

[54] **U-TUBE STEAM GENERATOR WITH SEGMENT SUPERHEATER**

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[52] U.S. Cl. **122/32, 122/483**

[51] Int. Cl. **F22b 1/06**

[58] Field of Search **122/32, 33, 34, 483**

[56] **References Cited**

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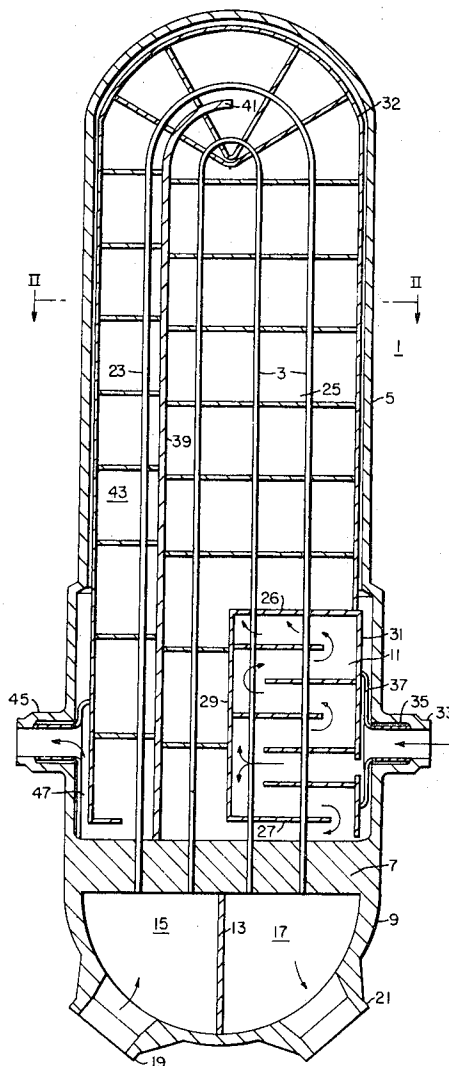
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[57]

ABSTRACT

A steam generator having a U-shaped tube bundle utilized to transfer heat from a first fluid to second fluid feedwater, and having a dividing plate, which acts in conjunction with an arcuate plate to form a steam enclosure encompassing at least a portion of the hot leg of the tube bundle to provide a superheater portion, which cooperates with a preheater portion, disposed on the cold leg, and a boiler portion to produce superheated steam.

7 Claims, 7 Drawing Figures



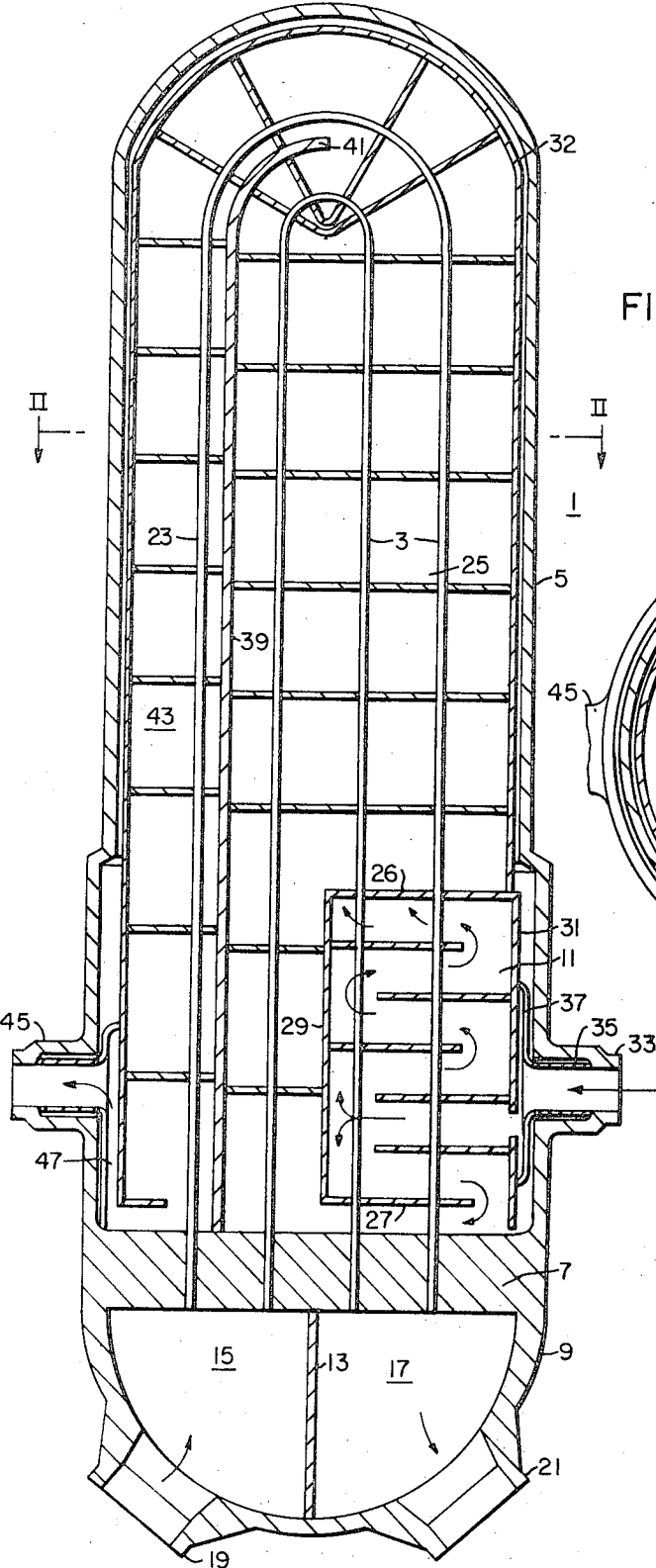


FIG. 1

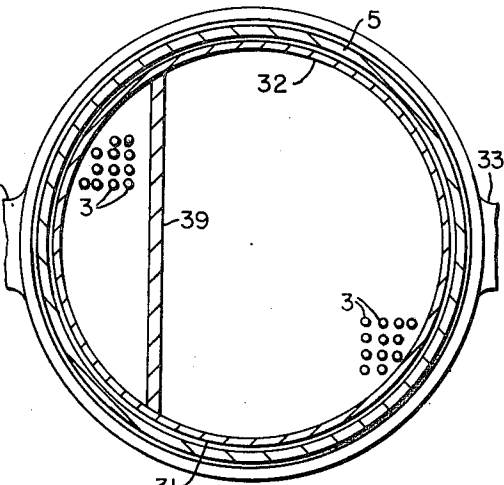
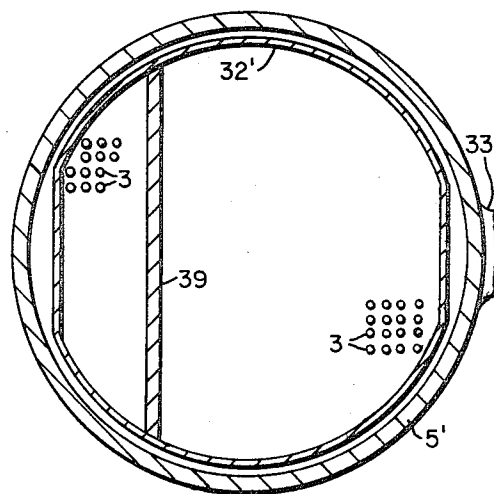
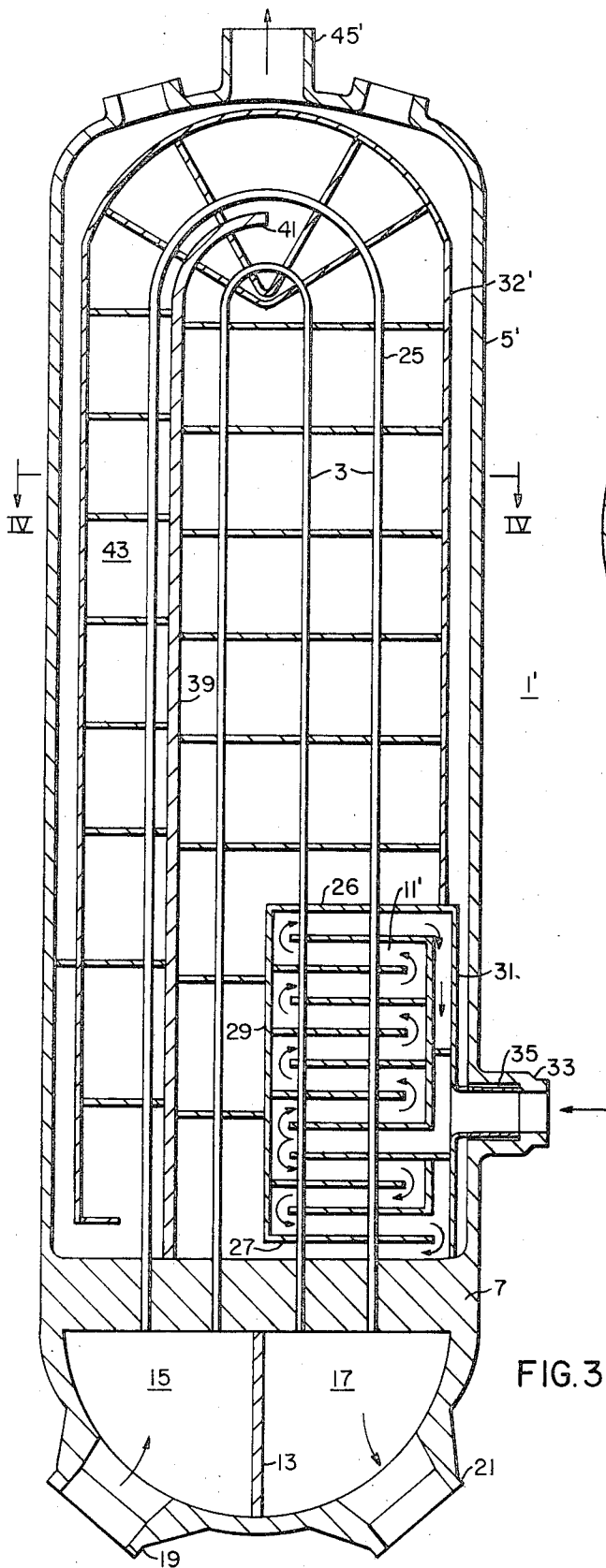


FIG. 2



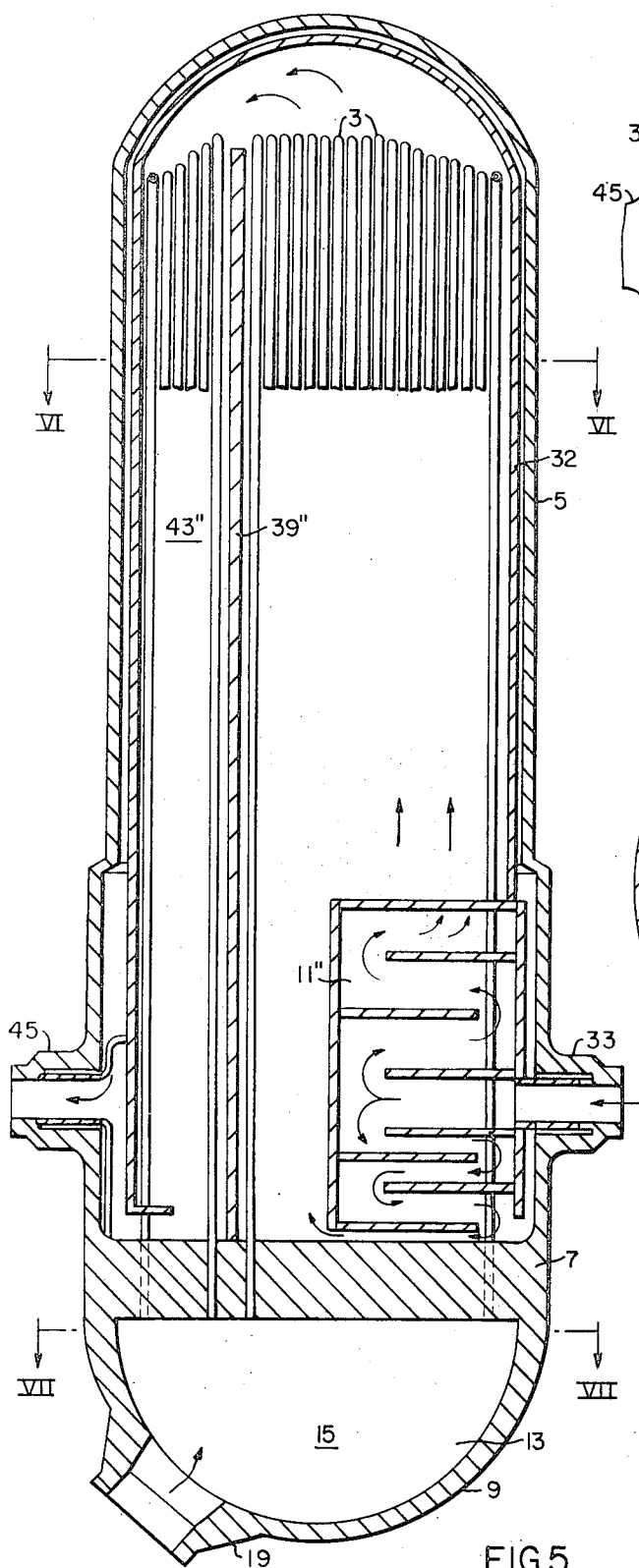


FIG. 5

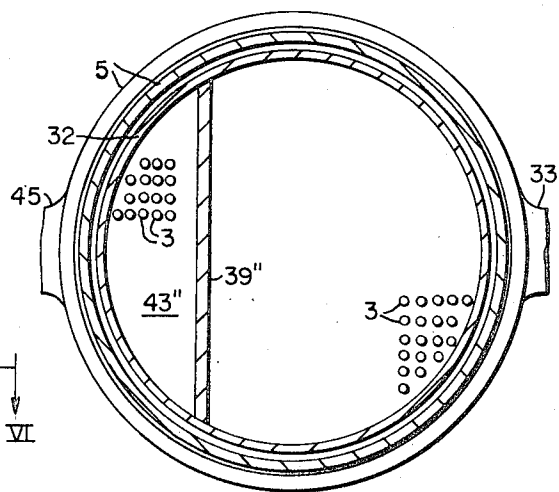


FIG. 6

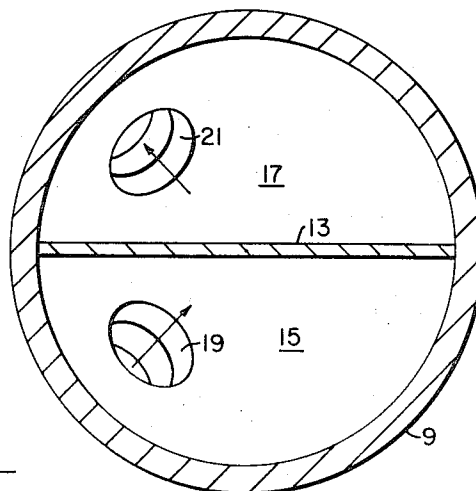


FIG. 7

U-TUBE STEAM GENERATOR WITH SEGMENT SUPERHEATER

BACKGROUND OF THE INVENTION

This invention relates to steam generators for nuclear power plants and more particularly to such steam generators which produce superheated steam.

In order to improve the efficiency of a nuclear power plant utilizing a pressurized water reactor, it is desirable to superheat the steam produced by the steam generator. Once-through straight tube steam generators have been designed; however, the straight-through tubes introduce problems, such as long hot leg pipes and the associated accident consideration, and manufacturing and stress problems due to the thermal expansion of the straight tubes.

U-tube steam generators which produce superheated steam and have downflow boiling are expected to have problems with instability and moisture carryover.

SUMMARY OF THE INVENTION

In general, a steam generator when made in accordance with this invention, utilizes a U-shaped tube bundle to provide the heat transfer surface for transferring heat from a first fluid to vaporize a second fluid. The tube bundle is so arranged that the first fluid flows through the tubes creating a hot leg portion and a cold leg portion in the tube bundle. The steam generator has a tube sheet in which the ends of the tubes are fastened, a preheater portion cooperatively associated with the cold leg portion of the tube bundle, and a fluid inlet nozzle for the second fluid. The second fluid inlet nozzle is disposed to introduce the second fluid into the preheater portion, which has baffles and walls which cooperate to cause the influent second fluid to split and follow two sinuous paths over an outer portion of the heat transfer surface of the tubes forming the cold leg. One path is in a generally upward direction and the other path is in a generally downward direction and leaves the preheater in such a manner as to sweep the tube sheet before it flows upwardly in the steam generator. The portion of the cold leg cooperatively associated with the preheater portion is limited to a predetermined heat transfer area, which will prevent vaporization of the second fluid until it is generally flowing in an upward direction in the steam generator.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects and advantages of this invention will become more apparent from reading the following detailed description in connection with the accompanying drawings, in which corresponding reference characters indicate corresponding portions in the various drawings and, in which:

FIG. 1 is a sectional view of a steam generator made in accordance with this invention;

FIG. 2 is a sectional view taken on line II—II of FIG. 1;

FIG. 3 is a sectional view of a second embodiment of a steam generator made in accordance with this invention;

FIG. 4 is a sectional view taken on line III—III of FIG. 2;

FIG. 5 is a sectional view of a steam generator made in accordance with this invention;

FIG. 6 is a sectional view taken on line VI—VI of FIG. 5; and

FIG. 7 is a sectional view taken on line VII—VII of FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings in detail, FIGS. 1 and 2 show a vapor or steam generator 1, which utilizes U-shaped tubes 3 to form a tube bundle, which provides a heat transfer surface to transfer heat from a first fluid to vaporize or boil a second fluid, generally water. The steam generator 1 comprises an elongated tubular shell 5, a tube sheet 7 in which the ends of the tubes 3 are fastened, a channel head 9, which forms a header for the tubes 3, and a preheater 11. The channel head 9 is a hemispherical head having a centrally disposed dividing plate 13, which separates the inlet and outlet portions 15 and 17, respectively. The inlet portion 15, the portion on the left as shown in FIG. 1, has an inlet nozzle 19 for the influent first fluid and the outlet portion 17 has an outlet nozzle 21 for the effluent first fluid. The U-tubes 3 are so disposed that the first fluid flows from the inlet portion 15 of the head 9 through the U-shape tubes 3 and into the outlet portion 17 of the head 9 creating a hot leg 23, the one on the left in the drawings, and a cold leg 25, the one on the right in the drawings.

The preheater 11 is disposed on the lower end of the cold leg 25 and comprises an enclosure having a top and bottom portion 26 and 27, respectively, and a flat and an arcuate plate 29 and 31, respectively, forming the side walls. The arcuate plate 31 extends from the lower portion of a wrapper 32 which encompasses the tubes 3 and forms a space adjacent the shell 5 to protect it from thermal shocks. The shell 5 is expanded outwardly adjacent the preheater 11 and a second fluid inlet nozzle or feedwater nozzle 33 is disposed in the shell adjacent thereto. A thermal sleeve 35 is disposed in the inlet nozzle 33 and is in communication with an inlet housing 37 disposed parallel to the arcuate wall 31 of the preheater 11 and directs the influent second fluid or feedwater to the preheater. The thermal sleeve 35 and inlet housing 37 cooperate to prevent the cold feedwater from contacting the inlet nozzle 33 or the shell 5, in order to reduce thermal shocks and stresses therein.

A divider plate 39 extends upwardly from the tube sheet 7 parallel to the tubes 3 and cooperates with the wrapper 32 to form a superheater or steam enclosure 43 encompassing at least a portion of the hot leg 23 of the tube bundle. The steam enclosure 43 is in communication with a secondary fluid or steam outlet nozzle 45 through a steam outlet enclosure 47, which directs the steam from the steam enclosure 43 to the steam outlet nozzle 45. The dividing plate 39 is so disposed to cooperate with the tube bundle 3 and preheater 11 to vaporize or boil the feedwater at such a rate that the second fluid entering the steam enclosure 43 is saturated steam or the quality is 100 percent and the effluent second fluid flowing through the outlet nozzle 45 is superheated steam.

The steam or vapor generator shown in FIGS. 3 and 4 is similar to the one shown in FIGS. 1 and 2 except the steam outlet nozzle 45' is disposed in the upper end of the vessel and the wrapper 32' encompasses the tube bundle and forms an annular space between the shell

5 and the wrapper 32'. The annular space is utilized to allow steam to flow from the lower end of the steam enclosure 43 to the steam outlet nozzle 45' at the top of the steam generator. The tube bundle 3 is also modified by omitting tubes adjacent the outer periphery to provide space for the feedwater inlet and the shell 5' is not expanded outwardly adjacent the preheater.

The steam or vapor generator shown in FIGS. 5, 6 and 7 is similar to the one shown in FIGS. 1 and 2 except the dividing plate 39'' is rotated 90° locating it in a plane parallel to a plane in which the U-shaped tubes are disposed so that preheater 11'', evaporator and superheater 43'' portions each contain both hot and cold leg portions of the U-shaped tubes.

The steam generators hereinbefore described advantageously utilize U-shaped tubes to form a tube bundle, which is free to expand with variation in temperature, and has a preheater portion, a boiler portion and a superheater portion cooperatively associated so that all boiling or vaporization takes place when the feedwater is flowing upwardly and saturated vapor enters the superheater portion when the unit is operating at rated load.

What is claimed is:

1. A vapor generator utilizing a U-shaped tube bundle to provide a heat transfer surface to transfer heat from a first fluid to vaporize and superheat a second fluid, said tube bundle being so arranged within said vapor generator that said first fluid flows through said tubes creating a hot leg portion and a cold leg portion in said tube bundle, said vapor generator comprising an elongated tubular shell, encompassing the tube bundle, a tube sheet in which the ends of the tubes are fastened, a head, secured to said tube sheet and forming a header for the tubes, a preheater cooperatively associated with a portion of said cold leg, a divider plate disposed lengthwise in said shell said divider plate forming a portion of a vapor enclosure, a second fluid inlet nozzle in communication with the preheater and a second fluid outlet nozzle in communication with the vapor enclosure

sure, whereby influent second fluid enters the preheater and is heated to a temperature below its vaporization temperature and then flows upwardly over a first major portion of the heat transfer surface of the tube bundle changing state of the second fluid from a liquid to a vapor and then the vapor enters the vapor enclosure wherein it flows over a second major portion of the heat transfer surface of the tube bundle incorporating at least a portion of the hot leg, increases in temperature and becomes superheated vapor prior to being discharged through the second fluid outlet nozzle.

2. A vapor generator as set forth in claim 1, wherein the vapor enclosure encompasses less than half of the tube bundle.

3. A vapor generator as set forth in claim 1, wherein the vapor enclosure encompasses a portion of the hot leg.

4. A vapor generator as set forth in claim 1, wherein the vapor enclosure comprises the dividing plate, a portion of a wrapper disposed to enwrap the tube bundle and an arcuate plate.

5. A vapor generator as set forth in claim 1, wherein the vapor enclosure, preheater and major portion of the tube bundle in which vaporization takes place are cooperatively associated in such a manner that the vapor entering the vapor enclosure is at 100 percent quality when there is rated load on the vapor generator.

6. A vapor generator as set forth in claim 1, and further comprising an enclosure disposed within the shell, said enclosure completely enwrapping the tube bundle and providing an annular space between the enclosure and the shell in which the vapor flows to the second fluid outlet nozzle which is disposed in the upper end of the shell.

7. A vapor generator as set forth in claim 1, wherein the tubes are U-shaped and the dividing plate is disposed in a plane parallel to planes in which the U-shaped tubes are disposed.

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