

Feb. 28, 1961

R. BAGLEY

2,972,986

VAPOR GENERATING UNIT WITH SEQUENTIAL BLOW-DOWN

Filed Dec. 21, 1954

3 Sheets-Sheet 1

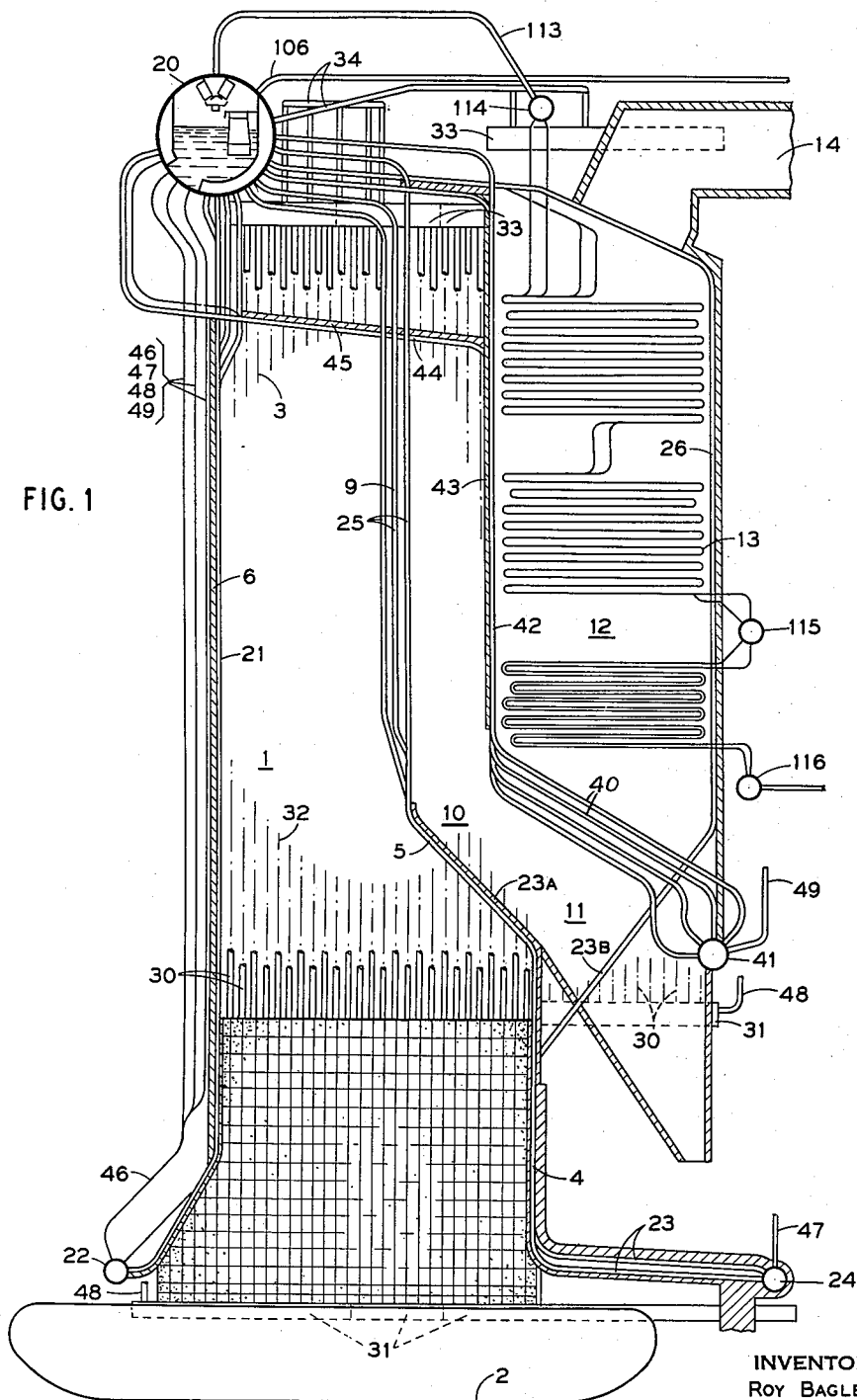


FIG. 1

INVENTOR
ROY BAGLEY
BY *R. Holbrook*
ATTORNEY

Feb. 28, 1961

R. BAGLEY

2,972,986

VAPOR GENERATING UNIT WITH SEQUENTIAL BLOW-DOWN

Filed Dec. 21, 1954

3 Sheets-Sheet 2

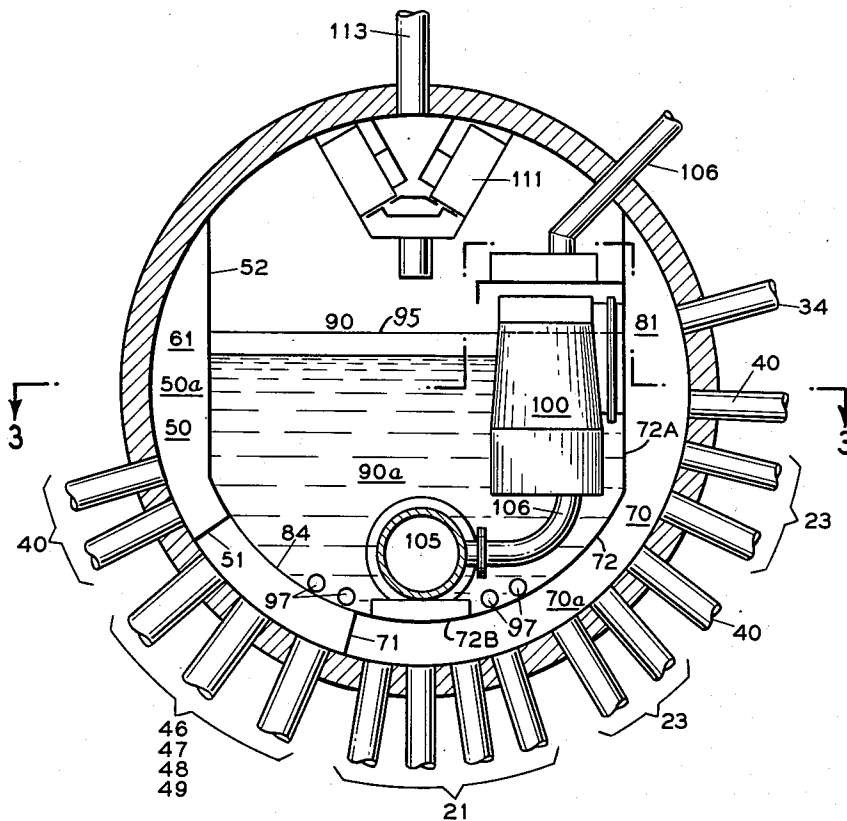


FIG. 2

INVENTOR
ROY BAGLEY
BY *R. M. Holbrook*
ATTORNEY

Feb. 28, 1961

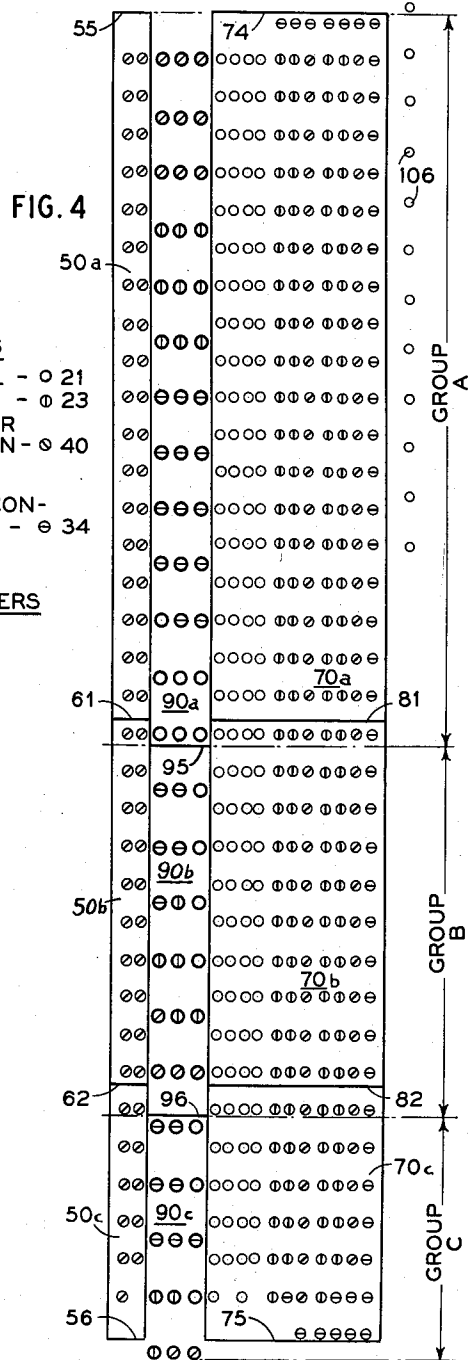
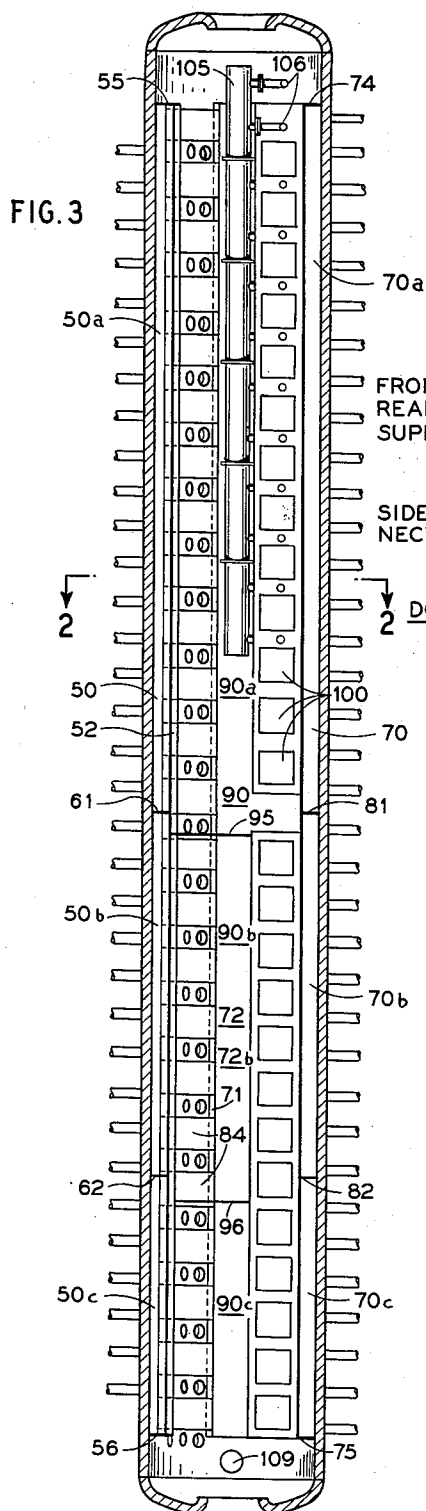
R. BAGLEY

2,972,986

VAPOR GENERATING UNIT WITH SEQUENTIAL BLOW-DOWN

Filed Dec. 21, 1954

3 Sheets-Sheet 3



INVENTOR
ROY BAGLEY

BY *R. W. Holbrook*
ATTORNEY

1

2,972,986

VAPOR GENERATING UNIT WITH SEQUENTIAL BLOW-DOWN

Roy Bagley, London, England, assignor to The Babcock & Wilcox Company, New York, N.Y., a corporation of New Jersey

Filed Dec. 21, 1954, Ser. No. 476,720

Claims priority, application Great Britain Dec. 23, 1953

4 Claims. (Cl. 122—379)

This invention relates to tubular natural circulation boilers. In the operation of such a boiler, the purity of the steam obtained depends at least in part upon the amount of water which is carried away by the steam and the purity of that water. Since evaporation leads to concentration of dissolved solids contained in the feed water and the purity of the steam generated is as a consequence adversely affected, limitation of the concentration of dissolved solids in the water of a boiler is necessary and to this end water is customarily discharged or blown-down from the boiler. Such blow-down represents a loss of heat and water and an object of the invention is the provision of an improved boiler in which steam of relatively high purity may be attained with a given blow-down or in which a given purity of steam may be attained with a relatively low rate of blow-down.

A tubular natural circulation boiler in accordance with the present invention has separate water-spaces disposed side by side and above each of which is a steam space, which water-spaces include a feed water-space arranged to receive feed water and an evacuating water-space with means for blowing-down water therefrom, groups of steam generating tubes arranged to be heated, respectively to be fed with water from the water spaces and to discharge mixtures of steam and water, and means for effecting transfer of water from water-space to water-space so that a part of the water supplied to the feed water-space is eventually transferred to the evacuating water-space, the means for transferring water from one water-space to another including provision for discharging directly to the latter water-space a proportion of the water discharged from the group of tubes fed with water from the former water-space, the provision being such as to preclude transfer through any tube of the group of liquid from the latter water-space to the former water-space.

The invention will now be described, by way of example, with reference to the accompanying partly diagrammatic drawings, in which:

Fig. 1 is a sectional side elevation of a tubular boiler;

Fig. 2 shows the steam and water drum of Fig. 1 drawn to a larger scale, the section being taken on the line 2—2 of Fig. 3 and as viewed in the direction indicated by the arrows;

Fig. 3 is a sectional plan view taken on the line 3—3 of Fig. 2; and

Fig. 4 is a developed view of a part of the interior surface of the drum shown in Fig. 3, certain cross-over boxes shown in that figure being omitted.

The boiler shown in Fig. 1 includes a vertically elongated furnace chamber 1 which extends upwardly above a traveling grate stoker 2 and has an upper portion 3 of reduced depth, the rear wall 4 of the chamber being formed with an arch 5 which extends across the width of the chamber and which slopes forwardly and upwardly towards the front wall 6 of the chamber. The part of the rear wall 4 which lies above the arch 5 is formed with a gas outlet 9 communicating with an upper part

2

of an open downpass 10 extending above the arch 5 and communicating at its lower end through a gas turning space 11 with an up-pass 12. The up-pass 12 contains a tubular convection superheater 13 and the upper end of the up-pass communicates with a flue 14 which leads to a chimney (not shown).

Steam is generated in three groups of steam generating tubes severally referred to herein as groups A, B and C (see Fig. 4), the tubes of which are connected at their upper ends either directly or through the intermediary of headers to a steam and water drum 20 disposed above the front wall 6. Each group of tubes includes tubes 21, hereinafter referred to as front wall risers, connected at their lower ends to a header 22 individual to that group, incorporated in the front wall 6 and directly connected at their upper ends to the drum 20. Each group of tubes also includes tubes 23, hereinafter referred to as rear wall risers, connected at their lower ends to a header 24 individual to that group. Certain of the tubes 23, designated by 23A, are incorporated in the rear wall 4 and in the arch 5 thereof and extend in spaced rows as at 25 across the gas outlet 9 and are directly connected at their upper ends to the drum 20. The remainder of the tubes 23, designated by 23B, are incorporated in a lower part only of wall 4, are bent rearwardly to extend below the up-pass 12, line the rear wall 26 of that pass, are bent forwardly across the entrance to the flue 14, and are directly connected at their upper ends to the drum 20. Each group of tubes furthermore include tubes 30, hereinafter referred to as side wall risers, connected at their lower ends to headers, such as the four headers 31, individual to that group, incorporated in opposite side walls of the boiler, that is to say the side walls of the furnace chamber 1, such as the side wall 32, and the side walls of the downpass 10 and the up-pass 12. These tubes are connected at their upper ends to headers such as the four headers 33, also individual to the group. Each of these headers, for example each of the headers 33, is connected by tubes, designated hereinafter as side wall riser connectors, such as the tubes 34, to the drum 20. Each group of tubes moreover includes tubes 40, hereinafter referred to as superheater screen risers, connected at their lower ends to a header 41 individual to that group, extending as part of a screen of spaced tubes across the lower end of the up-pass 12 below the superheater 13, and having intermediate parts 42 incorporated in rear wall 43 of the down-pass 10. Above the parts 42, certain of the tubes 40, indicated by 44, are bent forwardly and incorporated in a roof 45 of the chamber 1, and the remainder of the tubes 40 extend first upwardly and then forwardly to the drum 20, to which all of the tubes 40 are directly connected. Each tube group also includes unheated downcomer tubes 46, 47, 48 and 49, respectively connected at their lower ends to the headers 22, 24, 31 and 41 which are individual to that group and connected at their upper ends to the drum 20. Each group of separate headers 22, 24, 31 and 41 is arranged in substantially end to end relation in a well known manner (not shown).

The average heat absorption rates of the heated parts of the three tube groups in terms of heat transfer per square foot of area are approximately the same, but group B has a total heated area which is approximately 11/7 times that of group C and group A has a total effective area which is approximately twice that of group B, so that the amounts of heat absorbed respectively in the three groups A, B and C are approximately in the ratio 22:11:7.

As shown in Figs. 2, 3 and 4, the interior of the steam and water drum 20 is provided along one side with a longitudinally extending pocket 50 bounded along its lower edge by a longitudinally extending baffle plate 51

which extends radially from the drum wall for most of the length of the drum and by a bent baffle plate 52 attached at its upper end to the drum wall and at its lower end to the plate 51. The ends of the pocket 50 are closed by suitable part-annulus plates 55 and 56 (see Figs. 3 and 4), secured to the drum wall, the plate 51 and the plate 52. The length of the pocket 50 is divided into three parts by two transverse partitions 61 and 62 respectively positioned at approximately the mid-length and three-quarter length points of the drum; and the three successive pocket parts so formed are designated by numerals 50a, 50b and 50c, part 50a being the largest part.

The opposite side of the interior of the drum 20 and part of the floor of the drum are provided with a longitudinally extending chamber 70 bounded along its lower edge by a longitudinally extending baffle plate 71 which extends radially from the drum wall for most of the length of the drum and by a baffle plate 72 having a flat upright part 72A attached at its upper end to the drum wall and a curved lower part 72B connected to the plate 71. The ends of the chamber 70 are closed by suitable part-annulus plates 74 and 75 (see Figs. 3 and 4), secured to the drum wall, the plate 71 and the plate 72. The length of the chamber 70 is divided into three sub-chambers by two transverse partitions 81 and 82 respectively positioned transversely opposite the partitions 61 and 62 of the chamber 50; and the three successive sub-chambers so formed are designated by numerals 70a, 70b and 70c, part 70a being the largest part.

The lower ends of sub-chambers 50a, 50b and 50c are respectively connected to the lower ends of the transversely opposite chamber parts 70a, 70b or 70c by a series of cross-over boxes 84 which are spaced longitudinally of the drum as shown in Fig. 3. These boxes 84 are not shown in Fig. 4. Thus each of the sub-chambers 70a, 70b and 70c acts as a collecting chamber for the steam-water mixture of both itself and the associated part of chamber 50.

The central portion 90 of the drum, between the two chambers 50 and 70, is provided with two transverse baffles 95 and 96 which extend upwardly to a level above the highest water level which will occur on normal operation of the boiler, so that these baffles divide the lower part of the central portion 90 into three successive separate water-spaces 90a, 90b and 90c of which 90a is the largest. As shown in Fig. 4, baffle 95 is slightly displaced from the baffles 61 and 81, and the baffle 96 is slightly displaced from the baffles 62 and 82, in each case towards the end of the drum which contains the sub-chambers 50c and 70c. The baffles 95 and 96 are each provided with water-level equalization holes, relatively few in number and small in size, disposed at a low level in the drum. Thus the baffle 95 is provided with four holes 97.

Disposed within the central portion 90 of the drum are twenty-six centrifugal separators 100, suitably of the nature disclosed in the U.S. patent to Rowand et al. 2,321,628 (June 15, 1945). These separators are mounted on the part 72A of baffle plate 72, and thirteen of them are arranged to receive a mixture of steam and water from the sub-chamber 70a and to discharge separated water into the water-space 90a of the drum; eight are arranged to receive a mixture of steam and water from the sub-chamber 70b and to discharge separated water into the water-space 90b of the drum; and the remaining five are arranged to receive a mixture of steam and water from the sub-chamber 70c and to discharge separated water into the water-space 90c of the drum.

The upper ends of the unheated downcomer tubes 46, 47, 48 and 49 are arranged to terminate in the central portion 90 of the drum 20 (see Fig. 4), the downcomer tubes of the group A terminating in the water-space 90a, the downcomer tubes of group B terminating in the water-space 90b and the downcomer tubes of group C terminating in the water-space 90c. Thus all the risers

and riser connections of group A are fed with water from water-space 90a, all those of group B are fed with water from water-space 90b, and all those of group C are fed with water from water-space 90c. The actual arrangement of the tube holes in the drum 20 which accommodate the upper ends of the tubes of groups A, B and C is indicated in Fig. 4; and that figure also indicates how the upper ends of the front wall risers 21, the rear wall risers 23, the side wall riser connectors 34 and the superheater screen risers 40 of the three groups A, B and C are arranged to discharge into the parts of the chambers 50 and 70. It will be seen that all except thirteen of the risers and riser connectors of group A discharge into either the sub-chamber 50a or the sub-chamber 70a; two of those thirteen discharge into the sub-chamber 50b and the remaining eleven discharge into the sub-chamber 70b. It will also be seen that all except thirteen of the risers and riser connectors of group B discharge into either the sub-chamber 50b or the sub-chamber 70b; two of those thirteen discharge into the sub-chamber 50c and the remaining eleven discharge into the sub-chamber 70c. All the risers and riser connectors of group C discharge into either the sub-chamber 50c or the sub-chamber 70c.

A feed pipe 105 disposed within the water-space 90a of the drum 20, hereinafter called the feed water-space 90a, is connected by pipes 106 which extend through an upper part of the drum wall to an economizer (not shown) associated with the boiler and disposed in the flue 14.

A blowdown pipe (not shown) leading from an opening 109 (see Fig. 3) positioned at a low level in the water-space 90c, hereinafter called the evacuating water-space 90c, and provided with suitable stop and regulating valves, provides for the discharge of water from the evacuating water-space 90c to a suitable point of disposal. An alternative manner of effecting blowdown from the evacuating water-space 90c is to connect a blowdown pipe to one of the headers supplied with water from the water-space 90c.

Arranged within an upper part of the drum 20 is a steam scrubber 111 of suitable construction and steam pipes 113 lead from a steam collecting space in the drum above the scrubber 111 to an inlet header 114 of the superheater 13. An outlet header 115 of the superheater 13 is connected by pipes 116 to the point of use for the steam generated in the boiler.

During operation of the boiler described above, coal is fed onto the travelling grate 2 and is burned thereon. The hot products of combustion rise through the furnace chamber 1, pass through the gas outlet 9 into the open down-pass 10, turn in the space 11 and pass over the superheater screen risers 40 into the up-pass 12, where they pass over the tubes of the superheater 13, and then enter the flue 14.

Feed water is supplied to the economizer from which it passes through the pipes 106 to the feed pipe 105 and thence into the feed water-space 90a of the drum 20. Water from the feed water-space 90a passes downwardly through the downcomers 46, 47, 48 and 49 of group A to the associated headers 22, 24, 31 and 41, enters the heated risers 21, 23, 30 and 40 of group A and then is discharged, for the most part, into the sub-chambers 50a and 70a. The steam-water mixture from the sub-chamber 50a passes through the cross-over boxes 84 into the sub-chamber 70a, and from there the mixture enters the associated group of centrifugal separators 100, from which steam is discharged into the steam space of the drum, and separated water is discharged to the water-space 90a. It will be appreciated that since water is continually being withdrawn from water-space 90a and evaporated, the concentration of impurities in that water-space tends to rise.

Since, in operation, feed water is continually added to the feed water-space 90a, the concentration of impurities in the water in the feed water-space will at all times be

lower than the concentration of impurities in the separated water discharged from the centrifugal separators 100 and the water supplied to the downcomers of group A, while less pure than the feed water, will be more pure than the separated water. Furthermore, some of the water supplied through the downcomers of group A is passed on to the water-space 90b of the drum, since thirteen of the risers of group A discharge into the sub-chambers 50b and 70b, and the water separated from the steam-water mixture in those sub-chambers by the associated group of centrifugal separators is discharged downwardly into water-space 90b. Thus, in effect, feed water-space 90a of the drum is continually blown-down to water-space 90b and suitably the tubes of group A which discharge water into the water-space 90b are so selected that some 50% of the water supplied to the feed water-space 90a is blown-down to the water-space 90b.

The water supplied to the downcomer tubes of group B will thus have a higher concentration of impurities than the water supplied to the downcomer tubes of group A, and with 50% blow-down from water-space 90a to water-space 90b, the concentration of impurities will be substantially twice as high.

Water from the water-space 90b passes downwardly through the downcomers 46, 47, 48 and 49 of group B to the associated headers 22, 24, 31 and 41, enters the heated risers 21, 23, 30 and 40 of group B and then is discharged, for the most part, into the sub-chambers 50b and 70b. The steam-water mixture from the sub-chamber 50b passes through the cross-over boxes 84 into the sub-chamber 70b, and from there steam-water mixture enters the associated group of centrifugal separators 100. Steam from the separators is discharged into the steam space of the drum, and separated water is discharged to the water-space 90b of the drum. As water is continually being evaporated from water-space 90b, the concentration of impurities in that water-space tends to rise. In operation, this increase in concentration is limited by the transfer from water-space 90b to water-space 90c of some of the water supplied to the downcomers of group B, since thirteen of the risers and riser connections of group B discharge into the sub-chambers 50c and 70c, and the water separated from the steam-water mixture in those sub-chambers by the associated group of centrifugal separators 100 is discharged downwardly into the water-space 90c. Thus, in effect, water-space 90b of the drum is continually blown-down to water-space 90c, and suitably the tubes of group B which discharge water into the water-space 90c are so selected that some 50% of the water transferred from water-space 90a to water-space 90b is blown-down to the water-space 90c.

The water blown-down to water-space 90c will thus have a higher concentration of impurities than the water blown-down to water-space 90b, and with 50% blow-down from water-space 90b to water-space 90c, the concentration of impurities in water passed on to water-space 90c will be substantially twice as high as that supplied to water-space 90b.

Water from the water-space 90c passes downwardly through the downcomers 46, 47, 48 and 49 of group C, to the associated headers 22, 24, 31 and 41 of group C, enters the heated risers 21, 23, 30 and 40 of group C and then is discharged to the sub-chambers 50c and 70c. The steam-water mixture from the sub-chamber 50c passes through the cross-over boxes 84 into the sub-chamber 70c, and from there a steam-water mixture enters the associated group of centrifugal separators 100. Steam from the separators is discharged into the steam space of the drum, and separated water is discharged to the evacuating water-space 90c of the drum. As water is continually being evaporated from water-space 90c, the concentration of impurities in that water-space tends to rise. In operation, this increase in concentration is limited by the blow-down from water-space 90c through the opening 109 of a suitable portion of the water trans-

ferred to that section from the section 90b. In the boiler illustrated the portion blown-down is $\frac{1}{11}$, with which the concentration of impurities in the water blown-down through the opening 109 would be substantially 275% of the concentration of the water blown-down from water-space 90b to water-space 90c.

It will be seen that the tubes of group A are fed with water from the water-space 90a and that a proportion of the water discharged from that group is discharged directly to water-space 90b, the structure and arrangements of the tubes and headers for effecting the transfer of water being such as to preclude transfer through any tube of the group of liquid from the water-space 90b to the water-space 90a. To this end, appropriate diaphragms may be arranged within the headers.

Steam discharged from all twenty-six of the separators 100 mixes in the steam space of the drum 20 and passes through the steam scrubber 111 into the steam pipes 113 and thence through the superheater 13 to the pipes 116 and so to the point of use of the steam.

The progressive concentration of impurities in the three water-spaces 90a, 90b and 90c of the drum 20 is best understood by a numerical example. Thus, considering the boiler depicted in the drawings, the boiler is designed to supply a normal full load of 200,000 pounds of steam per hour. Feed water is supplied to the feed water-space 90a at a rate of 220,000 pounds per hour and has a concentration of solid impurities of some 250 parts per million. The arrangement of centrifugal separators 100 and steam scrubber 111 gives a concentration of solids in the steam leaving the drum 20 of some $\frac{1}{1000}$ of the concentration in the steam-water mixture from which the steam is separated.

With an effective blow-down from water-space 90a to water-space 90b of 50%, 110,000 pounds of steam per hour are generated at water-space 90a, 110,000 pounds of water per hour are transferred to water-space 90b, and the concentration of solids in the water of water-space 90a is some 500 parts per million. With this concentration of solids in the steam-water mixture entering the centrifugal separators 100 associated with water-space 90a, the steam leaving the boiler would have a concentration of impurities of some 0.5 part per million, i.e. the total solids contained in the 110,000 pounds of steam per hour would be some .055 pound.

Water-space 90b of the drum is thus fed with 110,000 pounds of water per hour having a concentration of impurities of some 500 parts per million. With an effective blow-down from water-space 90b to water-space 90c of 50% 55,000 pounds of steam per hour are generated at water-space 90b, 55,000 pounds of water per hour are transferred to water-space 90c, and the concentration of solids in the water of water-space 90b is some 1000 parts per million. With this concentration of solids in the steam-water mixture entering the centrifugal separators 100 associated with water-space 90b, the steam leaving the boiler would have a concentration of impurities of some 1.0 part per million, i.e. the total solids contained in the 55,000 pounds of steam per hour would be some 0.055 pound.

Water-space 90c of the drum is thus fed with 55,000 pounds of water per hour having a concentration of impurities of some 1000 parts per million. With an actual blow-down through the opening 109 of the 20,000 pounds of water supplied to the boiler in excess of steam requirements, 35,000 pounds of steam per hour are generated at the water-space 90c, and the concentration of solids in the water of water-space 90c is some 2,750 parts per million. With this concentration of solids in the steam-water mixture entering the centrifugal separators 100 associated with water-space 90c, the steam leaving the boiler would have a concentration of impurities of some 2.75 parts per million, i.e. the total solids contained in the 35,000 pounds of steam per hour would be some 0.096 pound.

Considering now the 200,000 pounds of steam which

flow in one hour from the drum 20, the total solids content is some 0.206 pound, so that the concentration of impurities in the steam is some 1.03 parts per million.

This figure of 1.03 parts per million may be compared with the solids content which would be obtained in the operation of the same boiler with the same amount of blow-down and arrangement of centrifugal separators and scrubber but without the provision of separate water-spaces: a blow-down of 20,000 pounds of water per hour out of a water supply of 220,000 pounds of water per hour at a concentration of 250 parts per millions would give a solids concentration in the water of the drum of some 2,750 parts per million, and a solids concentration in the steam leaving the drum of some 2.75 parts per million. Alternatively, to maintain an output of 200,000 pounds of steam per hour with a concentration of impurities as low as 1.03 parts per million would require a blow-down from the water-space of the drum of about 64,000 pounds of water per hour and of course a water input to the drum of 264,000 pounds of water per hour.

The magnitude of the improvement in the purity of the steam which is obtained by sectionalization of the water-space of the drum depends upon the proportion of the steam which is evaporated at the earlier water-spaces 90a and 90b where the water is relatively pure. It is therefore advantageous that, as in the preferred embodiment described above, the group of steam generating tubes arranged to receive water from the feed water-space should be of larger steam generating capacity than the group of tubes arranged to receive water from each other water-space. And it is preferable that, where several groups of tubes are arranged to receive water respectively from different water-spaces, that those groups of tubes should progressively decrease in vapor generating capacity from that group associated with the feed water-space to that associated with the evacuating water-space, as described with reference to the preferred embodiment.

It will be seen that with the drum and tube arrangement described, water is positively transferred from one water-space of the drum to the next in a manner which precludes the reverse flow from a subsequent water-space of the drum, such as the water-space 90c, to a preceding water-space, such as the water-space 90b, through the tubes of the tube groups. Also that water so transferred is heated and steam separated from it, thus effecting a further concentration of solids in the water during its transfer from one water-space to the subsequent water-space. And furthermore, that the transfer of water from one water-space to the next through the heated risers is quite independent of the water level in the second water-space. Should the water level in any water-space become different from that in an adjacent water-space, a corrective flow of water will take place through the water-level equalization holes, e.g. through the holes 97, but the rate of transfer of water will, in a properly designed boiler, normally be very small compared with the rate of blow-down of water from one water-space to the next.

As will be appreciated by those skilled in the art, the partitioning of the water-space could be continued to partition the steam space of the drum, if so desired, the steam from the various sections of the steam space mixing in a separate steam header.

What is claimed is:

1. In a vapor generating unit for generating vapor under pressure, an upper vapor and liquid separating drum constructed to provide a first separated liquid chamber and a second separated liquid chamber, a first natural circulation system including a first lower liquid chamber and groups of downcomer and heated riser tubes with the downcomer tubes normally conducting liquid from the first separated liquid chamber through said first lower liquid chamber to the inlet ends of the riser tubes, the riser tubes normally discharging vapor and liquid mixtures into said first separated liquid chamber, a second natural circulation system including a second

lower liquid chamber and groups of downcomer and heated riser tubes with the downcomer tubes normally conducting liquid from the second separated liquid chamber through said second lower liquid chamber to the inlet ends of said second group of riser tubes, the second group of riser tubes normally discharging liquid and vapor mixtures into said second separated liquid chamber, the heated riser tubes in both of said natural circulation systems being arranged in corresponding locations relative to the heating gas flow path through said unit to have approximately the same average heat absorption rate per unit of area, other heated riser tubes having their inlet ends connected to receive liquid from said first lower liquid chamber and their outlet ends connected to discharge into said second separated liquid chamber and thereby normally providing a blow-down connection from said first separated liquid chamber to said second separated liquid chamber, fuel burning means providing high temperature gases for heating said riser tubes, means supplying feed liquid to said first separated liquid chamber, and final blow-down means for the unit in communication with said second separated liquid chamber.

2. In a vapor generating unit for generating vapor under pressure, an upper vapor and liquid separating drum constructed to provide a first separated liquid chamber and a second separated liquid chamber of lesser volumetric capacity, a first natural circulation system of higher vapor generating capacity including a first lower liquid chamber and groups of downcomer and heated riser tubes with the downcomer tubes normally conducting liquid from the first separated liquid chamber of higher capacity through said first lower liquid chamber to the inlet ends of the riser tubes, the riser tubes normally discharging vapor and liquid mixtures into said first separated liquid chamber, a second natural circulation system of smaller vapor generating capacity including a second lower liquid chamber and groups of downcomer and heated riser tubes with the downcomer tubes normally conducting liquid from the second separated liquid chamber through said second lower liquid chamber to the inlet ends of said second group of riser tubes, the second group of riser tubes normally discharging liquid and vapor mixtures into said second separated liquid chamber, the heated riser tubes in both of said natural circulation systems being arranged in corresponding locations relative to the heating gas flow path through said unit to have approximately the same average heat absorption rate per unit of area, other heated riser tubes having their inlet ends connected to receive liquid from said first lower liquid chamber and their outlet ends connected to discharge into said second separated liquid chamber and thereby normally providing a blow-down connection from said first separated liquid chamber to said second separated liquid chamber, fuel burning means providing high temperature gases for heating said riser tubes, means supplying feed liquid to said first separated liquid chamber, and final blowdown means for the unit in communication with said second separated liquid chamber.

3. In a vapor generating unit for generating vapor under pressure, an upper horizontally arranged vapor and liquid separating drum having a transverse partition arranged to provide a first separated liquid chamber and a second separated liquid chamber occupying different portions of the length of said drum, a first natural circulation system including a first lower liquid chamber and groups of downcomer and heated riser tubes with the downcomer tubes normally conducting liquid from the first separated liquid chamber through said first lower liquid chamber to the inlet ends of the riser tubes, the riser tubes normally discharging vapor and liquid mixtures into said first separated liquid chamber, a second natural circulation system including a second lower liquid chamber and groups of downcomer and heated riser tubes with the downcomer tubes normally conduct-

ing liquid from the second separated liquid chamber through said second lower liquid chamber to the inlet ends of said second group of riser tubes, the second group of riser tubes normally discharging liquid and vapor mixtures into said second separated liquid chamber, the heated riser tubes in both of said natural circulation systems being arranged in corresponding locations relative to the heating gas flow path through said unit approximately the same average heat absorption rate per unit of area, other heated riser tubes having their inlet ends connected to receive liquid from said first lower liquid chamber and their outlet ends connected to discharge into said second separated liquid chamber and thereby normally providing a blowdown connection from said first separated liquid chamber to said second separated liquid chamber, fuel burning means providing high temperature gases for heating said riser tubes, means supplying feed liquid to said first separated liquid chamber, and final blowdown means for the unit in communication with said second separated liquid chamber.

4. In a vapor generating unit for generating vapor under pressure, an upper horizontally arranged vapor and liquid separating drum having a transverse partition arranged to provide a first separated liquid chamber and a second separated liquid chamber of lesser volumetric capacity occupying different portions of the length of said drum, a first natural circulation system of higher vapor generating capacity including a first lower liquid chamber and groups of downcomer and heated riser tubes with the downcomer tubes normally conducting liquid from the first separated liquid chamber of higher capacity through said first lower liquid chamber to the inlet ends of the riser tubes, the riser tubes normally discharging vapor and liquid mixtures into said first separated liquid chamber, vapor and liquid separating means connected to said riser tubes to receive said mixtures and

discharging the separated liquid into said first separated liquid chamber, a second natural circulation system of smaller vapor generating capacity including a second lower liquid chamber and groups of downcomer and heated riser tubes with the downcomer tubes normally conducting liquid from the second separated liquid chamber through said second lower liquid chamber to the inlet ends of said second group of riser tubes, the second group of riser tubes normally discharging liquid and vapor mixtures into said second separated liquid chamber, the heated riser tubes in both of said natural circulation systems being arranged in corresponding locations relative to the heating gas flow path through said unit to have approximately the same average heat absorption rate per unit of area, other heated riser tubes having their inlet ends connected to receive liquid from said first lower liquid chamber and their outlet ends connected to discharge into said second separated liquid chamber and thereby normally providing a blowdown connection from said first separated liquid chamber to said second separated liquid chamber, fuel burning means providing high temperature gases for heating said riser tubes, means supplying feed liquid to said first separated liquid chamber, and blowdown means for the unit in communication with said second separated liquid chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

521,946	Cooper	June 26, 1894
2,055,781	Angermuller	Sept. 29, 1936
2,333,644	Ebbetts	Nov. 5, 1943
2,669,976	Frisch	Feb. 23, 1954

FOREIGN PATENTS

657,799	Great Britain	Sept. 26, 1951
---------	---------------	----------------