United States Patent

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[54] **SODIUM VAPOR TRAP**
8 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **277/22,** 277/56, 165/73
[51] **Int. Cl.** **F02f 11/00,** F16j 15/00
[50] **Field of Search** 277/53–57, 67, 133, 22; 165/73, 105; 137/254

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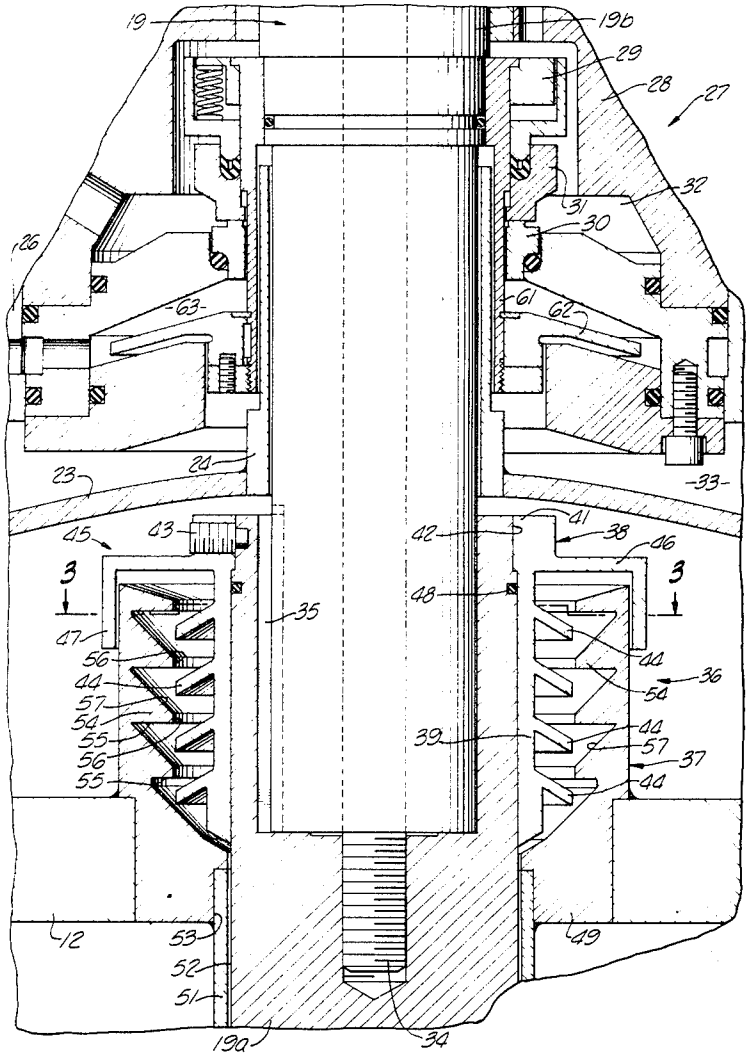
ABSTRACT: A sodium vapor trap for sealing a rotary shaft to a housing, the trap having a stationary member carried by the housing and surrounding the shaft and a rotary member carried by the shaft for rotation within the stationary member, the rotary member and the stationary member having transverse baffles cooperating to provide a tortuous passageway communicating the interior of the housing with the exterior and forming a reflux condenser for condensing the sodium vapor to liquid sodium and returning it to the housing.



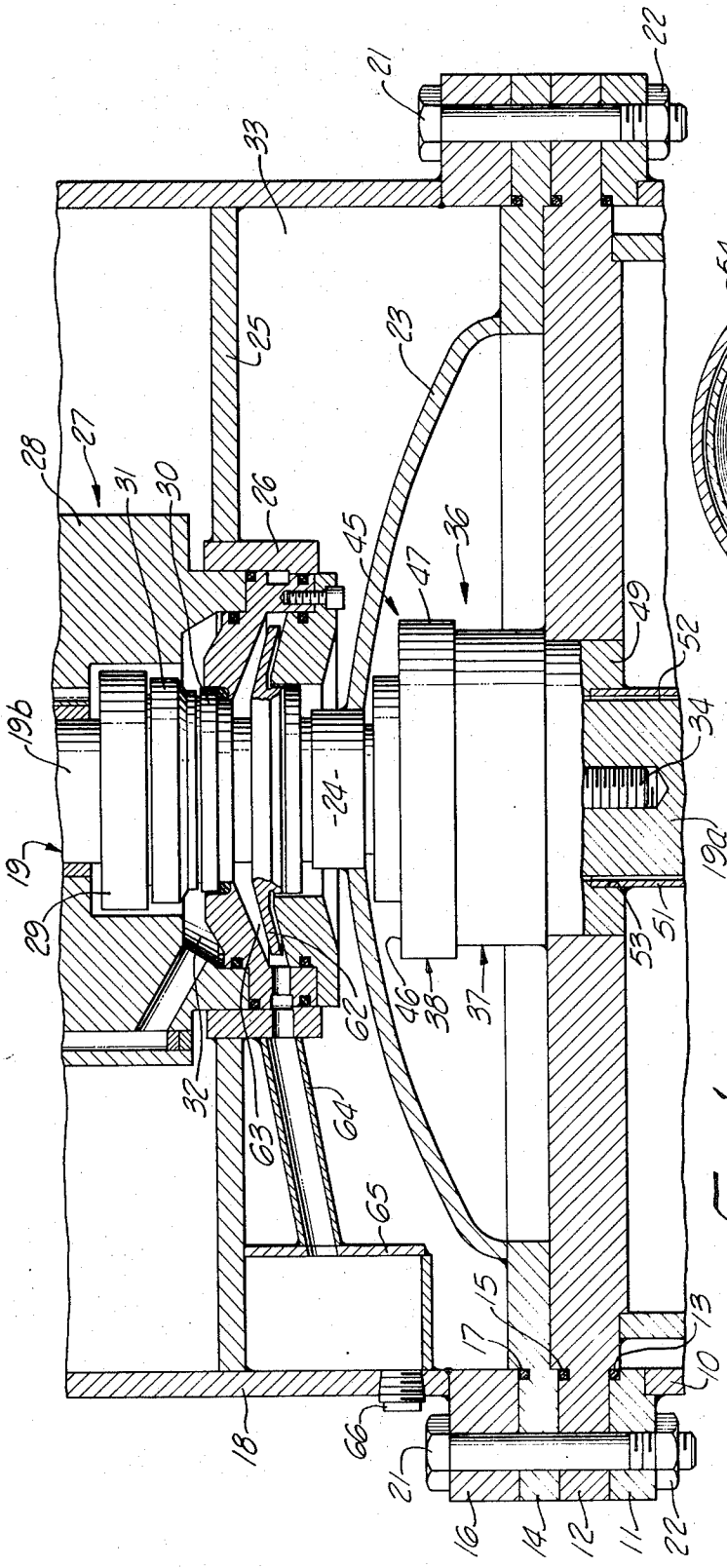


FIG. 1.

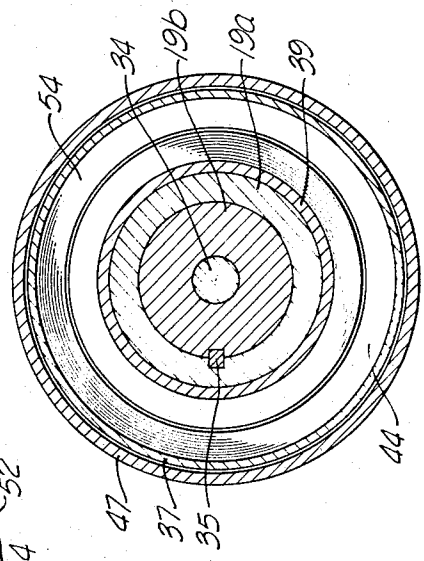


FIG. 3.

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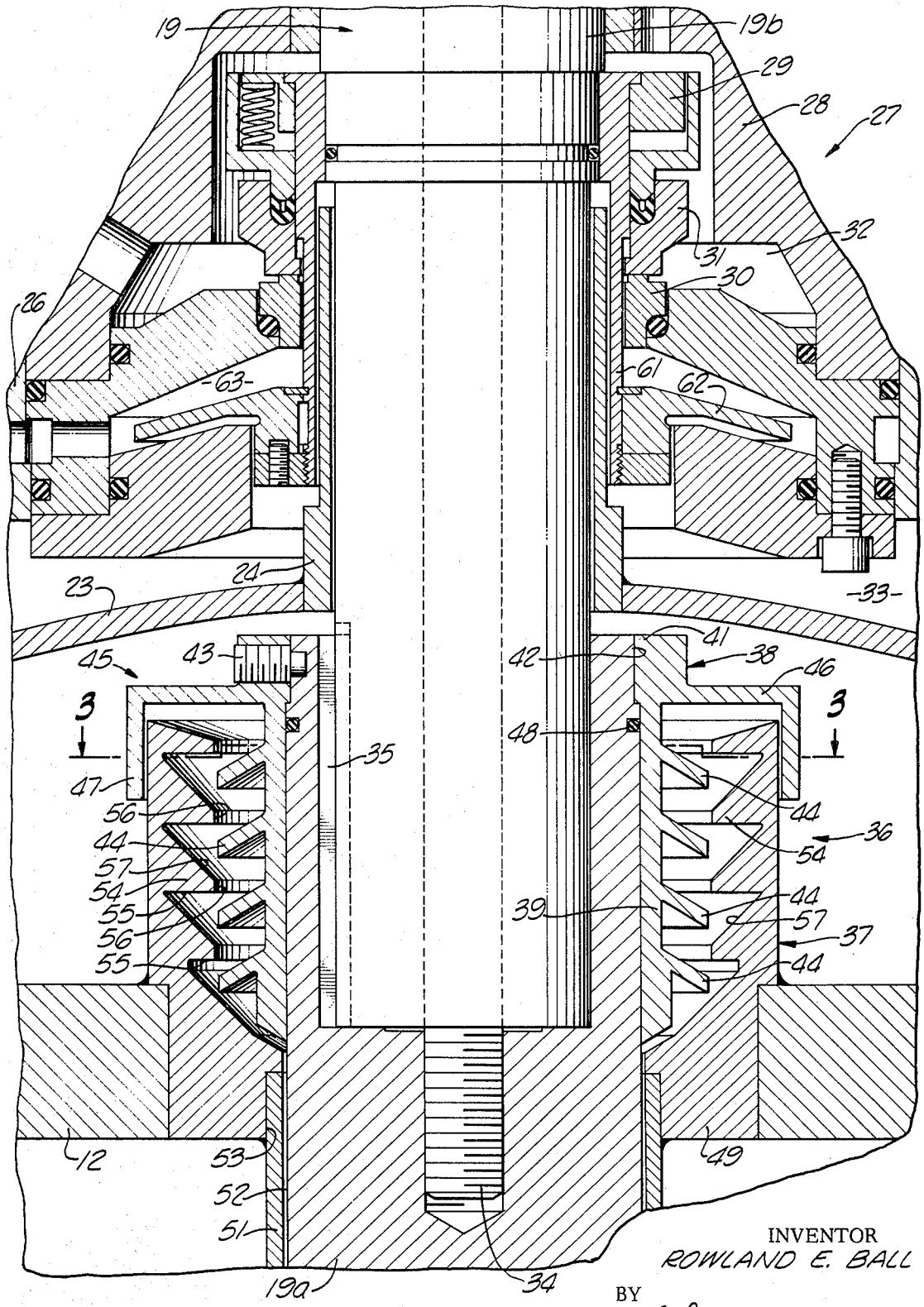

FIG. 2.

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SODIUM VAPOR TRAP

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a sodium vapor trap for sealing a rotary shaft to a housing having a shaft opening with a rotary shaft extending therethrough. More particularly, the invention relates or pertains to such a trap for mounting between a vertical shaft and a housing surrounding it. The sodium vapor trap of the present invention is adapted to prevent the escape of sodium vapor along the vertical shaft of a liquid sodium pump from the space within the pump to the space outside the pump.

2. Description of the Prior Art

Certain liquid sodium pumps of the prior art have included a centrifugal impeller driven by a vertical shaft extending above the impeller through a pump barrel and passing through a shaft opening in the head of the barrel. The shaft is driven by an electric motor mounted on the top of the barrel. A shaft seal, of the mechanical seal type, and shaft bearings have been provided between the head of the pump barrel and the electric motor thereabove. The shaft seal has prevented the escape of argon used as protective atmosphere over the liquid sodium in the pump. The impeller shaft rotates in a tube that is spaced with a close clearance from the shaft and sealed by transverse partitions at the top and bottom of the tube to the interior of the pump barrel. The space enclosed by the upper and lower partitions, the shaft tube, and the pump barrel is filled with insulation or shielding material to prevent or minimize the escape of sodium vapor and to block radiation, if the sodium is radioactive. However, the space between the shaft and the shaft tube is open at the bottom to the sodium-vapor-containing atmosphere above the liquid sodium in the pump, and is open at the top to allow escape of sodium vapor into the mechanical seal compartment thereabove. Such sodium vapor as migrates into the mechanical seal compartment condenses therein to solid sodium and interferes with the proper functioning of the seals.

SUMMARY OF THE INVENTION

An object of the invention is to provide a sodium vapor trap for substantially eliminating the escape of sodium vapor from a housing along a shaft, such as a pump impeller shaft, that extends into the housing through a shaft opening.

A further object is to provide such a trap that will act as a reflux condenser to condense the sodium vapor to liquid and return it as a liquid to the housing.

The foregoing and other objects of the invention are attained in a sodium vapor trap for sealing a rotary shaft to a housing having a shaft opening with a rotary shaft to a housing having a shaft opening with a rotary shaft extending therethrough, the trap substantially preventing the escape of sodium vapor along the shaft from the space within the housing to the space outside the housing, the trap comprising: a rotary member carried by and sealed to the shaft; a stationary member surrounding the rotary member and carried by and sealed to the housing; the rotary member having axially spaced, transverse baffles projecting away from its axis; and the stationary member having axially spaced, transverse baffles projecting toward its axis and cooperating with the first-mentioned baffles to provide a tortuous passageway communicating the space within the housing with the space outside the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an axial, sectional view of portion of a sodium pump with a sodium vapor trap in accordance with the invention installed therein;

FIG. 2 is an enlarged axial sectional view of a portion of the structure of FIG. 1 that shows in section the sodium vapor trap shown in elevation in FIG. 1; and

FIG. 3 is a sectional view on a reduced scale taken along the line 3—3 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the several figures of the drawings and in the following description, the same part is always designated by the same reference numeral.

Referring to the drawings, particularly to FIG. 1, there is shown a portion of a liquid sodium pump having a pump barrel 10 with a flange 11 welded to its top. A head 12 is sealed to the flange 11 by an O-ring 13. An annular, ring-shaped member 14 is supported upon the head 12 and is sealed to the latter by another O-ring 15. The member 14 supports a concentric ring 16, the two members being sealed to each other by yet another O-ring 17. A cylindrical housing member 18 is welded to the top of the ring 16, the housing member 18 supporting an electric motor (not shown) which drives the pump impeller (not shown) through a shaft 19, as is conventional. Bolts 21,21 having nuts 22,22 are employed to secure together the concentric annular ports 11, 12, 14 and 16.

A dome 23 is welded to the annular, ring-shaped member 16 and has a sleeve 24 welded to it and surrounding the shaft 19, as more clearly seen in FIG. 2.

As shown in FIG. 1, a transverse plate 25 is welded to the housing member 18 and is positioned above the dome 23. This plate 25 carries a collar 26 providing a seat for a mechanical seal assembly designated by the general reference numeral 27 and having a stationary subassembly 28 and a rotary subassembly 29 carried by the shaft 19. The stationary subassembly has a nonrotating mechanical seal ring 30. In rotating sealing relationship to this seal ring is a rotary mechanical seal ring 31. Referring to FIG. 2, there is a chamber 32 in the stationary subassembly 28 that is filled with oil under a static pressure somewhat above the static pressure of the gas in the space 33 below the mechanical seal assembly and above the dome 23. This mechanical seal assembly prevents the escape of gas along the shaft from below the mechanical seal assembly to the atmosphere. As a mechanical seal assembly of this type is known in the prior art, a further detailed description thereof is not deemed necessary herein.

The rotating subassembly 29 of the mechanical seal has a depending skirt 61 carrying a flange or flinger 62 that rotates with the shaft. Any oil that seeps past the seal rings 30,31 is caught by the flinger 62 and spun outwardly into the chamber 63. As seen in FIG. 1, a conduit 64 drains the oil from the chamber 63 into a sump 65 from which it may be withdrawn upon removal of the plug 66. Thus, oil is prevented from flowing downwardly along the shaft into the sodium pump.

Turning to FIG. 2, it is seen that the shaft 19 has a lower section 19*a* secured to an upper section 19*b* by screw 34, the two shaft sections being prevented from relative rotation by a key 35.

A sodium vapor trap designated by the general reference numeral 36 is interposed between the shaft 19 and the head 12 for the purpose of substantially preventing the escape of sodium vapor along the shaft and across the head. The sodium vapor trap has a stationary member 37 carried by the head 12 and a rotary member 38 carried by the shaft 19; these members preferably are fabricated from austenitic stainless steel.

The rotary member 38 has a cylindrical portion 39 fitted to the shaft section 19*b*. A reduced-diameter portion 41 of the rotary member is received in a corresponding rabbet 42 in the shaft section 19*a*. The rotary member is locked to the shaft section by a set screw 43. The cylindrical section 39 carries axially spaced, outwardly projecting, downwardly sloping baffles in the form of fins 44. These fins are bodies of revolution and have the same outer diameters; they are evenly spaced in the axial direction and sloped downwardly at an angle of approximately 30° from the horizontal. The rotary member 38 has a cap portion 45 with a horizontal top 46 and depending skirt 47. The cap overlies the stationary member 37 and is spaced slightly therefrom so that it may rotate freely and without interference and yet provide for the outward flow of gas between the stationary and rotary members of the trap. An O-ring 48 seals the rotary member to the lower shaft section 19*a*. It will be seen that the fins 44 have a uniform thickness.

The stationary member 37 of the trap is welded to the barrel head 12. The stationary member is generally cylindrical. It has a bottom portion 49 that closely encircles the shaft section 19*a* and underlies the bottom portion of the rotary member 38. The portion 49 receives the upper end of a tube 51 that encompasses the lower section 19*a* of the shaft and is spaced therefrom to provide a clearance 52. The upper end of the tube 51 is received in a recess 53 in the bottom portion of the stationary member and is welded therein. The stationary member 37 has a plurality of inwardly projecting baffle members 54 positioned opposite to the spaces between the fins 44 on the rotary member. These baffle members have generally horizontal bottom surfaces 55, cylindrical inner surfaces 56, and downwardly sloping upper surfaces 57. The inner diameters of the baffle members are equal and slightly greater than the outer diameters of the fins 44 of the rotary member; this enables the rotary member to be inserted into and removed from the stationary member.

In operation, the sodium vapor trap 36 acts as a reflux condenser for the sodium vapor that rises through the clearance space 52 between the shaft section 19*a* and the tube 51. This sodium vapor is carried in an inert atmosphere such as an atmosphere of argon, the argon being employed to prevent oxidation of the sodium and sodium vapor in the pump. The sodium vapor passing between the rotary and stationary members of the trap is deflected by the fins and baffle members against the internal surfaces of the trap upon which the sodium vapor is condensed to the liquid state,, the liquid flowing downwardly along the internal surfaces of the trap and returning towards the pump through the clearance space 52.

Although the specific configuration of the fins 44 and baffle members 54 may be varied somewhat, the interior surfaces of the trap components should be so sloped that all of the condensed metal will flow back to the pump; preferably there should be no recesses in the trap to retain condensed metal. The shape and disposition of the fins 44 tends to direct the flow of argon and sodium vapor substantially normally upon the upper faces 57 of the baffle members 54. These surfaces 57 are the principal condensing surfaces of the trap; they are cooled more rapidly than the fins 44, as the heat radiates outwardly from the radial outer surfaces of the stationary member 37. Condensation of sodium vapor and radiation from the trap maintain the condensing surfaces of the trap slightly to somewhat above the melting point of sodium, namely, 99.5° C. The trap of the present invention is extremely efficient, and substantially no sodium vapor exits from the trap into the space beyond the trap. Moreover, because the sodium vapor condenses to a liquid, and not to solid metal, the interior of the trap does not become clogged with condensed solid metal. Rotation of the shaft, and with it the rotary member 38 of the trap, promotes high condensation efficiency. The rotary motion causes the gasses to impinge on the stationary member with higher velocity than would be the case without such rotation. This higher velocity improves condensation. Although the trap is more efficient when the member 38 rotates, it nevertheless is an effective reflux condenser when the member 38 is stationary.

With the present invention, sodium vapor from the pump cannot escape to any appreciable extent and condense as liquid or solid metal in and around the shaft and mechanical seal assembly.

Although the specific embodiment of the invention herein shown and described has been described with reference to the condensation of sodium vapor, it will be understood that the trap can also be employed to condense other metal vapors, more particularly alkali metal vapors, and specifically vapors of potassium or sodium-potassium alloys known as NAK. Therefore, the term sodium is used herein in a generic sense, and is not intended to limit the invention to the condensation of sodium vapor, but is intended to be broadly construed to include other alkali metals and alloys thereof.

The number of alternate fins and baffle members may be more or less than the four shown in the drawings.

I claim:

1. A sodium vapor trap for sealing a rotary shaft to a housing having a shaft opening with a rotary shaft extending therethrough, said trap substantially preventing the escape of sodium vapor along the shaft from the space within the housing to the space outside the housing, said trap comprising:
   a. a rotary member carried by and sealed to the shaft;
   b. a stationary member surrounding said rotary member and carried by and sealed to the housing;
   c. said rotary member having axially spaced, transverse baffles projecting away from its axis;
   d. said stationary member having axially spaced, transverse baffles projecting toward its axis and cooperating with said first-mentioned baffles to provide a tortuous passageway communicating the space within the housing with the space outside the housing; said members constituting
   means for maintaining said trap at a temperature above the melting point of said sodium such that vapor thereof between said members is condensed to the liquid state,
   f. said baffles sloping downwardly toward the interior of the housing such that the condensed liquid sodium flows freely into the space within the housing.

2. A sodium vapor trap as defined in claim 1, wherein said baffles are bodies of revolution.

3. A sodium vapor trap as defined in claim 1, wherein said first-mentioned baffles alternate with said second-mentioned baffles.

4. A sodium vapor trap as defined in claim 1, wherein said rotary member has a cap portion surrounding and spaced from the axially outer end of said stationary member.

5. A sodium vapor trap as defined in claim 1, wherein said stationary member has an axially inner end portion underlying the axially inner end of said rotary member.

6. A sodium vapor trap as defined in claim 1, wherein said first-mentioned baffles are slightly smaller in diameter than said second-mentioned baffles.

7. A sodium vapor trap as defined in claim 1, wherein said members comprise austenitic stainless steel.

8. A sodium vapor trap as defined in claim 1, wherein said members are disposed vertically about a vertical shaft.

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