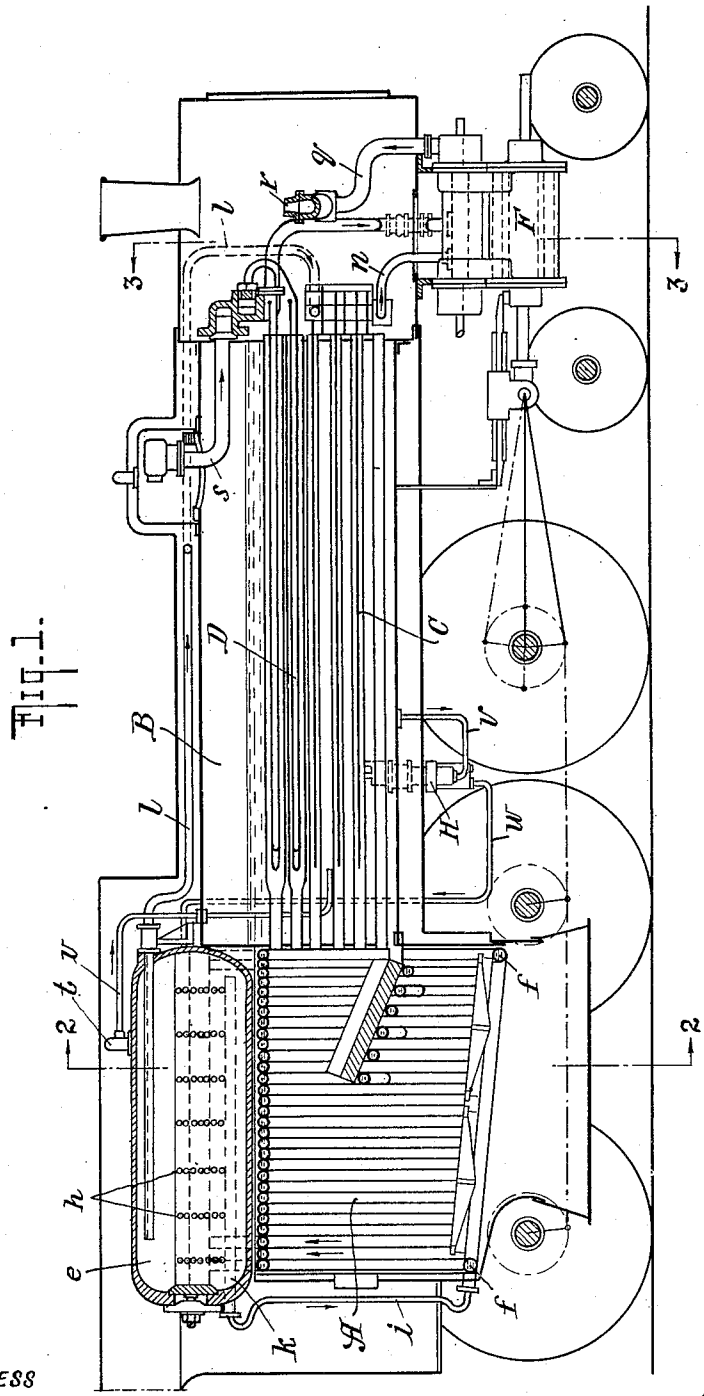
Jan. 14, 1930. O. H. HARTMANN 1,743,451

HIGH PRESSURE STEAM BOILER PLANT WITH GENERATION OF STEAM BY INDIRECT HEATING

Filed Sept. 16, 1926 3 Sheets-Sheet 1

Fig. 1.



WITNESS

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Fig. 5.

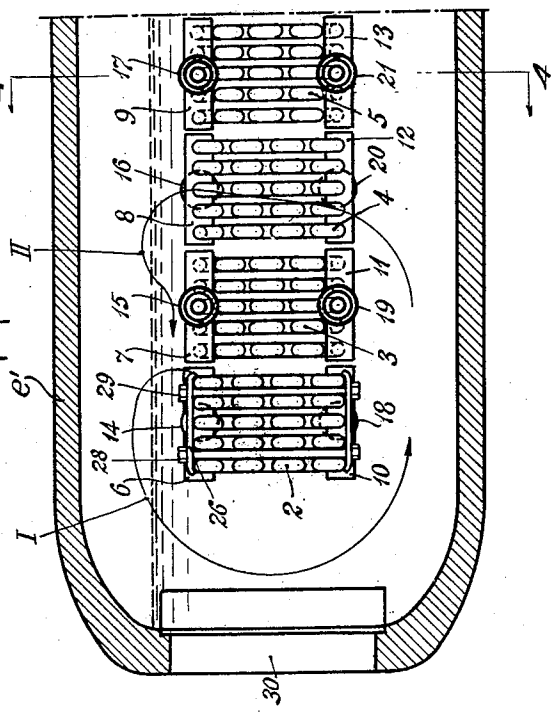
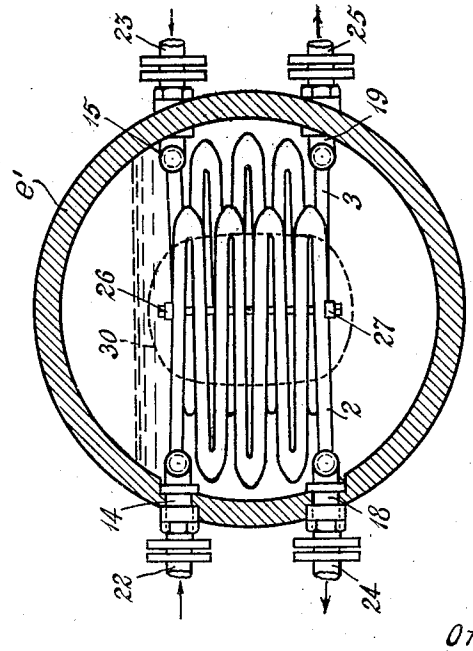


Fig. 4.



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HIGH PRESSURE STEAM BOILER PLANT WITH GENERATION OF STEAM BY INDIRECT HEATING

Filed Sept. 16, 1926 3 Sheets-Sheet 3

Fig. 1.

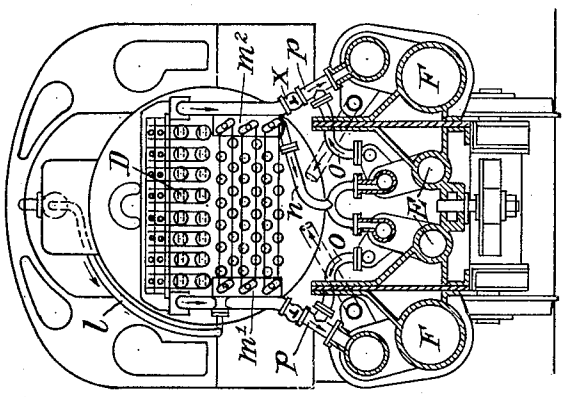
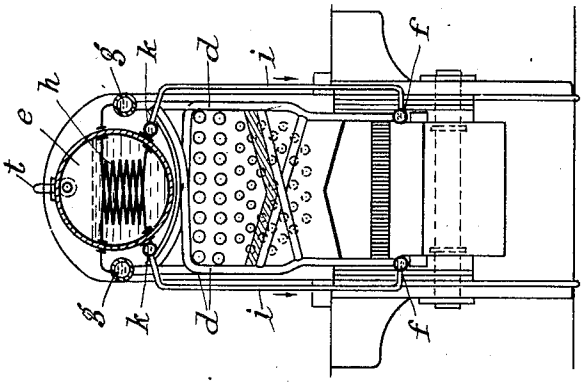


Fig. 2.



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UNITED STATES PATENT OFFICE

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HIGH-PRESSURE STEAM BOILER PLANT WITH GENERATION OF STEAM BY INDIRECT HEATING

Application filed September 16, 1926, Serial No. 135,746, and in Germany January 28, 1924.

My present application is a continuation in part of my pending application filed in the United States Patent Office on September 12, 1924, Serial No. 737,311. The object of my invention is to provide efficient forms of high-pressure steam boiler plants in which indirect heating is resorted to for the generation of the high-pressure steam. The invention has been designed especially for use in conjunction with locomotive engines, but is suitable for other boiler plants as well, particularly those of a portable or traveling character such as, for instance, those of portable engines, ships or vehicles of all kinds.

In my preferred boiler plant I provide two boiler sections, one of which is constructed as a fire-box and used to generate, by indirect heating, live steam of a high pressure, say at least 30 atm., while the other boiler, which generally is a fire tube boiler, will be employed to generate steam of up to about 20 atm. The existing fire tube boiler of usual locomotives may be utilized when such a locomotive is converted into an improved one embodying my present invention. These existing locomotives may be converted readily into high-pressure locomotives, by the addition of a separate high-pressure boiler and by making certain other changes that will appear from the description following hereinafter. Among these changes I will mention the provision of a special fire box for the high-pressure boiler and the provision of a high-pressure cylinder in addition to those in use originally, or instead of this a new set of cylinders may be provided. The high-pressure steam produced by indirect heating is then conveyed to the high-pressure cylinder or cylinders and allowed to expand therein down to the pressure usually employed for the live steam of existing locomotives, for instance about 16 atm. The exhaust steam of the high pressure steam is then mixed with the steam generated in the low-pressure boiler, and the mixture is then employed as the motive agent in the subsequent stages of the engine. The new high-pressure locomotive requires no material alterations in the present way of constructing or operating it and yet will show an advantage of from 25 to 35% as compared with existing locomotives, either in horse power, or if no increase in horse power is desired, a corresponding saving in fuel will be effected. Even converting existing locomotives into high-pressure locomotives according to the present invention will enable the fuel consumption to be reduced about 20%. The weight of the locomotive is not increased and there are no difficulties as regards the arrangement of the boiler or of the engine proper. It is well known that engines employing a high initial steam pressure will yield better results if operated with intermediate superheating of the steam; such intermediate superheating can be carried out very readily with fire gases of the locomotive when constructed according to this invention, since the difficulties experienced with stationary engines on account of questions of available space, do not arise with locomotive engines.

Two satisfactory and preferred forms of my invention have been illustrated in the accompanying drawings, in which Fig. 1 is a longitudinal section of a locomotive engine embodying my present improvement, Figs. 2 and 3 are cross-sections on the lines 2—2 and 3—3 respectively of Fig. 1, Fig. 4 is a cross-section on line 4—4 of Fig. 5 showing a detail of a second form of my invention, and Fig. 5 is a longitudinal section of the drum with the heating coils shown in full.

Referring first to the construction illustrated by Figs. 1, 2 and 3, A indicates the fire box of the engine, constructed of a system of tubes constituting together a high-pressure steam generator. The drawings show these tubes as located at the sides and top of a fire box or furnace in which fuel is burned in any suitable manner, for instance, upon grates as indicated in Figs. 1 and 2. This boiler A is intended to supply steam at a pressure of at least 30 atmospheres and the construction is such that pressures of 80 atmospheres and even higher may be obtained readily. At *d*, I have indicated the upright pipes forming the side walls of the fire box, the steam generated in these upright pipes passing to the longitudinal collectors *g*, located at the upper

ends of the pipes *d*, while the lower ends of said pipes are connected with longitudinal collectors *f*. At the upper portion of the locomotive above the fire box, I have indicated a steam and water drum *e* within which is located a heating coil arrangement *h* connected at its upper portion with the collectors *g*. The lower portion of the heating arrangement *h* is connected with tubular vessels *k*, from which conduits *i* lead to the lower collectors *f*. Thus, the water or other medium employed in this part of the structure will circulate within the parts *f*, *d*, *g*, *h*, *k*, and *i*. From the drum *e* a conduit *l* leads to the saturated steam chest *m'* of a superheater C. The chests m^2 containing the superheated steam are connected with the high-pressure cylinders E by a conduit *n*. Another conduit *o* leads from each of these cylinders to a pipe *p* affording a connection to the low-pressure cylinders F and also affording another connection to the superheater D, which heats the steam coming from the boiler B. This latter boiler may be a fire tube boiler of the usual type supplying steam at a pressure of say 16 atmospheres. From the steam dome of this boiler, a pipe *s* conveys the saturated steam to the superheater D. From the low-pressure cylinders, a conduit *q* leads to the blast pipe *r*.

The drum *e* is provided with a safety valve *t* connected with the boiler B by a conduit *u* in such a manner that any excess of pressure arising in the drum *e* may be relieved by the passage of steam into the boiler B.

H indicates a feed water pump which takes a portion of the water contained in the boiler B, through a pipe *v* and delivers such water as feed water to the high-pressure boiler A, through a conduit *w*. In view of this arrangement, the deposit of boiler scale will take place largely in the boiler B, thus relieving the high-pressure boiler A of such deposits.

It will be seen that in the example illustrated and described above, the high-pressure steam generated by utilizing the heat of the fire box is produced in the drum *e* by indirect heating. In any event, the level of the water is higher in the fire box generator in which the high-pressure steam is produced than in the boiler B in which the low-pressure steam is generated, and the water and steam spaces of said high-pressure generator are separate from those of the low-pressure boiler.

The boiler plant described above operates as follows:

In the fire box A, the radiant heat and the heat of the combustion gases are absorbed by the heat carrying medium (water) circulating through the parts *k*, *i*, *f*, *d*, *g*, *h*, and in the coil or equivalent heat transferring device *h*, the heat of this heat carrier is transferred to the water in the boiler or drum *e*, so that high-pressure steam (30 atm. or over) is produced in said boiler *e*. After thus producing high-pressure steam with the aid of the heat carrying medium circulating through the path indicated above, the combustion gases enter the fire tubes or smoke tubes of the boiler B and pass therethrough to the smoke box to finally escape through the stack. In this boiler B, the steam of comparatively low pressure is produced. If the boiler B is constructed for generating steam at the customary pressure of about 16 atmospheres, it is advisable when using such a boiler in conjunction with my invention, to operate at a somewhat lower pressure, for instance, about 13 atmospheres. Should the boiler *e*, heated by means of the fire box A, temporarily generate more steam than required for the operation at that moment, the excess steam may be passed to the boiler B through the valve *t* and the conduit *u*. This boiler B will therefore then serve as a storage receptacle or accumulator. The combustion gases flowing through the smoke tubes of the boiler B serve not only for the generation of steam but also for superheating the steam coming from the high-pressure section A as well as the steam coming from the low-pressure section B. In the particular embodiment illustrated, the superheater D has been shown as of the type in which the smoke flues are comparatively large, while for the superheater C, I have shown a construction using comparatively small smoke flues. The exhaust steam from the high-pressure cylinder E becomes mixed in the conduit *p* with the steam coming from the boiler B by way of the superheater D, and this steam mixture then enters the cylinders F, see Fig. 3, from which it passes through the conduit *q* to the blast pipe *r*. Check valves *x* located in the conduits *p* prevent the passage of the exhaust from the high-pressure cylinders to the superheater D and the boiler B, if, for any reason, this exhaust should be of a pressure higher than that prevailing in the boiler B. In this manner, I obtain the advantage that the oil contained in the exhaust of the high-pressure stage will not reach the superheater with the attending danger of having the oil burn and stick to the walls of the superheater, and the oil is also utilized for the lubrication of the low-pressure stage. Furthermore, the superheat contained in the exhaust is not lost, as it would be if the exhaust were allowed to come in contact with the saturated steam or with the water contained in the boiler B. Mixing the low-pressure steam coming from the boiler B and superheater D, with the exhaust steam of the high-pressure stage, insures an effective superheating of the steam admitted to the low-pressure cylinders. The check valves also, to a certain extent, regulate automatically the steam supply to the low-pressure stage.

The fire box A serving as a high-pressure boiler or as part of such boiler, occupies a

space about equal to that of the usual fire box. Should it be necessary in any particular case to enlarge this space, the boiler B could be shortened correspondingly. If the fire box is made with a heating surface of proper area, the reverse connections at the ends of the superheater elements can be arranged close to the front flue sheet of the boiler B without any detrimental effect and thus effective superheating of the steam of both boilers may be obtained.

Figs. 4 and 5 illustrate another form of the device located in the drum *e* for generating steam from the water contained in such drum. In other words, Figs. 4 and 5 illustrate another species of the indirect heating arrangement, which may be substituted for the heating coil *h* shown in Figs. 1 and 2. In other respects, the construction of the boiler may be exactly as shown in Figs. 1, 2 and 3, and it will be understood that the parts not shown in Figs. 4 and 5 might be of the same construction as represented in Figs. 1, 2 and 3. In both constructions the connections which carry the fluid to and from the interior of the heating coils *h* extend through the side wall or shell of the drum *e*, and the individual coils themselves are arranged in planes extending transversely of said drum. The arrangement of the individual coils transversely of the drum offers important advantages in that transverse coils are less bulky and lighter than longitudinal coils such as have been employed hitherto generally when indirect heating was resorted to. It will be evident that if heavy coils have to be removed from a boiler drum when repairs are necessary, this offers considerable difficulties; hence, the substitution of transverse coils for longitudinal coils is a decided improvement. Certain difficulties are also met in practice when the connections to the heating coils extend through the end walls of the drum, as the space available at this point is often cramped. In both forms of my invention illustrated, I have avoided extending any of the connections to the heating coils through the end walls or heads of the drum, and have arranged all these connections to pass through the side wall or shell of the drum. Moreover, the connections have been arranged in such a way as to allow each of the individual coils or units to be disconnected individually from its supply pipe and discharge pipe, thereby facilitating very considerably the individual removal of the heating units and repairs thereto. As shown in Fig. 4 the portions of such connections extending through the side wall of the drum are shorter than the clearance between the opposite ends of the heating units and the adjacent portion of the drum wall to permit such removal. The heating units are also of greater width than height for the same purpose. The transverse arrangement of the heating coils also enables a great heating surface to be obtained than when the heating coils range lengthwise of the drum. Furthermore, when the heating coils extend lengthwise, only a relatively small inclination can be given to them, and the discharge of water resulting from condensation, toward one end of the coil, is relatively slow. When, however, the heating coils are disposed transversely of the drum, they can be inclined at a much greater angle, so that the flow of water resulting from condensation will be much more rapid than in the other case. Finally, the transversely disposed heating coils are much more readily accessible, for instance for the purpose of removing scale from their outer surfaces, since hand-holes provided in the shell of the drum will give access to all parts of the heating coils much more readily than hand-holes provided only in the heads of the drum.

According to Figs. 4 and 5, the transverse heating coils located within the drum *e* are constructed in groups, of which four have been shown in Fig. 5, and designated respectively as 2, 3, 4 and 5. Each of these groups or units, as illustrated, comprises five coils arranged in parallel transverse vertical planes, and each coil is represented as having eight superposed transverse members the adjacent ends of which are connected by bends, as shown best in Fig. 4. The upper ends of the five coils of the same group or unit are connected with a supply chamber or header 6, 7, 8 and 9 respectively, while their lower ends are connected with a discharge chamber or header 10, 11, 12 and 13 respectively. The superposed transverse members of the individual coils are inclined alternately in opposite directions to facilitate the passage of any condensation of water to the respective discharge chambers or headers. Each of the supply chambers has a connection or conduit 14, 15, 16, 17 respectively extending through the cylindrical side wall or shell of the drum *e*, and similar connections 18, 19, 20 and 21 extend through said shell from the discharge chambers at the lower ends of the units. These inlet and outlet connections are arranged at different points of the length of the drum, and preferably adjoining groups are staggered. Thus, Fig. 4 shows that the group or unit 2 is placed toward the left and the group or unit 3 toward the right, the inlet and outlet connections of group 2 being at the left and those of group 3 at the right. Fig. 5 shows that group 3 is of the same arrangement as group 5 but differs in arrangement from groups 2 and 4, which latter two are of like arrangement. In other words, the odd numbered groups or units have their connections extended through the side wall of the drum at one side, and the even numbered groups or units have their inlet and outlet connections extended through the side wall of the drum at the opposite side. This ar-

rangement facilitates access to the individual connections and moreover minimizes the weakening of the drum wall. Exteriorly of the drum, the conduits 14 to 21 are connected with suitable conduits for the supply of the heating medium and for the return of the heating medium. For instance, the supply connections 14, 15, 16 and 17 might be connected with tubes 22, 23 coming from longitudinal tubes of the same character as those shown at *g* in Fig. 2, and the outlet conduits 18, 19, 20, 21 might be connected with pipes 24, 25 leading to collectors or tubular vessels such as indicated at *k* in Figs. 1 and 2. It will be understood that the fire box construction proper and its connections with the tubes *g*, *k* would be of the same type as shown in Figs. 1 and 2. Each unit has been shown as provided with a holder 26 at the top and a corresponding holder 27 at the bottom to embrace the coils of the same unit, the holders 26, 27 of the same unit being connected and held together by means of bolts 28, 29. At 30 I have indicated an opening in the end wall or head of the drum, and it will be noted that this opening is of such a size and shape that the individual heating units may be passed through it so as to facilitate the insertion and removal of the units. More particularly, the height of the opening 30 is greater than the height of each heating unit and the width of such opening is greater than the depth of the heating unit measured in a direction lengthwise of the drum. It will be understood that when a heating unit is to be removed, it will be first disconnected from the supply and discharge conduits and then turned about 90° so that the plane of the coil which was originally transverse will be longitudinal with respect to the drum, and while the coils are in this position the unit will be moved out through the opening 30. The corresponding reverse operation will be employed when inserting the units.

In the embodiment illustrated by Figs. 4 and 5, connections from and to the heating units are disposed alternately at the left and the right respectively. This construction would be employed especially in those cases where a single drum *e* is employed for the generation of high-pressure steam, as exemplified by Fig. 2. In some cases and particularly in stationary generators of large sizes, the high-pressure portion of the boiler will consist of two or even more steam generating drums of the character set forth. If two such drums are employed, they will generally be located side by side, and the connections of the heating coils would be only at one side of each of the drums, that is, at the left-hand side of the left-hand drum and at the right-hand side of the right-hand drum. Figs. 1, 2, 4 and 5 show that sufficient space is left above and below the heating coils to allow a workman convenient access to these parts when the drum is empty. This arrangement also improves the circulation of water within the drum especially as the last heating coil unit is at a relatively considerable distance from the nearest end wall or head of the drum, see the left-hand portion of Fig. 5. The water contained in the drum and heated by the steam or other medium passing within the heating coils boils violently so as to produce a kind of wave motion, rising along and between the coils, and falling in the spaces free from heating coils, at the ends of the drum, and returning to the lower portion of the drum beneath the heating coils. This circulation is of the character indicated approximately by the arrows I and II in Fig. 5.

Instead of connecting the inlets and outlets of all the heating coil units with the same tubes forming wall portions of the fire box, I may sub-divide the fire box in such a way that two or more separate circulation paths will be provided. For instance, each of the four heating coil units shown in Fig. 5 might have its own set of fire box tubes so that one body of water and steam would circulate through the group or unit 2 while a different body of water and steam would circulate through the group or unit 3, still another through the group or unit 4, and yet another through the group or unit 5. This arrangement of separate circuits for the individual heating units presents the additional advantage that any unit may be thrown out of operation temporarily while the others continue to function.

Various changes in the specific forms shown and described may be made within the scope of the claims without departing from the spirit of my invention.

I claim:

1. In a steam generator, a longitudinal drum adapted to contain water, a plurality of individual heating units comprising pipe members extending in substantially vertical planes transversely within said drum at different points of its length, and individual connections to said units extending through the cylindrical side wall of the drum, said pipe members forming a path directed continuously downward from inlet to outlet.

2. In a steam generator, a longitudinal drum adapted to contain water, a plurality of individual heating units extending in substantially vertical planes transversely within said drum at different points of its length, and individual connections to said units extending through the cylindrical side wall of the drum, said heating units being of greater width than height and consisting of pipe members each inclined downwardly from its inlet end to its outlet end.

3. In a steam generator, a longitudinal drum adapted to contain water, a plurality of individual heating units of greater width than height extending in substantially ver-

tical planes transversely within said drum at different points of its length and consisting of coiled pipe members each inclined downwardly from its inlet end to its outlet end, headers connecting similar ends of the coils of the same unit, and individual connections from said headers extending through the cylindrical drum of the generator.

4. In a steam generator, a longitudinal drum adapted to contain water, a plurality of individual heating units having a greater width than height and comprising pipe members extending in substantially vertical planes transversely within said drum at different points of its length, and individual connections to said units extending through the cylindrical side wall of the drum, the portions thereof extending through the side wall of the drum being shorter than the clearance between the opposite ends of the heating units and the adjacent portion of the drum wall, said pipe members forming a path directed continuously downward from inlet to outlet.

5. In a steam generator, especially for locomotives, a fire box boiler comprising a longitudinal drum adapted to contain water, a plurality of individual heating units extending in substantially vertical planes transversely within said drum and comprising pipe members each inclined downwardly from its inlet end to its outlet end, pipes forming the walls of the fire box, and exposed to the heat of the fire, connections between said heating units and said pipes for circulating a heating medium through said pipes and heating units, the pipe members of the latter presenting, within said drum, a path for said heating medium directed continuously downward from inlet to outlet.

6. In a steam generator, a longitudinal drum adapted to contain water, a plurality of individual heating units comprising pipe members extending transversely within said drum in planes substantially perpendicular to the axis of the drum and directed continuously downward, and individual connections to said units extending through the cylindrical wall of the drum and arranged to feed a heating medium to the upper portion of said coils and to withdraw the same from the outlet end of such coils.

7. In a steam generator, a longitudinal drum adapted to contain water, a plurality of individual heating units comprising pipe members extending transversely within said drum and in planes substantially perpendicular to the axis of the drum, and directed continuously downward, and individual connections to said units extending through the cylindrical wall of the drum and arranged to feed a heating medium to the upper portion of said coils and to withdraw the same from the outlet end of such coils, the connections through the drum to adjacent units being arranged at opposite sides of the drum.

8. In a steam generator, especially for locomotives, a fire box boiler comprising a longitudinal drum adapted to contain water, a plurality of individual heating units comprising pipe members extending transversely within said drum in planes substantially perpendicular to the axis of said drum and directed continuously downward, pipes forming the walls of the fire box and exposed directly to the heat of the fire, connections between said heating units and said pipes whereby a closed circulating system is formed, and a heating medium in said system, said medium being fed into said heating units at the upper portions thereof and withdrawn from the lower outlet ends thereof, said pipe members presenting a plurality of heat-exchange surfaces for said heating medium and the water in said drum distributed along the length of the latter.

In testimony whereof I have hereunto set my hand.

OTTO H. HARTMANN.