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GAS LIQUEFIER

Filed Oct. 21, 1965

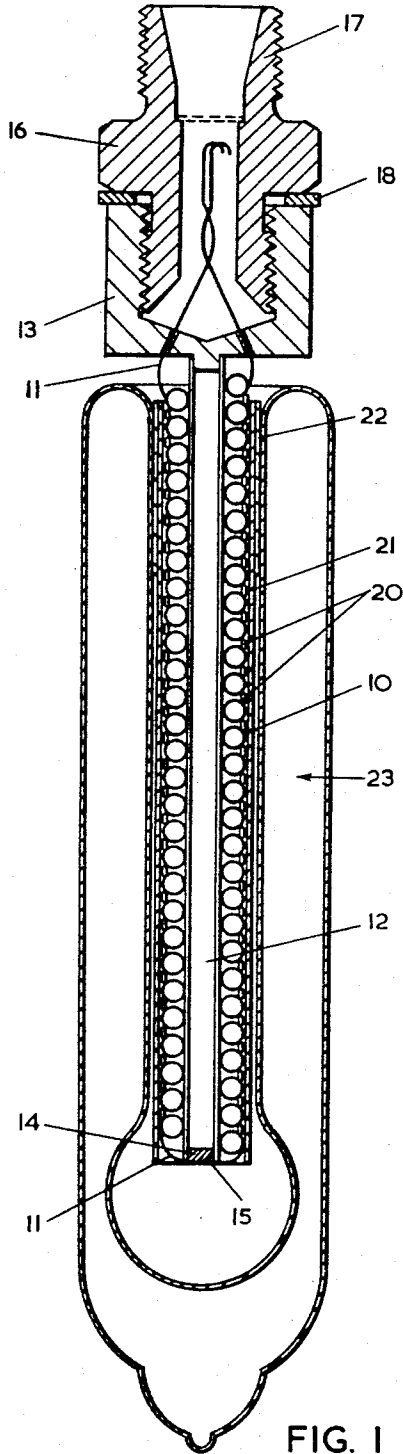


FIG. 1

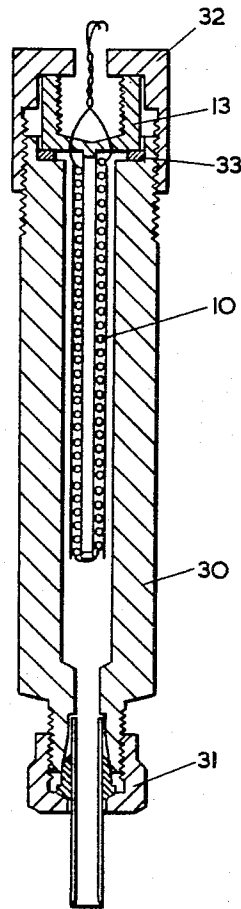


FIG. 2

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GAS LIQUEFIER

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Claims priority, application Great Britain, July 30, 1965, 32,783/65

1 Claim. (Cl. 62—514)

ABSTRACT OF THE DISCLOSURE

An improved construction of miniature gas liquefier of the type comprising a heat exchanger of coiled capillary tubing adapted to fit within a cylindrical Dewar and to be connected at an inlet end to a source of pressurized gas, and having an outlet orifice through which the gas is expanded and flows out of the Dewar over the heat exchanger giving progressive cooling and eventual liquefaction. In the improved construction, the heat exchanger consists of a double coil formed from a single U-shaped length of coiled capillary tubing, the ends of which are sealed into an inlet header, and the expansion orifice consists of an aperture formed in the tube wall at the base of the U.

The present application is a companion to the application of Thomas John Webster, Ser. No. 499,934, filed Oct. 21, 1965, for Gas Liquefier, and owned by the assignee of this application, now Patent No. 3,326,015.

This invention relates to gas liquefiers in which so-called "permanent" gas at high pressure is expanded to substantially atmospheric pressure in an expansion nozzle or orifice after passing through a heat exchange coil, the expanded gas flowing back over the coil in countercurrent with the incoming high pressure stream. The cooling of the coil by the expanded gas results in progressive lowering of the temperature of the high pressure gas flowing through the coil until a portion of the gas issues from the orifice as liquid. The so-called permanent gases which can be liquefied in this manner include air, oxygen, nitrogen, argon, krypton, and xenon.

Hydrogen can also be liquefied in this manner but the compressed steam of hydrogen must be pre-cooled with a liquefied gas such as nitrogen before it is fed into the heat exchanger.

To meet sporadic demands for small quantities of such liquefied gases for demonstration purposes in educational establishments or for other purposes, small portable liquefiers have been made adapted within a short time of the order of one minute or less to produce liquefied gas from high pressure storage vessels or cylinders.

The heat exchanger in such portable liquefiers may take the form of a coil, a coiled helix or a series of coils or coiled helices wound round a mandrel which is inserted in a vacuum insulated cylindrical flask or Dewar. The inner wall of the Dewar, in combination with the mandrel, serves to provide an annular passage for the return gas, causing it to traverse the coil. For demonstration purposes the Dewar is made of transparent material such as glass so that the formation of liquid can be easily seen. Such portable liquefiers may also be used for cooling small instruments, such as an infra red detector, which can be housed in the transparent vessel. Other sporadic demands for small quantities of liquefied gas arise in cryosurgery and in the low temperature preservation of biological tissue, such as corneal graft material.

The heat exchanger of such portable liquefiers has hitherto comprised several, usually three, lengths of helical capillary tubing wound as a multiple helix around a

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mandrel. At the inlet end, the terminal portion of each length of tubing is sealed into a passage in an inlet header adapted to be connected to a source of high pressure gas. At the discharge end, the terminal portion of each length is sealed into a passage in an outlet header having a throttling device such as an expansion nozzle or orifice through which the gas is expanded and thereby cooled. The use of solder is necessary to achieve a mechanically sound and gas tight joint between the capillary tubes and the respective passages in the inlet and outlet headers. In practice such joints are extremely difficult to make as molten solder tends to flow into the tubes by capillary action. Further, if one or more tubes should become blocked this is extremely difficult to detect once the unit has been completed, except by the poor performance of the unit.

It is an object of this invention to provide a liquefier of simplified coil construction which is inexpensive to manufacture.

A further object of this invention is to provide a liquefier wherein risk of solid particles entering and blocking the heat exchange tube is minimized.

Yet a further object of this invention is to provide a liquefier so constructed that in the event of blockage of the heat exchange tube, such blockage may be readily removed.

According to this invention there is provided a gas liquefier heat exchanger assembly comprising a header having an inlet adapted to be connected to a source of gas under pressure, and a heat exchanger communicating with said header, said heat exchanger consisting of a single length of helically wound capillary tubing doubled into a U-shaped element having projecting terminal portions sealed into said header, the U-shaped element being wound helically to form a substantially cylindrical structure, the capillary tubing having an aperture at the base of the U-shaped structure to serve as an expansion orifice.

The ends of the capillary tubing may extend into a chamber in the inlet header and may be bent over therein so that incoming compressed gas enters the capillary tubing in a direction opposed to the gas flow into the chamber, whereby entry into the tubing of solid particles entrained in the gas stream is minimized.

The gas liquefier may be adapted to be fitted within a back-flush unit for the clearance of any blockage occurring in the capillary tubing.

An embodiment of the invention is shown by way of example in the accompanying drawings in which:

FIG. 1 is a view in longitudinal section of a gas liquefier fitted into a Dewar flask, and

FIG. 2 is a view in longitudinal section of the liquefier fitted into a back-flush unit.

Referring to FIG. 1, the liquefier comprises a double heat exchange coil 10 of coiled capillary tubing 11 wound around a mandrel 12. The mandrel 12 is a thin walled stainless steel tube three inches long, one end of which is soldered onto a central boss of a header 13. The mandrel tube is closed at its other end by a plug 14. The header 13 is internally screw threaded for the reception of an adaptor 16 having a nipple 17 for connection to a high pressure gas source such as a pressurized cylinder. The header is sealed by a resilient washer 18.

The double coil 10 is formed from a single 10 ft. length of capillary tubing 11 of 0.3 mm. inside diameter. This is first coiled into a helix leaving its ends uncoiled, and is then straightened in the region of its centre 15 and bent into a U-shape, the two arms of which are coiled around the mandrel 12 as a double helix. The uncoiled ends of the capillary tube extend into the header 13, within which the tube ends are twisted together, and the open ends are bent over as indicated to minimize entry

into the tubes of solid particles entrained in the gas stream. The tube is now soldered in three places only, namely at the holes where the ends enter the manifold and where the bottom 15 of the U is attached to the mandrel 12. Because of the clear length of tube inside the inlet manifold there is no possibility of the tubes becoming blocked with solder, and at the bottom 15 of the U the tube is as yet imperforated so that no blockage can occur.

The centre portion 15 of the tubing 11 at the base of the U is located in a small slot in the plug 14. In this region an orifice of about 0.003 inch diameter is drilled in the capillary tube wall, this providing an outlet orifice for pressurized gas supplied to the tube ends via the header 13.

After the coil 10 has been formed, Terylene cord 20 is wrapped around the coil outside to fill in the surface indentations and to give a relatively smooth cylindrical surface. Terylene tape is then tightly wound around the outside of the whole coil, so as to form an insulating sheath 21. An additional winding of tape 22 is provided around the inlet end of the coil so as to provide a plug which is a push fit into the Dewar vessel 23. This plug provides sealing means which prevent return gas flow outside the sheath 21, so ensuring that all expanded gas passes over the coil. Apart from directing the return gas in this way, the sheath reduces inflow of heat from the relatively warm inner wall of the Dewar vessel, and substantially improves performance of the liquefier on warm start-up.

FIG. 2 shows a back-flush unit which may be used for clearance of a blockage in one of the capillary tubes of the liquefier. The unit comprises a casing 30 having a central bore adapted to be connected to one end to a source of compressed gas by a coupling 31. The other

end of the casing 30 is provided with a screw cap 32 adapted to retain the header 13 of the liquefier when positioned with its coil 10 extending along the bore. A washer 33 seals the coil 10 into the bore, and pressurized gas fed into the coupling 31 can only escape via the orifice of the coil and the two arms of the capillary tubing.

With the liquefier in place, pressurized gas is passed into the unit and the tube ends are tested for gas flow. If a first arm of the coil appears to be blocked, the gas pressure is shut off while the second arm is sealed with a spot of solder at the outlet end. On restoring the gas pressure, gas is forced to flow through the first arm thus clearing the blockage. The solder may then be removed from the second tube end by heating this while applying the gas pressure.

What is claimed is:

1. A gas liquefier heat exchanger assembly comprising a header having an inlet adapted to be connected to a source of gas under pressure, a mandrel depending from said header, and a heat exchanger communicating with said header, said heat exchanger consisting of a single length of helically wound unfinned capillary tubing doubled into U-shaped element having projecting terminal portions sealed into said header, the U-shaped element being wound helically around said mandrel to form a substantially cylindrical structure, the capillary tubing having an aperture at the base of the U-shaped structure to serve as an expansion orifice.

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MEYER PERLIN, *Primary Examiner*.