June 15, 1965 M. H. KUHNER 3,189,007

STEAM GENERATING UNIT

Filed Sept. 23, 1963

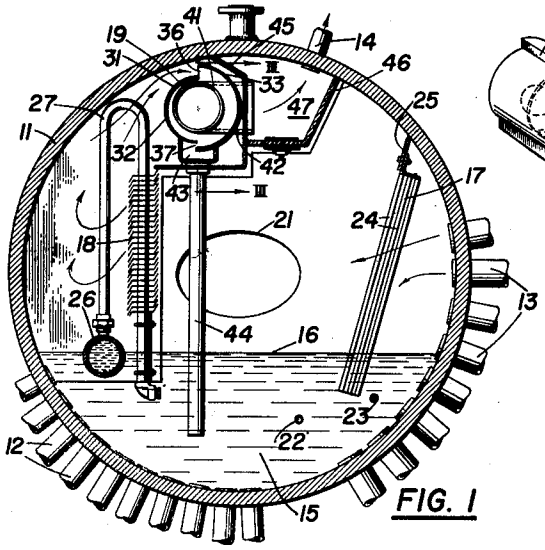


FIG. 1

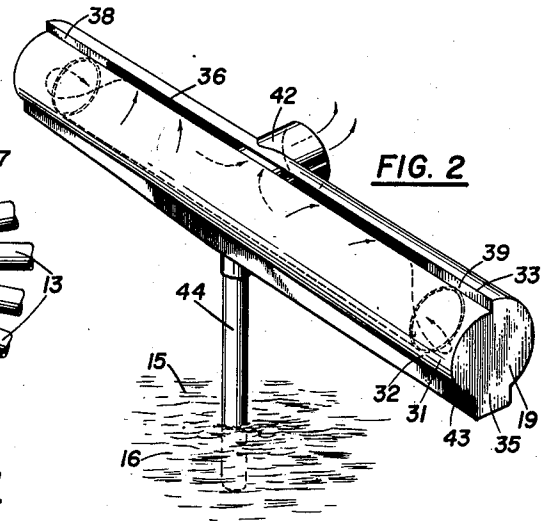


FIG. 2

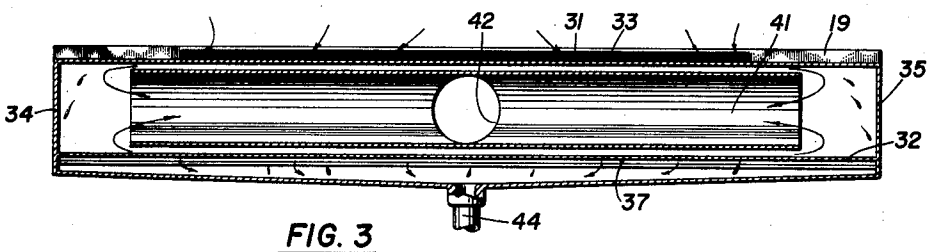


FIG. 3

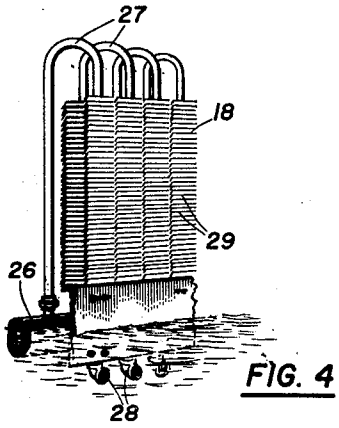


FIG. 4

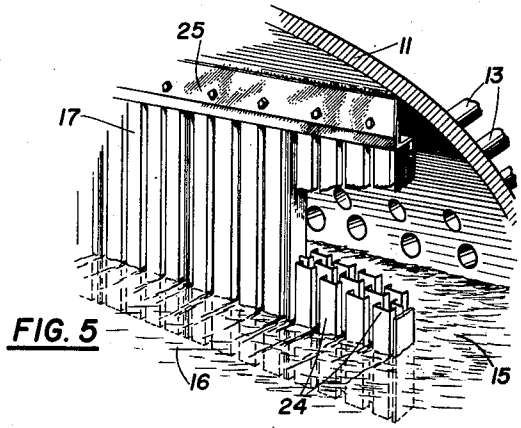


FIG. 5

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STEAM GENERATING UNIT

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This invention relates to a steam generating unit and, more particularly, to apparatus arranged to produce steam for use in an electrical generating turbine.

In the art of generating steam, one of the outstanding problems is that of obtaining pure steam. It is the usual practice to separate the steam from the boiler water in a separating vessel known as a "steam-and-water drum," the water falling to the bottom of the drum for recirculation through the boiler and the steam rising to the top eventually to progress to a turbine. In most cases, however, after leaving the drum, this steam is first subjected to further heating to superheat it. Whether the steam flows directly to the turbine from the drum or is subjected to a superheating step, it is important that no particles of water pass out of the drum with the steam. It is also important that certain chemicals, such as dissolved silica, do not leave the drum with the steam because this would result in a coating of the superheater or turbine surfaces and destroy their effectiveness. Many schemes have been provided in the past for purifying steam in the drum, but they have been, as a rule, quite expensive and have been economically unfeasible for boilers of smaller intermediate size where cost is an important consideration. These and other difficulties experienced with the prior art devices have been obviated in a novel manner by the present invention.

It is, therefore, an outstanding object of the invention to provide a steam generating unit containing a steam separating apparatus which is extremely effective in operation and yet is low in cost.

Another object of this invention is the provision of a steam generating unit containing steam cleaning apparatus which is simple and uncomplicated in construction and which is relatively free of maintenance problems.

A further object of the present invention is the provision of a steam generating unit having steam cleaning equipment which may be readily installed and replaced through a manhole in the steam-and-water drum.

It is another object of the instant invention to provide a steam cleaning apparatus which is simple and uncomplicated in concept and which will not be rendered inoperative by salt deposits or the like.

It is a further object of the invention to provide a steam separator which is inexpensive to manufacture and which is capable of a long life of useful service with a minimum of care.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

The character of the invention, however, may be best understood by reference to one of its structural forms, as illustrated by the accompanying drawings in which:

FIG. 1 is a vertical transverse sectional view of a steam generating unit embodying the principles of the present invention,

FIG. 2 is a perspective view of a steam separator forming part of the invention,

FIG. 3 is a longitudinal vertical sectional view of the apparatus taken on the line III—III of FIG. 1,

FIG. 4 is a perspective view of a steam condenser portion of the apparatus, and

FIG. 5 is a perspective view of a steam release portion of the invention.

Referring first to FIG. 1, wherein is best shown the general features of the invention, the steam generating unit, indicated by the reference numeral **10**, is shown as comprising a steam-and-water drum **11** having boiler downcomer tubes **12** extending from its lower portion, riser or steam release tubes **13** extending into one side, and steam offtake tubes **14** extending from the upper portion. The steam offtake tubes **14** are connected to a superheater and from the superheater to a turbine (not shown). Within the steam-and-water drum **11** is a body **15** of water having an upper surface **16** located generally below the centerline of the drum. Also located in the drum are a primary separator **17**, steam condensers **18**, and a steam separator **19**. The drum is provided with a manhole **21**, a chemical feed pipe **22**, and a continuous blow-down pipe **23**.

The primary separator **17** is mounted immediately in front of the steam release tubes **13** and consists of a series of channel irons **24** arranged in staggered relationship supported at their upper ends on the inside surfaces of the wall by means of a bracket **25** and having their lower ends extending below the surface **16** of the body **15** of water. This construction is shown particularly well in FIG. 5.

The condensers **18** are clearly shown in FIG. 4. A large feed water pipe **26** receives fresh feed water from the feed water pump (not shown). Connected to the upper portion of the pipe **26** are a series of hairpin-shaped pipes **27** having discharge nozzles **28** mounted on their lower or discharge ends which reside below the surface **16** of the water. The intermediate parts of the pipes **27** are provided with fins **29** which act as extended surface elements. The pipes **27** are spaced side-by-side and the fins **29** extend laterally sufficiently so that there is little or no space between them. It is interesting to note that the nozzles **28** are located below the surface **16** of the body **15** of water and are directed at various angles to promote proper distribution of the water within the drum.

Referring to FIGS. 2 and 3, it can be seen that the steam separator **19** consists of a main housing **31** which is of tubular form and which has a generally spiral shape. The housing is formed from a first semi-circular metal sheet **32** and a second semi-circular metal sheet **33** which are held in fixed relation by end plates **34** and **35**. The top edges of the first and second sheets **32** and **33** are spaced radially apart to provide an inlet slot **36**. The bottom edges are separated slightly to provide a water outlet slot **37**. Elongated plates **38** and **39** fill in the slot at the ends adjacent the end plates **34** and **35**, respectively, so that the slot **36**, as is evident in FIG. 2, occupies substantially less than the entire length of the housing **19**. Located generally coaxially of the main housing **31** is a dry pipe **41** which is an elongated tube of circular cross-section having open ends and a steam outlet conduit **42** which is located in its central portion and which extends horizontally through the wall of the second sheet **33** of the housing **31**. Underlying the water outlet slot **37** is an enclosed trough **43** from which extends at least one elongated vertical pipe **44** whose lower end is located well below the surface **16** of the body **15** of water. It should be noted, of course, that the water outlet slot **37** is arranged so that the edge of the first sheet **31** is slightly raised above the edge of the second sheet **33**, for a purpose which will be explained more fully hereinafter. Furthermore, as is evident in FIG. 1, although the dry pipe **41** is generally coaxial of the main housing **31**, its axis is slightly above the axis of the first sheet **31** and slightly to the left of it, thus providing a generally diminishing spiral effect in the passage from the entrance inlet slot **36** around the dry pipe and back to the slot again.

A sheet metal baffle or wall **45** is fastened to the inside surface of the drum **11** immediately above the steam sep-

arator **19**, extends at an angle, then vertically downwardly, and then horizontally to the left (in FIG. 1) to terminate immediately above the top of the fins **29** of the condensers **18**. A second wall **46** is fastened to the inner surfaces of the drum **11** at the other side of the superheater tubes **14**, advances downwardly at an angle and then horizontally to join the vertical portion of the wall **45**. The wall **45** and the wall **46**, therefore, form an elongated enclosure **47** surrounding the ends of the steam offtake tubes **14**. Furthermore, the steam outlet conduit **42** not only extends through the wall of the housing **31** but also extends through the wall **45** into the enclosure **47**.

The operation of the apparatus will now be readily understood in view of the above description. In the usual way, water leaves the body **15** of water and passes downwardly through the boiler downcomer tubes **12**. Eventually, after passing through the boiler and being subjected to heat from hot products of combustion, steam is generated in the tubes and a mixture of the water and steam leaves the riser or steam release tubes **13**. In the ideal situation, of course, pure steam would leave the steam release tubes but, as a practical matter, considerable water falls out of the tube ends into the body **15**. The steam, however, rises and passes laterally over the top of the surface **16** of the body **15**, through the channel irons **24** of the primary separator **17** where a considerable portion of retained water is knocked down and falls into the body **15**. The steam continues laterally across the drum in the area of its horizontal diameter. Eventually, it passes over the condensers **18**. The steam, when it strikes the plates **24**, is condensed because of the cold feed water which enters the system through the feed water pipe **26** and passes through the pipes **27** for discharge into the body **15**. This cold feed water cools the fins **18** as well as the surface of the pipes and the steam passing over these cold surfaces condenses to a certain extent, making the surfaces wet, so that particles of chemical, foreign matter, and water are trapped in the wet liquid. The steam thus purified passes around the condenser and moves upwardly in the drum **11**. The steam, incidentally, is constrained to pass through the condensers **18** because of the presence of the walls **45** and **46** which define a passage between the upper surface **16** of the water and the lower surfaces of the walls **46** and **45**. This passage is entirely occupied by the condensers **18**, so that the steam must pass over the condensers.

The steam eventually reaches a wedge-shaped passage between the surface of the first sheet **32** of the main housing **31** of the steam separator **19** and the inner surface of the drum **11**. The steam enters this wedge-shaped pasage and, eventually, is led to the slot **36** in the steam separator.

Now, the flat slot **36** is dimensioned both in its width and its length in such a manner that steam flows through it at a velocity at design load of approximately 75 feet per second; this particular value has proved to be successful in practice. Passing through the slot, the steam, presumably with some water still retained, passes counterclockwise in the space between the outer surface of the dry pipe **41** and the inner surface of the main housing **31**. At the extremely high velocity, described above, centrifugal force throws the heavier elements, particularly the water particles, outwardly, so that they glide along the inner surface of the housing. Eventually, the material reaches the slot **37** and because of the fact that the upper edge of the slot **37** is above the lower edge, the thin layer of water on the inner surface of the second sheet **33** of the housing passes through the slot and is separated by this dividing line or knife edge from the rest of the material flowing around the housing. The remainder of the material is mostly steam and continues around and, at the same time, moves axially outwardly toward the ends of the housing. At these ends it is able to enter the ends of the dry pipe **41** and flow inwardly lengthwise of the dry pipe to the central steam outlet conduit **42**. The steam passes through the conduit, through the wall of the housing **31**, then through the wall **45** into the enclosure **47**. From the enclosure the steam enters the tubes **14** and passes on either to the superheater or to the turbine, depending on the particular arrangement of the boiler. The water which passed through the water outlet slot **37** does so with extremely high kinetic energy. The water drops into the trough **43** and then passes downwardly through the pipe **44** into the body **15** of water. The kinetic energy in this water produces an extremely high downward pressure in this pipe, thus assuring that there will be no suction action which would have a tendency to draw water up through the pipe from the body **15** into the pipe and possibly up into the steam separator itself. Such a drawing of water into the steam separator, of course, would promote steam carry-over into the tubes **14**, which is the condition that it is most desirable to avoid. In other words, the present apparatus not only separates the water particles which are left in the steam after they leave the condensers **18** but also guarantees that no further water would be added.

By the practice of the present invention, it has been found that water of extremely high purity enters the tubes **14** and there is no danger of water being carried over into these tubes with consequent damage to the superheater and turbine. Generally speaking, such water would contain very high amounts of chemicals, such as salts, which, if deposited on the inner walls of the superheater, would eventually cause destruction of the superheater because of reduction of heat transfer ability, since the salt acts as an insulation. Such salt deposits on the turbine destroy the carefully-formed aerodynamic surface of the turbine blades and destroys the efficiency of the turbine. It should be noted that the fact that the passage between the main housing and the dry pipe reduces in cross-sectional area from the slot **36** around the dry pipe produces a tendency in the steam to move axially outwardly of the dry pipe so that it is able to enter the open ends of the dry pipe which lie adjacent the end plates **34** and **35** of the housing. As can be seen at the upper part, there is a small space between the upper surface of the dry pipe **41** and the first sheet **32** of the housing and some steam will pass around and recirculate around the circuit once more, but there is no harm in this recirculation.

It can be observed that this construction is quite simple and foolproof. There are no intricate or moving parts to be rendered inoperative by salt deposits and the apparatus will work well, even when some of the dimensions have been changed by the deposits which normally take place in a boiler drum. Also, it may be observed that the housing **31** is of small enough diameter that it may be readily removed through the manhole **21** in case replacement is necessary. Connections, such as the pipes **44** and so on, are, of course, removed before such removal from the drum is attempted. In other words, it requires only a short time and relatively little expense to replace the separator.

It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to include all such as properly come within the scope claimed.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent, is:

1. A steam generating unit, comprising
   (a) a steam-and-water drum of generally elongated cylindrical form,
   (b) a steam separator housing of elongated tubular form lying in the drum with its axis parallel to the axis of the drum, the housing having closed ends,
   (c) a dry pipe lying within and spaced from the housing generally coaxial thereof, the pipe being shorter than the housing and having at least one open end

extending to a point immediately adjacent to the end of the housing,

(d) a steam off-take conduit located on the dry pipe at a position substantially removed from the said open end, the off-take conduit extending from the pipe and through the housing,

(e) means forming an entrance slot extending longitudinally of the housing,

(f) a water outlet slot extending longitudinally of the housing diametrically opposite the inlet slot,

(g) a drain trough underlying the housing to receive water from the outlet slot, and

(h) means forming a passageway surrounding the dry pipe leading from the outlet slot to the entrance slot to cause steam which does not flow from the inlet slot to the inside of the dry pipe to join steam entering the entrance slot for the first time.

2. A steam generating unit as recited in claim 1, wherein the drum has a horizontal axis and the separator housing is located in the upper portion of the drum.

3. A steam generating unit as recited in claim 1, wherein the dry pipe is open at both ends and the steam off-take conduit is located midway between the ends.

4. A steam generating unit as recited in claim 1, wherein the entrance slot lies in a radial plane and the housing provides an edge which is spaced radially outwardly of the main body of the housing, the edge and the slot being directed toward the oncoming steam.

5. A steam generating unit as recited in claim 1, wherein the water outlet slot is defined by an edge directed toward the oncoming steam and spaced radially inwardly of the adjacent portion of the housing.

6. A steam generating unit as recited in claim 1, wherein the housing is formed of two semi-cylindrical sheets of different diameter joined in facing relationship, the slot being formed by the differences in diameters of the two sheets, and wherein the dry pipe is coaxial of the sheet of larger diameter.

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