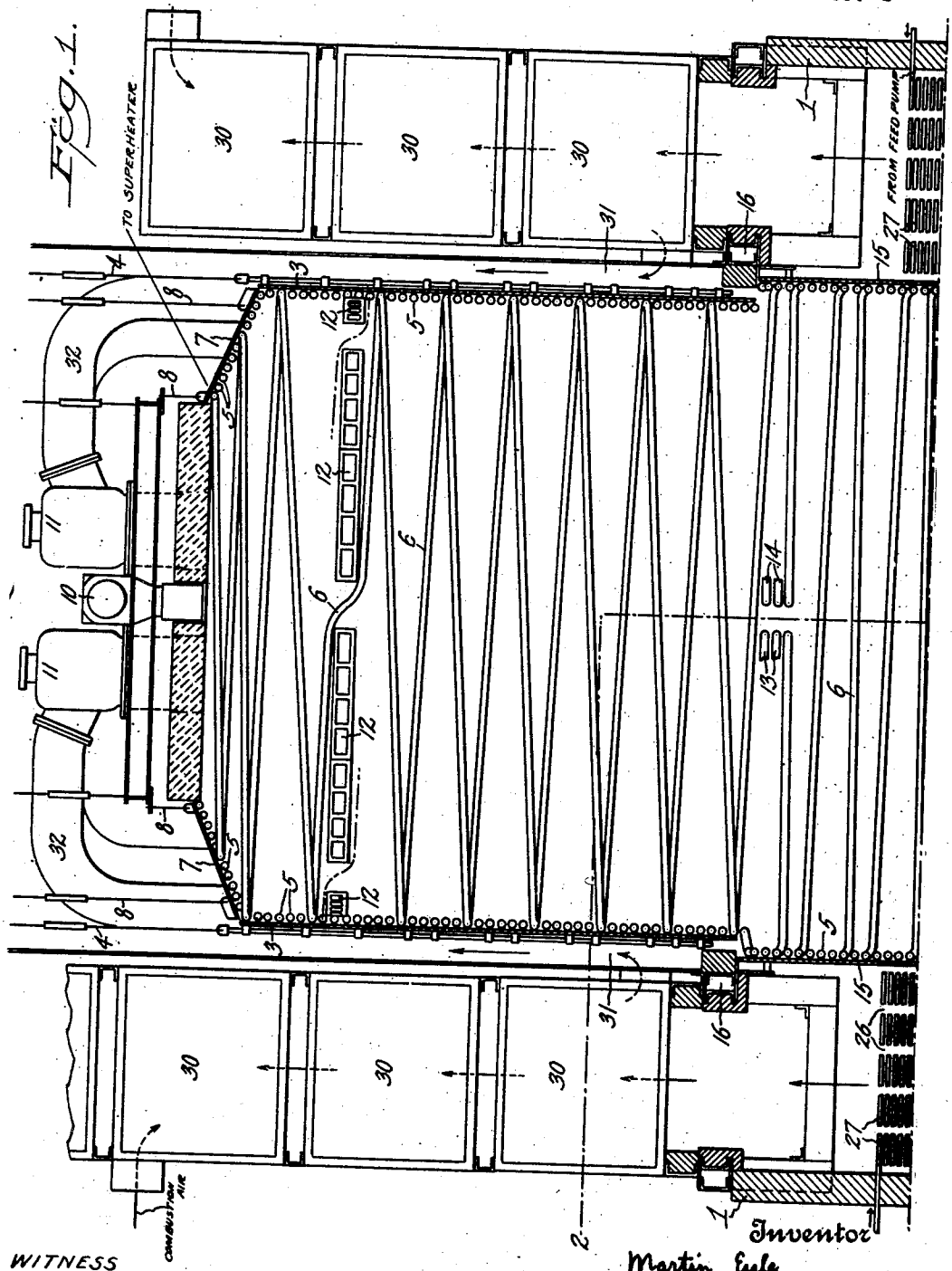
Jan. 31, 1933. M. EULE 1,895,790

TUBULAR STEAM BOILER

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Fig. 1.



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TUBULAR STEAM BOILER

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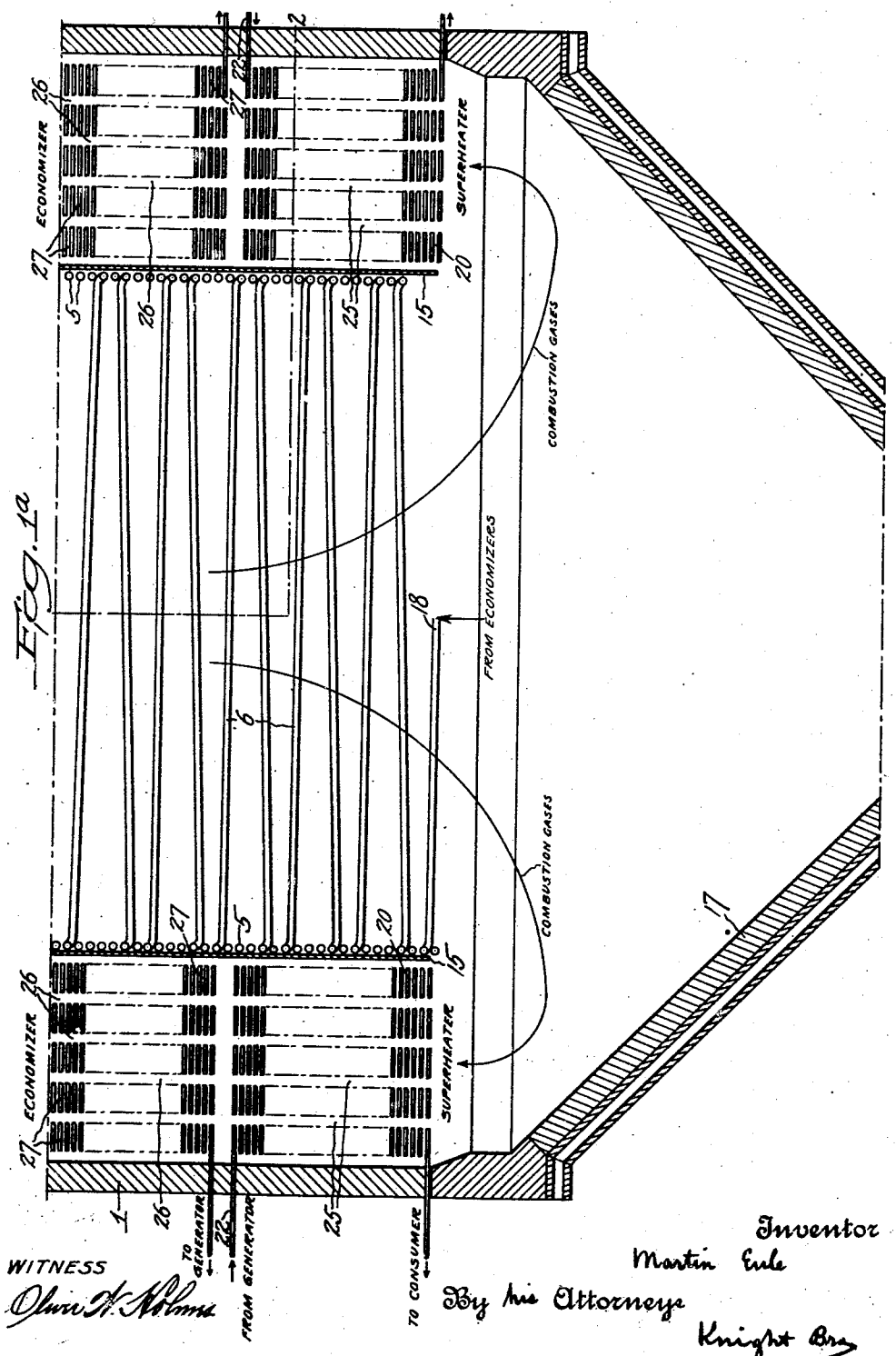


Fig. 1a

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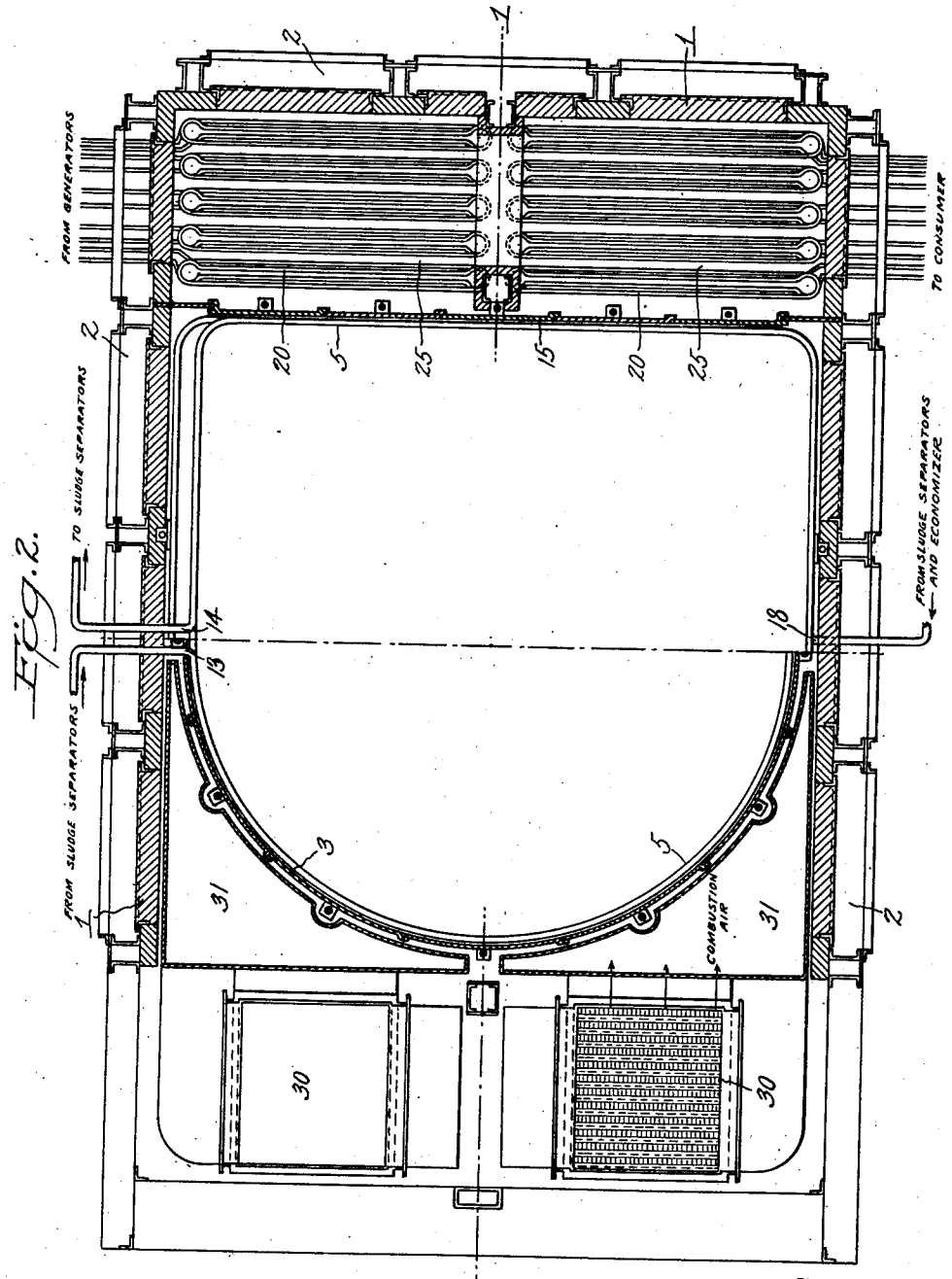


Fig. 2.

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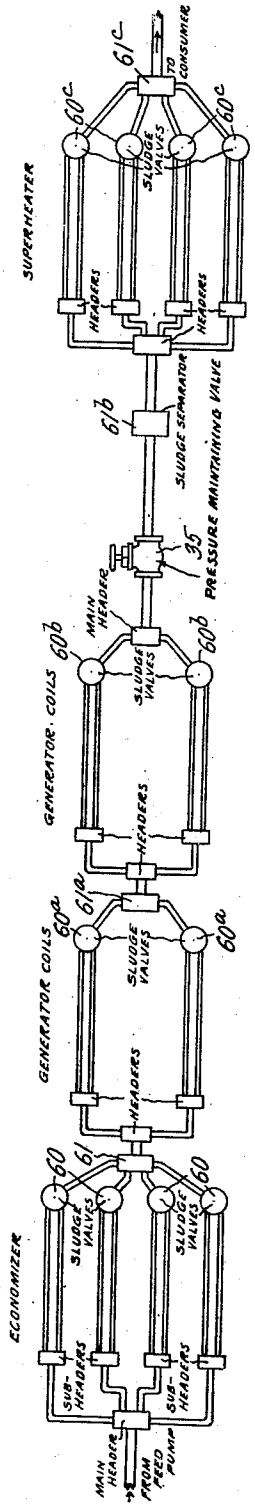


Fig. 3.

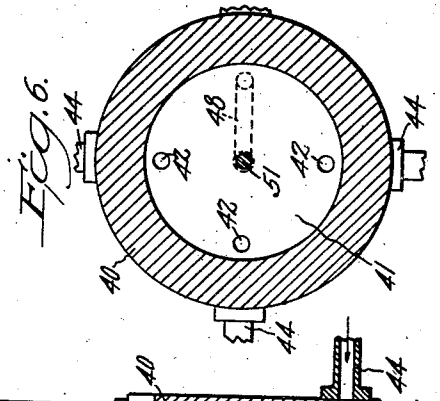


Fig. 6.

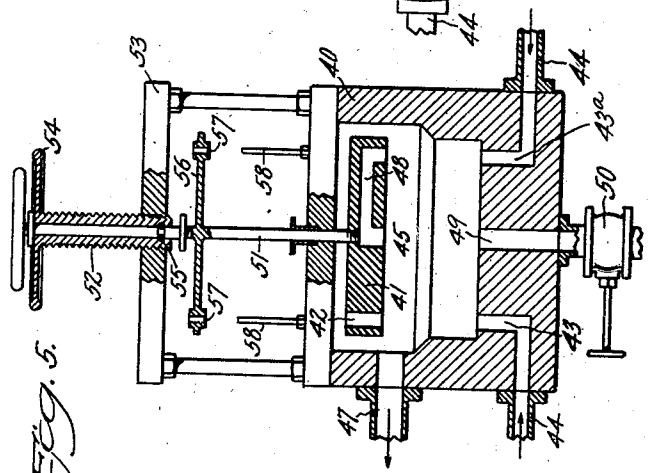


Fig. 5.

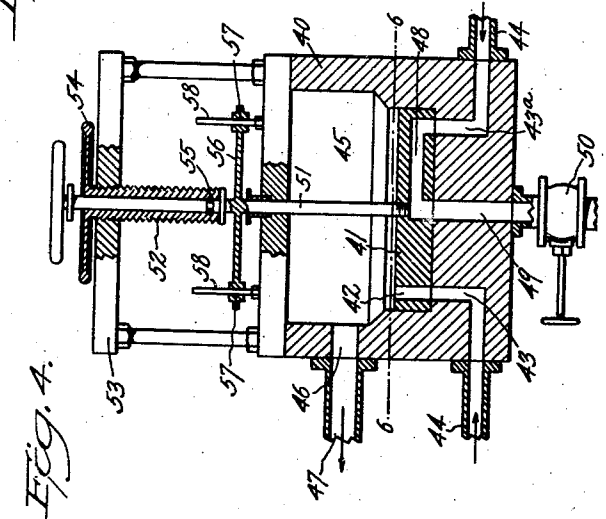


Fig. 4.

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Fig. 7.

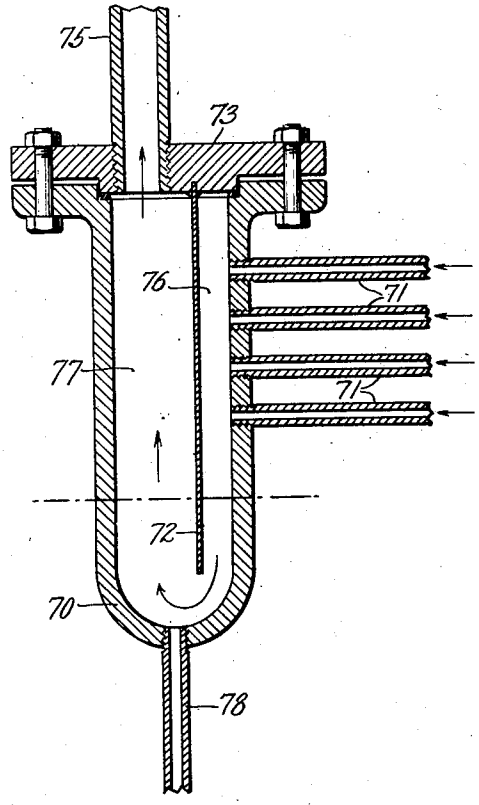
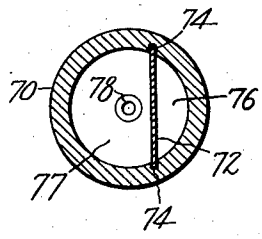


Fig. 8.



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UNITED STATES PATENT OFFICE

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TUBULAR STEAM BOILER

Application filed November 14, 1929, Serial No. 407,137, and in Germany March 14, 1929.

My invention relates to tubular steam generators and in particular to the type of generator in which steam is produced at or near critical pressure and in which comparatively high temperatures are employed in the combustion chamber, all of which features involve particular constructions different from those heretofore employed in the art.

The specific improvements involve first, the provision of a vertical boiler of polygonal outside contour, having a cylindrical combustion chamber in the first part, and a polygonal, specifically rectangular combustion chamber in the second part of the path of the flame, the walls of both chamber portions being lined with steam generating tubes (which form respectively round and rectangular coils), whereby these coils form as it were the walls of the combustion chamber. Second, the provision of a combustion chamber dome which is circumferentially partly built up of generating tubes. Third, the arrangement of the tube coils in the form of multiple thread pipe coils, the individual threads being discontinuous, i. e. interrupted at certain intervals at which they terminate in common headers and auxiliary devices, to be described more fully hereinafter, for the purpose of mixing the operating medium passing through the individual tubes, and for redistributing the medium uniformly among the subsequent threads, and for facilitating the blowing out of the individual tubes in order to remove the sludge and scale apt to collect during the operation. Fourth, the arrangement in such a steam generator of the steam generating tubes and the superheating tubes and the economizing tubes in such manner that all steam generating tubes form the walls of the combustion chamber and receive the heat originally produced in the chamber by radiation, the superheating tubes being grouped with respect to the combustion gas flow, so as to encounter directly the gases discharged from the combustion chamber, and the economizing tubes being grouped so as to encounter directly the combustion gases after they have passed the superheating tubes.

The accompanying drawings portray the arrangement of such a boiler.

In these drawings

Figs. 1 and 1[a] combined show a longitudinal vertical section through the boiler on the line 1—1 in Fig. 2,

Fig. 2 shows a horizontal section through the boiler on the broken line 2—2 in Figs. 1, 1[a]

Fig. 3 shows a flow diagram of the medium through the boiler.

Figs. 4 and 5 show a sludge and distributing valve (such as is indicated in the flow diagram by the legends) in longitudinal vertical section in two operating positions,

Fig. 6 shows a horizontal section through the valve on the line 6—6 in Fig. 4, and

Figs. 7 and 8 show in longitudinal vertical and in transverse section respectively a suitable form of continuous sludge separator, indicated in Fig. 3.

Referring to Figs. 1 and 1[a] the boiler structure comprises in its lower portion a vertical wall structure 1 which may be surrounded for heat insulating purposes by an air jacket 2 shown in detail in Fig. 2. This air jacket, for simplicity's sake and in order to save space, has been omitted in Figs. 1 and 1[a] since it has no particular bearing on the novel features of the present invention. Within this outer wall structure is suspended the combustion chamber which contains the generating tubes in the following manner. The upper portion of the chamber shown in Fig. 1 is cylindrically shaped and is formed by an iron cylinder 3 which is suspended from the roof structure of the boiler, (not shown here) by means of cables 4. On the inner periphery of this cylinder are disposed the cylindrical tube coils 5 spaced closely adjacent to each other, such that they virtually form the immediate wall of the combustion chamber, thereby protecting the iron cylinder, to which the tubes are attached by suitable means known in the art, and not shown here, sufficiently from the heat of radiation in the combustion chamber. These generating tubes 5 while spaced closely adjacent to each other do not form a single coil, but form a multiple thread coil, a single tube of this group of

threads having a considerable pitch such as is shown with respect to one single tube coil 6 in Fig. 1. The remaining tubes are only shown in cross-section so as not to obscure the view. The cylindrical combustion chamber is closed at the top by a dome which is partly formed by generating tubes 5 also arranged in multiple thread fashion, as has just been described, and fastened to iron plates 7 suspended from the roof structure of the boiler by means of cables 8. The central portion of the dome is composed of refractory material suspended from the superstructure, and in this refractory disc the nozzles 10 and 11 for the fuel and air are arranged. Thus, the heat is supplied in this particular boiler from the top.

A short distance from the top secondary air nozzles 12 are provided in the wall circumference of the combustion chamber. These nozzles are arranged in groups spaced apart as shown, and the generating tubes pass between these groups as shown in full lines with respect to one single tube and in dash-dot lines with respect to some of the other tubes. At the point 13 the entire group of tubes, coming from the top and forming the multiple thread coil, is interrupted in its path through the combustion chamber, and is led to a header outside of the combustion chamber. The detail arrangement of the header structure with respect to the boiler structure is immaterial. Its functional position will clearly appear from Fig. 3 which will be shortly described. At the point 13 in Fig. 1 only a few of the group of coils coming from the top are shown for simplicity's sake. One half of the upper portion of the cylindrical combustion chamber is shown at the left hand portion of the horizontal section, Fig. 2, and there some of the coils are shown leading to the outside at the point 13.

The tubes reenter the combustion chamber at the point 14 closely adjacent to 13 and continue forming the lower part of the combustion chamber which will now be described. Referring to the lower portion of Fig. 1 and to Fig. 1ª and Fig. 2, right hand side, it will be noted that this portion of the combustion chamber is substantially rectangular. It is formed by an outer wall of plate iron 15 which is attached to the supporting structure 16 of the boiler housing, this iron mantle carrying on its inner periphery the generating tubes 5 in multiple thread coils similar to the manner which has been explained with reference to the upper cylindrical portion of the boiler. Here again only one single tube thread 6 is shown for clearness sake, and in order to portray the approximate pitch at which each of the individual tube threads passes downward along the wall of the chamber. This rectangular combustion chamber extends down to the lower portion of the outer wall structure 1 of the boiler, and substantially to the point at which this outer boiler structure is contracted to form a funnel 17 at the bottom of which the ashes are collected and removed (not shown here). At the lower end of the rectangular combustion chamber the tubes leave the chamber as shown at the point 18 and are lead to another header and to auxiliary devices not shown in Fig. 1ª, but which will appear from Fig. 3.

As will appear from Fig. 1ª and from the right hand side of Fig. 2 a considerable space is provided between the iron walls 15 of the rectangular combustion chamber, and the outer wall 1 of the lower boiler structure. Within this space the superheater tubes 20 are disposed in a plurality of parallel groups corresponding with the number of groups of generating tubes passing through the boiler, and being divided if necessary into additional parallel groups among themselves as expediency may dictate. This latter feature is not shown in the drawings as being obvious and well known in the art. The essential feature according to the present invention is the arrangement of these groups of superheater tubes 20 in a space adjacent to the lower portion of the combustion chamber, and at a point at which they are encountered directly by the combustion gases as they leave the combustion chamber. The path of the combustion gases is indicated in Fig. 1ª by the two curved arrows. These groups of superheater coils extend only a small distance upward on two opposite sides of the rectangular combustion chamber, so that they are located in the hottest zone of the discharged combustion gases. The legends in Fig. 1ª "To superheater" and "From generator" (at the point 22) indicate where the generating tubes leave the combustion chamber and where they enter the superheater groups. At the lower portion of the superheater chamber the superheater tubes leave the boiler and lead to the consumer. This point is indicated in Fig. 1ª by the legend "To consumer". The particular chamber portion in which the superheater coils are located as indicated in Fig. 1ª and Fig. 2 with 25. The discharged combustion gases rise in the superheater chamber 25 and encounter in the upper portion 26 of this chamber groups of economizer tubes 27 in which the water delivered by the feed pump is heated preliminary to its supply to the steam generating tubes. The upper ends of these economizer coils shown in Fig. 1 receive the water delivered by the feed pump and the lower ends of these coils discharge the water, as shown in the upper portion of Fig. 1ª by the legend "To generator". With this latter legend corresponds the legend appearing in the lower portion of Fig. 1ª "From economizer" which points to the beginning of the steam generating tubes at the bottom of the combustion chamber into which the water

discharged by the economizer is delivered in well heated condition.

The hot gases leaving the economizer space travel in the direction of the arrows in Fig. 1 and pass through the air preheaters 30 which are represented in Fig. 1 by three squares on diametrically opposite sides of the cylindrical combustion chamber and which may be of any suitable type known in the art. In Fig. 2 one of the air preheaters is diagrammatically shown in section. It consists of a large group of plates between which alternately combustion gases and combustion air pass. The details have been entirely omitted in this illustration and only the portions of the preheater carrying combustion air have been indicated with horizontal dashes, and those portions carrying combustion gases have been indicated with vertical dashes. The combustion gases are finally discharged from the preheaters into the upper portion of the boiler structure, not shown here. The combustion air which enters the preheaters at the top as shown by the curved arrows in Fig. 1 leaves the lowermost air preheaters at the point shown by the curved arrows and enters the spaces 31 between the air preheaters and the cylindrical combustion chamber portion. These spaces are more clearly shown at the left hand portion of Fig. 2 and occupy the corners formed by the outside boiler wall 1 and the superheaters and the cylindrical portion of the combustion chamber. The air rises in these spaces and thereby protects the iron plate walls 3 of the cylindrical combustion chamber against overheating by carrying the heat conveyed by the boiler tubes away. Thus, the combustion air is simultaneously further heated before it is supplied to the burners. The combustion air enters the air supply ducts 32 which lead to the air supply nozzles. The details of this arrangement are not shown in the drawings as these features do not form part of, and are not necessary for the understanding of the present invention. They are besides well known in the prior art.

Referring now more particularly to Fig. 3 which represents the flow diagram, it will be noted that the water supplied by the feed pump enters the system at the left hand end indicated by the legend "From feed pump". It first enters a main header so labeled, whence it is distributed over a number of sub-headers also thus labeled, and from these sub-headers the water enters the economizer tubes 27 located in the economizer chamber 26 shown in Fig. 1^a. Before the water discharged by the economizer enters the generating coils as described hereinbefore, it passes, as shown in Fig. 3, through a group of sludge separators 60 indicated in Fig. 3. These valves will be described hereinafter in detail with reference to Figs. 4 to 6. The object of these valves is to selectively connect each individual economizer tube through a blow down valve, with a chamber of low pressure, or with the outside atmosphere, and thus to blow out the content of one individual tube line together with all sludge which may be deposited therein. From sludge valves 60 the water passes into a sludge separator 61 of the continuously separating type, also to be described in detail hereinafter with reference to Figs. 7 and 8, and thence through a number of headers into the steam generating coils of the boiler at 18, the point in Fig. 1^a labeled "From economizer". The generating coils in leaving the rectangular portion of the combustion chamber at the point 14 in Fig. 1 enter outside of the boiler a number of sludge valves 60^a of the type aforementioned and indicated in Fig. 3, whence the steam passes into another continuously operating sludge separator 61^a and thence into a number of headers so labeled, through which it reenters the boiler at point 13 in Fig. 1. When the steam is discharged from the generating chamber at the upper part of cylindrical coils 5 in Fig. 1, it first enters again a number of sludge valves 60^b as shown in Fig. 3, before the steam is collected from all the coil groups by a main header so labeled in Fig. 3. From this main header the steam enters a pressure maintaining valve 35, which is indicated in Fig. 3 only in a conventional manner, before it passes through another continuous sludge separator 61^b and a number of headers and sub-headers into the superheater coils shown in Fig. 1^a and thus labeled in Fig. 3. Before the steam is discharged from the superheater into the conduit that leads to the consumers as shown in Fig. 1^a it first passes, as indicated in Fig. 3 at 60^c again through a number of sludge valves and a continuous sludge separator 61^c.

The interposition of such a large number of sludge valves and separators is extremely important in this type of tubular boiler on account of the comparatively small cross-section of the tubes in which even slight reductions in cross-section by accumulating scale and sludge may have very undesired and detrimental results.

In Figs. 4 to 6 I have illustrated in detail one of the forms which the sludge valves 60—60^c mentioned hereinbefore with reference to Fig. 3, may assume for practical purposes. Referring to Fig. 4 more particularly, it will be noted that such a valve consists of a valve body 40 in the bottom of which a disc 41 is located which is provided with a number of axial borings 42, (in this case 3, see Fig. 6) arranged in a circle, which borings register with similarly arranged passages 43 provided in the bottom of the casing. To these casing passages 43 are connected the individual tubes 44 which may come from any of the boiler portions such

as the economizer or the generator or the superheater. As will be noted from Figs. 4 and 6 the passages 42 of disc 41 register in this case with three of the tube passages, so that the tubes 44 connected to these passages can freely discharge their contents into the casing space 45 which is connected with an outlet 46 to which one of the main conduits 47, for instance such as would be employed between the economizer and the generator, or between the generator and the superheater is connected.

Disc 41 is provided besides with an internal passage 48 which terminates at one end in the bottom center of the disc and at the other end at the periphery of the same circle on which passages 42 terminate. Thus, passage 48 registers with one of the passages 43 provided in casing 40, for instance in the present case with the passage denoted with 43^a in Fig. 4, so that the steam discharge through passage 43^a into the valve will not reach the interior 45 of the valve, but will be discharged through a central bottom passage 49 provided in the casing as soon as the valve 50 connected at this point to the valve casing is opened. Thus, any sludge which has collected in the tube 44 which is connected to the inlead 43^a of the casing will be directly discharged at high speed through valve 50 without reaching the interior of the casing.

Disc 41 is normally raised from its seat as shown in Fig. 5, so that all tubes 44 connected to the valve can freely discharge the operating medium into the interior 45 of the valve casing, whence it passes out through conduit 47. Disc 41 is raised by means of a valve rod 51 which is disposed in a screw spindle 52 threaded into a yoke 53 mounted on top of valve casing 40. This screw spindle can be operated by a wheel 54. Spindle 51 is prevented from axially shifting in screw spindle 52 by means of two pins 55. When valve disc 41 is raised, as shown in Fig. 5, it can be rotated into any position in which its internal passage 48 registers with the desired tube to be flushed, and in order to exactly ascertain from the outside the desired tube, valve rod 51 is provided on the outside with a disc 56 which has holes 57 at its periphery corresponding in number and angular position with the bottom passages 43 of the valve casing. Two diametrically opposite pins 58 are provided on top of the valve casing by which the disc 56 is engaged when in the desired angular position, and then the valve disc can be lowered onto its seat for the purpose of flushing the desired tube.

It will be noted that such a sludge valve may serve the purposes of a sludge valve proper, such as is indicated by the round symbols in Fig. 3, as well as also the purpose of a header, collector, or distributor.

The continuous sludge separators 61—61^c mentioned hereinbefore may be constructed for instance as shown in Figs. 7 and 8 as follows. 70 represents a container of suitable form in the lateral wall of which terminate the tubes 71 which carry the medium from which the sludge is to be continuously removed. In container 70 is arranged in vertical position, and rather close to the terminals of tubes 71, a transverse baffle plate 72 which extends from the container cover 73 in which it is fixed down to the vicinity of the container bottom. As shown in Fig. 8 this baffle plate is guided at its lateral edges in slots 74 provided in the container wall. Thus the chamber formed by the container is divided into two compartments 76 and 77 of unequal volume, in the smaller of which 76 the medium supply tubes terminate, and the larger of which 77, is connected at the top with the medium discharge tube 75, through which the medium collected from all tubes 71 is conducted away. By this arrangement the medium flows downward at high velocity through the small compartment 76 and, reversing its flow abruptly at the lower end of baffle plate 72, flows upward at low velocity through compartment 77. By this sharp diversion of the flow and its speed reduction thereafter the solid matter contained in the medium is constantly thrown towards the bottom of the container, whence it can be continuously drained off through discharge pipe 78.

I claim:

1. A vertical boiler having a polygonal outside contour and having a vertical combustion chamber, and means for supplying fuel from one of its ends, the portion of said chamber near the fuel supply having cylindrical form, and the remainder of the chamber having polygonal form, and steam generating tubes arranged in coils along the walls of both chamber portions to follow respectively the round and polygonal contour of said chambers, said combustion chamber being dome-shaped at its fuel supply end, said dome consisting in part of a pipe coil following the dome contour and uniformly surrounding the flame emanating from the fuel supply and forming part of the generating coil system, whereby the coil dome is heated by radiation from said flame.

2. A vertical boiler having a polygonal outside contour and having a vertical combustion chamber, and means for supplying fuel from one of its ends, the portion of said chamber near the fuel supply having cylindrical form, and the remainder of the chamber having polygonal form, and steam generating tubes arranged in coils along the walls of both chamber portions to follow respectively the round and polygonal contour of said chambers, the coils in said combustion chamber being divided into two main sections, one located in the cylindrical portion, the other in the polygonal portion of the

chamber, each section being composed of a multiple thread coil, sludge valves, headers and subheaders for connecting the individual threads of each section and for connecting said two sections, to purify and redistribute the operating medium during the vapor generating process.

3. A steam generator having a polygonal outside contour and having a combustion chamber whose walls are lined with steam generating tubes, and means for supplying fuel from one of its ends, a plurality of convection chambers containing heat absorbing elements and being located outside of the walls of said combustion chamber, but within the outside contour of the generator, and being arranged to receive each a portion of the combustion gases from said combustion chamber, the portion of said combustion chamber near the fuel end having substantially cylindrical form and the remainder having polygonal form similar to the polygonal generator form, whereby the gas streams passing from the polygonal chamber portion into the several convection chambers are uniformly distributed over the entire width of the convection chambers.

4. A steam generator having a combustion chamber, and means for supplying fuel to it at one of its ends, and at least one convection chamber arranged to receive the gases from said combustion chamber, both kinds of chambers containing heat absorbing elements, the portion of said combustion chamber near the fuel supply end having substantially cylindrical form, and the remainder of said chamber having polygonal form, whereby the gas streams passing from the polygonal combustion chamber portion into the convection chamber are uniformly distributed over the entire width of the convection chamber.

5. A steam generator having a combustion chamber, and means for supplying fuel to it at one of its ends, and at least one convection chamber arranged to receive the gases from said combustion chamber, the portion of said combustion chamber near the fuel supply end having substantially cylindrical form, and the remainder of said chamber having polygonal form, whereby the gas streams passing from the polygonal combustion chamber portion into the convection chamber are uniformly distributed over the entire width of the convection chamber, both of said combustion chamber portions containing heat absorbing tubes forming the wall lining of said chamber, said convection chamber containing superheating tubes.

6. A steam generator having a polygonal outside contour, and having a combustion chamber extending longitudinally through said generator, and means for supplying fuel to said chamber at one of its ends, at least one convection chamber located outside of the combustion chamber wall, but within the outer contour of the generator, and extending substantially over the entire length of the combustion chamber and being connected to the discharge end of said combustion chamber to receive the combustion gases, both kinds of chambers containing heat absorbing elements, the portion of the combustion chamber at the fuel supply end having substantially cylindrical form, and the remainder having polygonal form, the corner spaces formed between said cylindrical chamber portion and the convection chamber having ducts for conveying combustion air to the fuel supply end of said combustion chamber.

7. A steam generator having a polygonal outside contour, and having a combustion chamber extending longitudinally through said generator, and means for supplying fuel to said chamber at one of its ends, at least one convection chamber located outside of the combustion chamber wall, but within the outer contour of the generator, and extending substantially over the entire length of the combustion chamber and being connected to the discharge end of said combustion chamber to receive the combustion gases, the portion of the combustion chamber at the fuel supply end having substantially cylindrical form and the remainder having polygonal form, heat absorbing tubes forming the wall lining for the entire combustion chamber, and superheating tubes disposed in said convection chamber.

8. A steam generator having a polygonal outside contour, and having a combustion chamber extending longitudinally through said generator, and means for supplying fuel to said chamber at one of its ends, at least one convection chamber located outside of the combustion chamber wall, but within the outer contour of the generator, and extending substantially over the entire length of the combustion chamber and being connected to the discharge end of said combustion chamber to receive the combustion gases, the portion of the combustion chamber at the fuel supply end having substantially cylindrical form and the remainder having polygonal form, heat absorbing tubes forming the wall lining for the entire combustion chamber, and superheating tubes disposed in said convection chamber in the portion adjacent to the polygonal combustion chamber portion, and an air preheater disposed in the remainder of said convection chamber.

9. A tubular steam generator having a rectangular outside contour and having a combustion chamber extending in its central portion longitudinally through the generator, means for supplying fuel to said chamber at one of its ends, and heat absorbing tubes in said chamber forming a lining for its entire wall, two convection chambers containing superheating tubes and being disposed on

diametrically opposite sides of said combustion chamber for its entire length, and being connected to the discharge end of said combustion chamber to receive the combustion gases therefrom, the portion of the combustion chamber at the fuel supply end having substantially cylindrical form and the remainder having substantially rectangular form, whereby the gas streams passing from the combustion chamber into the several convection chambers are uniformly distributed over the entire width of said convection chambers.

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