Oct. 25, 1949. W. S. PATTERSON 2,485,767

STEAM SEPARATOR

Filed Dec. 30, 1944 2 Sheets-Sheet 1

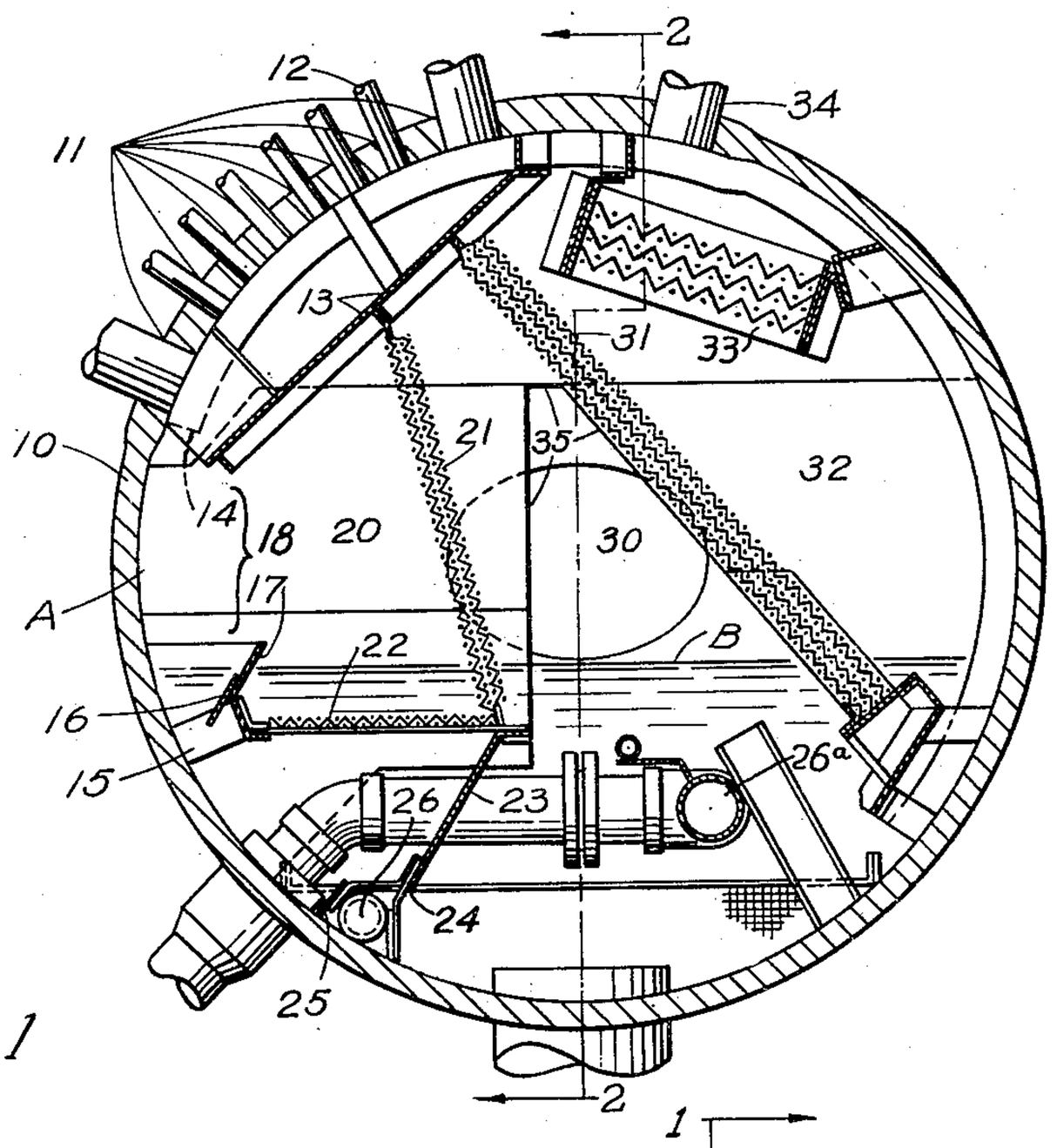
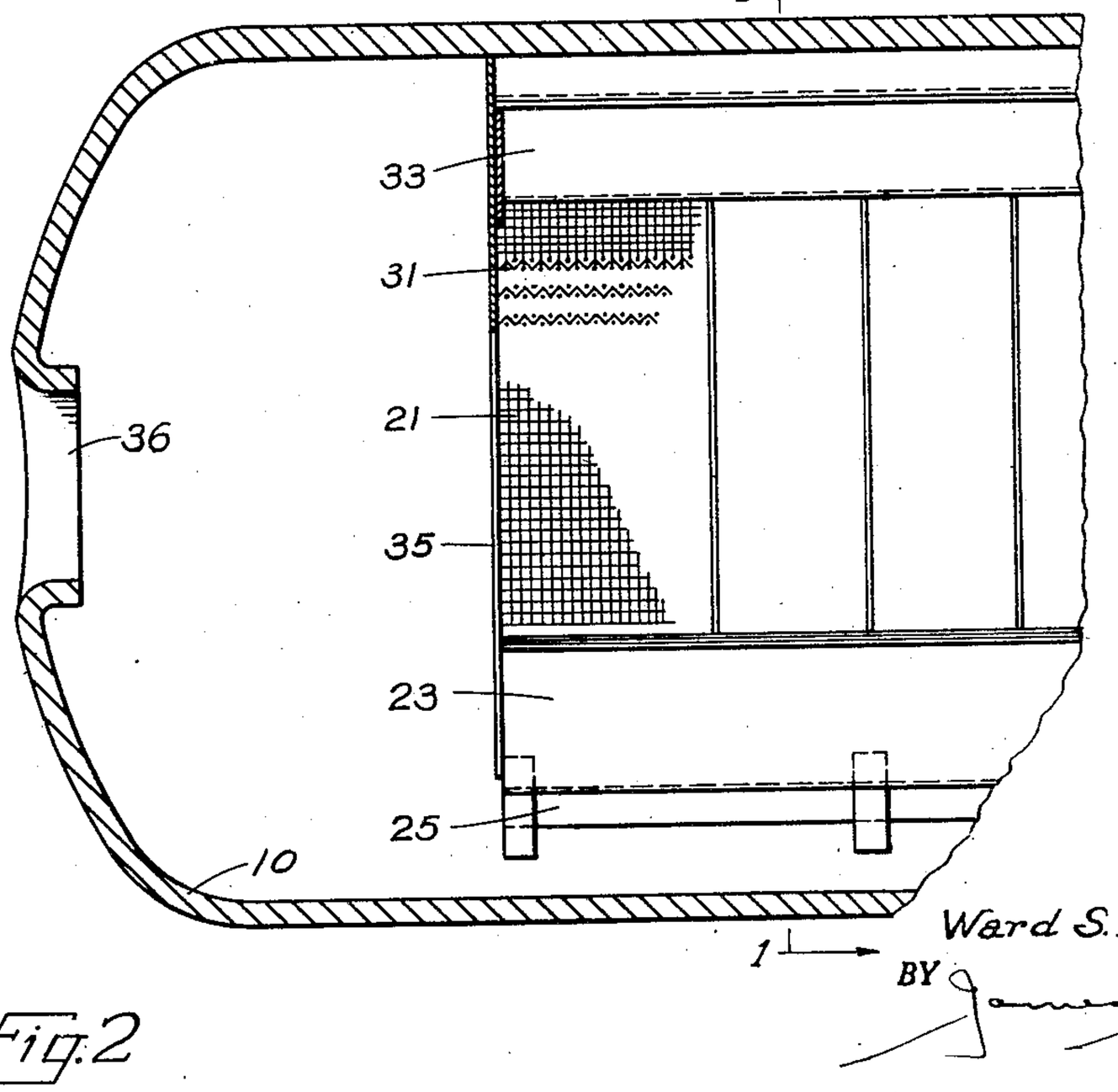


Fig. 1



INVENTOR.
Ward S. Patterson
BY James J. Wheeler

Fig. 2

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STEAM SEPARATOR

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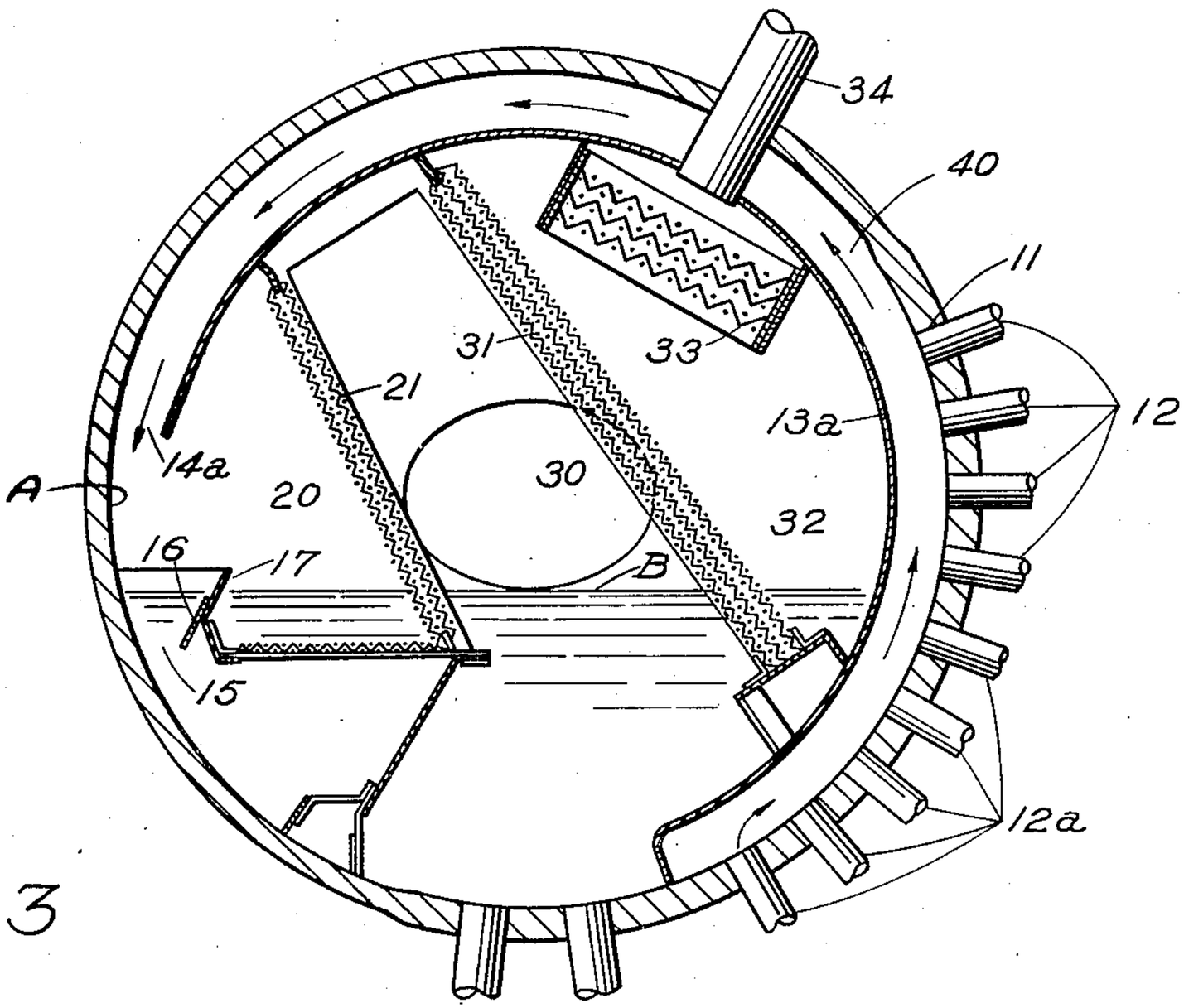

Fig. 3

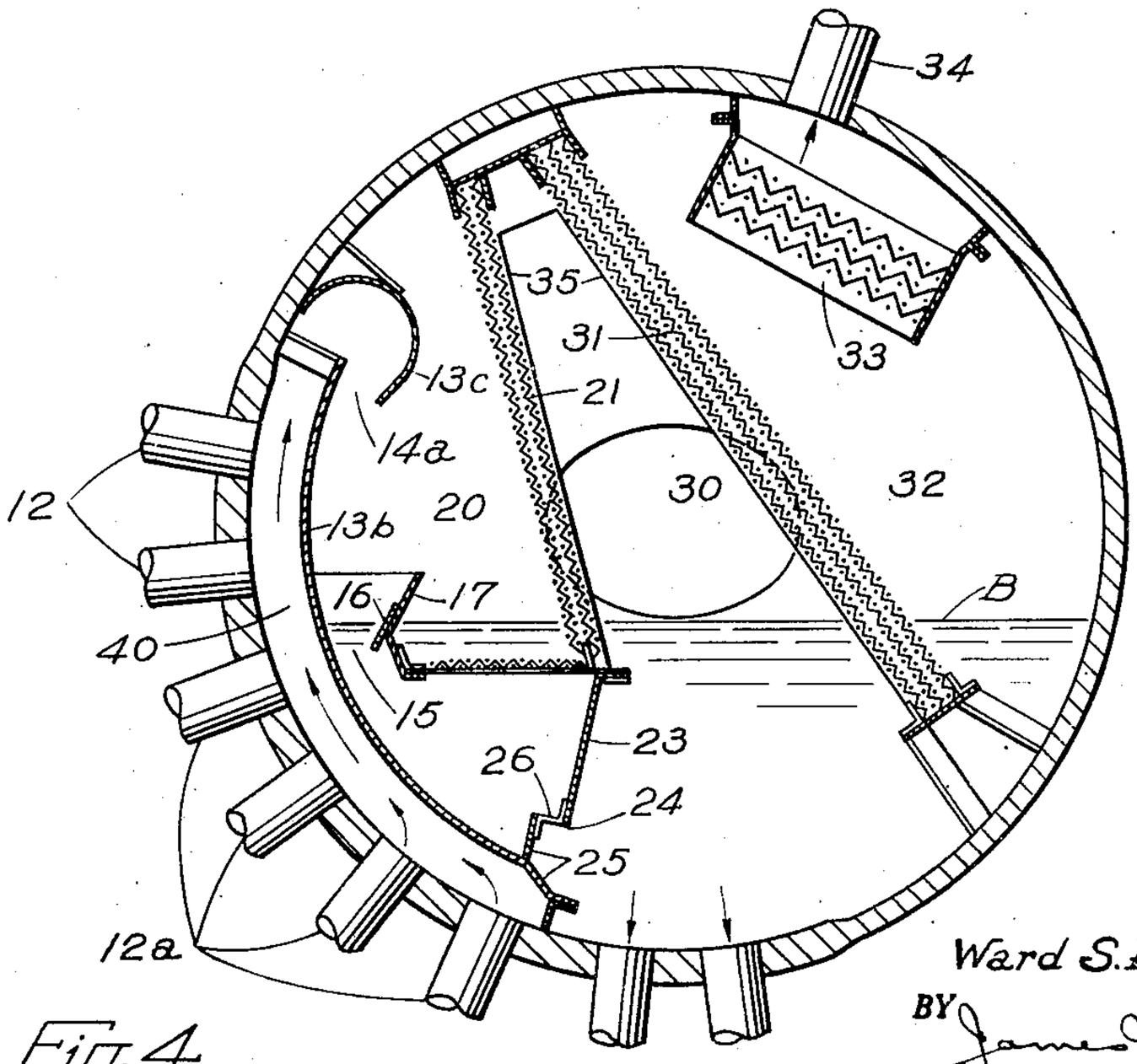

Fig. 4

INVENTOR.
Ward S. Patterson
BY James J. Whalen

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STEAM SEPARATOR

Ward S. Patterson, Chappaqua, N. Y., assignor to Combustion Engineering-Superheater, Inc., a corporation of Delaware

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4 Claims. (Cl. 183—9)

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This invention relates to separators and particularly to the separation of moisture from steam within the drum of a steam boiler.

In a water-tube boiler of the natural circulation type and in some forced circulation boilers, only part of the water passing through the heated tubes is evaporated into steam to travel along with the water as a more or less heterogeneous mixture. The steam must then be separated from the water, and the water recirculated with fresh feed water through the boiler tubes. This separation must be accomplished in such an efficient manner that the steam is practically "dry" or free of entrained moisture, because any moisture carried with the steam also carries with it dissolved and suspended solids, which, on evaporation of the water, become deposited on the internal surfaces of the superheaters, on turbine blades, or in valves, etc., where it is very objectionable.

In steam generating units it has been found that up to a certain output of steam the steam is dry but if this output is exceeded the moisture in the steam increases rapidly. The maximum output at which commercially dry steam is obtainable is a function of the drum pressure, the steam space in the boiler drums, the character of the boiler water and the type of boiler. In an article entitled "Boiler capacity has outgrown its terminology" published in "Combustion" of March 1934, page 11, the chart designated Fig. 1 shows the steam liberation in cubic feet and pounds of steam per hour at various pressures for each cubic foot of steam space in the separation drum of a number of boilers. This will aid in visualizing the limitations of the steaming capacities of drums at that time. It is shown that in a drum not equipped with separating devices steaming capacities generally follow a law for the settling velocities of particles of moisture falling through the steam. Since then various attempts have been made to improve those liberations by installing apparatus of various types within the drum with more or less success.

An object of this invention is to provide improved means for the separation of moisture from steam within the steam space of a boiler drum.

Figure 1 is a transverse sectional view through a steam and water drum of a steam boiler showing one embodiment of the invention, as viewed on line 1—1 of Fig. 2;

Figure 2 is a partial longitudinal section through the drum taken on line 2—2 of Fig. 1; and

Figures 3 and 4 are transverse sections, similar

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to Fig. 1, of other embodiments of the invention.

Figure 1 illustrates the principal features of the device as applied to a boiler drum in which all of the steam enters the steam space above the water level. The steam and water drum 10 is provided with tube openings 11 through which the steam and water mixture is discharged from the tubes 12 into the drum. An imperforate baffle 13 opposite and close to the tube openings 11 directs the mixture of steam and water downwardly through a discharge opening 14 formed by the space between baffle 13 and shell 10. The area of discharge opening 14 is selected to give a relatively high discharge velocity. Baffle 13 is positioned in downward and outward inclination to cause the discharge of the steam-water mixture in the form of a sheet directed against the drum shell at approximately location A above the water line. The density of the water is much greater than that of the steam so that a heterogeneous mixture no longer exists because as the denser water is thrown against the drum shell the less dense steam is displaced toward the center of the drum thereby causing a primary separation of water and steam. This separation is accomplished in a very small space between discharge opening 14 and location A. To prevent depression of the water level B at a location directly below discharge opening 14 where the steam and water leaving said opening would strike the drum at high velocity, a funnel-shaped or convergent throttling throat 15 is preferably provided. This throat is formed by plates 16 and drum 10. Plate 16 is preferably adjustably movable along the surface of plate 17 so as to vary the size of the throat formed between the outer edge of plate 16 and drum 10. By varying the size of throat 15 the amount of water flowing therethrough may be controlled. The water discharging through opening 14 and separated from the steam may then pass through throat 15 or spill over the top edge of baffle plate 17. It has been found that under certain conditions of steam pressure and density satisfactory results may be obtained by omitting plates 16 and 17 and allowing the water discharged from opening 14 to jet directly into the water within the drum and also that the screen 22 may be omitted. The steam and any entrained moisture not yet separated therefrom passes toward the center of the drum through the opening 18 between the bottom of baffle 13 and the top of plate 17 or the water level and passes into space 20 toward screens 21. Any steam entrained with the water and passing downwardly through the throat 15 rises through submerged

screen 22 and likewise enters the space 20 ahead of screens 21. The submerged screen 22 distributes and diffuses the steam so as to produce a minimum of disturbance at the water level directly thereabove. A baffle 23 extends downwardly from the end of screens 21 with its lower end spaced at 24 from drum 10. This baffle assists in preventing submerged steam below screen 22 from rising upwardly without passing through said screen. A baffle 25 offset with respect to baffle 23 extending to drum 10 serves as a dam which deflects water flowing against it from above along the drum shell upwardly thereby insuring that all submerged steam in said water will pass upwardly through screen 22 into space 20. A perforate blow-off pipe 26 is located below and adjacent to the opening between the bottom 24 of baffle 23 and the baffle 25 which may serve as a continuous blow down. Since the water delivered by the tubes 11 contains a relatively large concentration of solids, and is delivered from opening 14 downwardly toward and in part through the opening just above pipe 26 and since this concentrated water has not as yet been admixed with relatively pure feed water entering through pipe 26*a*, the location of pipe 26 is most advantageous for a blow down. Obviously the blowoff pipe 26 may also be located submerged within the water between baffle 23 and said surface against which the flow of the mixture issuing from opening 14 passes.

Screens 21 serve several purposes. They are so selected with respect to free area that they offer sufficient resistance to the flow of steam to insure a uniform distribution and uniformly low velocity of the steam within the steam space 20. Screens 21 also deliver the steam uniformly into space 30 beyond. The screens 21 also offer a relatively large contact surface that becomes wetted by the entrained moisture remaining in the steam, thereby removing said moisture and the relatively low velocity over said screens permits the screens to drain away the moisture. The low velocity in the spaces 20 and 30 allows a relatively long period of time for settling out of the moisture by gravity, thereby improving the moisture separation efficiency of these spaces. The steam then passes through screens 31 which have a greater resistance than screens 20 in order to maintain a uniform distribution and low velocity of the steam in space 30 and again to provide a large amount of contact surface for any remaining entrained moisture. The large screens 31 are inclined at a substantial angle from the horizontal to insure good drainage of the moisture from the screens and their lower ends may optionally be submerged in the water. After passing through screens 31 which function like screens 21 to uniformly distribute the steam flowing therethrough, the steam discharges into space 32 prior to passing through screens 33 and thence to steam outlet 34. Screens 33 are inclined from the horizontal and so placed that any remaining moisture extracted by them from the steam and draining down the screens will drop from their lowest edge into a zone of relatively low velocity of steam in space 32 so as not to be re-entrained. It will be noticed that after an effective primary separation in a very small space at the side of the drum where the steam and water mixture enters, the steam passes through the drum through substantially the entire available steam space with a minimum flow velocity.

The drum internals including baffles 13, 16, 17, 23, and 25 and the screens 21, 22, 31, and and 33 extend continuously throughout the length of the drum between end plates 35, located beyond the last tube openings 11 adjacent the ends of the drum. The end plates 35 form enclosures so as to confine the flow of the steam to a path around the baffles and through the screens. Obviously the baffles and the various screens may be assembled in narrow sections as shown in Fig. 2, so that they may be removed through the manhole 36 of the drum.

In Figs 3 and 4 part of the steam and water mixture is discharged from tubes 12*a* entering the drum below the water level. Part of baffles 13*a* and 13*b* are submerged and the entire baffle spaced from the shell to form a passage confining the mixture and leading it to the opening 14*a*.

In Fig. 3 the mixture is discharged against drum 10 as in Fig. 1. In Fig. 4 baffle 13*b* confines the mixture while directing it upwardly toward a baffle 13*c* which in turn directs it against the other side of baffle 13*b* and toward opening 15. The separation of the steam and water after leaving discharge opening 14*a* in both Figs 3 and 4 occurs in the same manner as it does in Fig. 1 and thereafter the steam flows toward the steam outlet 34 as described for Fig. 1.

An actual installation of the drum internals made in accordance with this invention has shown that at a steam pressure of 800 p. s. i. about 1950 pounds of steam per hour have been passed through each cu. ft. of steam space and upon leaving the drum contained less than ¼ of 1% moisture. When compared with the 1050 pounds limit shown in Fig. 1 of the article referred to above, it shows the output to have increased to 185%. This marked increase is due to a combination of the improvement in the length of time spent by the steam within the steam space of the drum, thereby permitting more moisture to fall out, the effective primary separation within a small space of the steam and water mixture both above and below the water level where the mixture enters the drum, and the subsequent elimination of moisture by its deposit upon the relatively large surface of the several screens which also serve to equalize the flow of steam throughout the steam space.

What I claim is:

1. In a steam separator having a drum containing a body of water, tubes connected to discharge a mixture of steam and water at least in part above the water level, and a steam outlet; means forming a smooth surface in said drum located above the water level and remote from said outlet; baffle means mounted opposite said tubes and disposed to direct said steam and water mixture downwardly through the steam space onto said surface at an acute angle thereto; means forming a funnel shaped throat below said surface and extending to a point under the water level; submerged baffle means offset toward the center of said drum with respect to said funnel and extending upwardly from adjacent the bottom of said drum toward the water level; a submerged screen extending from the throat of said funnel to adjacent upper end of said second baffle means; a second screen extending through the steam space to a point below the water level dividing it into separate chambers; and other steam separating means mounted intermediate and above said second screen and the steam offtake.

2. In a steam separator having a drum containing a body of water, tubes connected to discharge a mixture of steam and water at least in part above the water level, and a steam outlet; means forming a smooth surface in said drum located above the water level and remote from said outlet; baffle means mounted opposite said tubes and disposed to direct said steam and water mixture downwardly through the steam space onto the surface of the inner wall of said drum at an acute angle thereto in a location adjacent said tubes and above the water level; means forming a funnel shaped throat below said surface and extending to a point under the water level; submerged baffle means offset toward the center of said drum with respect to said funnel and extending upwardly from adjacent the bottom of said drum toward the water level; a submerged screen extending from the throat of said funnel to adjacent upper end of said second baffle means; a second screen extending from said first baffle means through the steam space to a point below the water level; and other steam separating means mounted intermediate and above said second screen and the steam offtake.

3. In a steam separator having a drum containing a body of water, tubes connected to discharge a mixture of steam and water at least in part above the water level, and a steam outlet; means forming a smooth surface in said drum located above the water level and extending therebelow and remote from said outlet; baffle means mounted opposite said tubes and disposed to direct said steam and water mixture downwardly through the steam space onto said surface at an acute angle thereto; submerged baffle means offset toward the center of said drum with respect to said surface spaced from the bottom of said drum and extending upwardly toward the water level; a screen extending through the steam space to a point below the water level dividing it into separate chambers;

and other steam separating means mounted intermediate said second screen and the steam offtake.

4. In a steam separator having a drum containing a body of water, tubes connected to discharge a mixture of steam and water at least in part above the water level, and a steam outlet; means forming a smooth surface in said drum located above the water level and extending therebelow and remote from said outlet; baffle means mounted opposite said tubes and disposed to direct said steam and water mixture downwardly through the steam space onto said surface at an acute angle thereto; submerged baffle means offset toward the center of said drum with respect to said surface spaced from the bottom of said drum and extending upwardly toward the water level; a screen extending through the steam space to a point below the water level dividing it into separate chambers; other steam separating means mounted intermediate said second screen and the steam offtake; a submerged feed water inlet located beyond said second mentioned baffle with respect to said surface; and a blow-off pipe submerged within the water between said surface and said second mentioned baffle means.

WARD S. PATTERSON.

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