-chamber connected by tubes to the rear end plate $2^a$ of the fire-box; but such constructions, which are outside the scope of my invention, are objectionable in practice, because should anything happen to the boiler-tubes 7, Figs. 1 and 3, the water-tubes or water chamber and tubes prevent ready access being gained to such tubes. This objection is obviated by arranging the water-tubes in the manner hereinbefore described.

I am also aware that it has heretofore been proposed to connect the crown of the fire-box by water-tubes to the sides and front wall or tube-plate of the fire-box, but in such cases

no provision has been made to admit of such tubes being easily and readily removed and replaced without the necessity of taking the boiler to pieces. This drawback is overcome by employing the couplings or union hereinbefore described.

What I claim is—

1. In a steam-generator of the locomotive type, the combination with the inner shell of the fire-box, of a series of bent tubes within the fire-box on either side secured at their ends in said shell and extending obliquely from the forward end of the box toward the rearward end, whereby access to the flues is unobstructed and efficient circulation of the water between the shells forming the walls of the fire-box is effected.

2. In a steam-generator of the locomotive type, the combination with the fire-box of such generator, of water-tubes located within said fire-box and each of which has its ends connected to the portion of the inner shell of the fire-box in rear of the tube-plate, so as to be in free communication with the water-space formed by and between the inner and outer shells of said fire-box, all of said tubes being so arranged as to admit of free and unobstructed access to the boiler-tubes from the fire-door, substantially as described.

3. In a steam-generator of the locomotive type, the combination with the fire-box of such a generator, of water-tubes located within said fire-box and having their ends connected to the portion of the inner shell of the fire-box in rear of the tube-plate, so as to be in free communication with the water-space formed by and between the inner and outer shells of said fire-box, and coupling devices whereby the ends of said tubes can be readily connected to and disconnected from the said inner shell from the inside of said fire-box, substantially as described.

4. In a steam-generator of the locomotive type, the combination with the fire-box of such generator, of water-tubes located within said fire-box, and coupling devices provided in the inner wall of the fire-box adapted to thrust the ends of the tubes endwise and to connect them in a detachable manner to said inner wall, substantially as described.

5. In a steam-generator of the locomotive type the combination with the fire-box of such generator, of water-tubes located within said fire-box, hollow plugs or nipples screwed into the inner shell of the fire-box from the inside and adapted to form seatings at their inner ends, the ends of the said tubes being adapted to form a joint with said seatings, and coupling-nuts within the fire-box adapted to tighten the ends of the tubes against the said seatings, substantially as described.

6. In a steam-generator of the locomotive type the combination with the fire-box of such generator, of water-tubes located within said fire-box, hollow plugs fixed in the wall of, and projecting inwardly into, the fire-box, the projecting ends of each plug being externally screw-threaded and formed with a conical seating, and coupling-nuts each threaded internally at one portion to screw upon the corresponding plug and provided at another portion of smaller diameter with internal screw-threads of a different pitch to the others and adapted to screw upon the screw-threaded end portion of the adjacent water-tubes, the ends of said water-tubes being coned correspondingly to the seatings on the plugs, substantially as described.

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

WALTER MACKERSIE SMITH.

Witnesses:
RALPH J. ROBSON,
JOHN WEATHERBURN,