

Nov. 12, 1968

W. A. HOYES

3,410,110

COOLING DEVICES

Filed Feb. 6, 1964

2 Sheets-Sheet 1

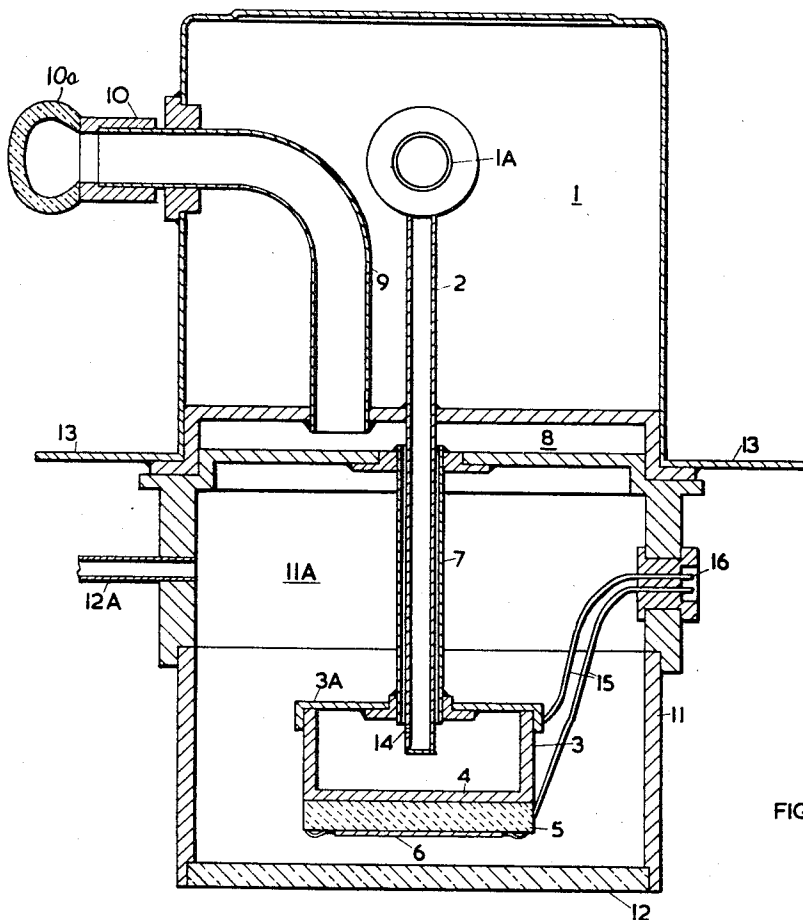


FIG. 1.

W. A. HOYES
Inventor
By *W. A. Hoyes*, *Attorney*
Attorneys

Nov. 12, 1968

W. A. HOYES

3,410,110

COOLING DEVICES

Filed Feb. 6, 1964

2 Sheets-Sheet 2

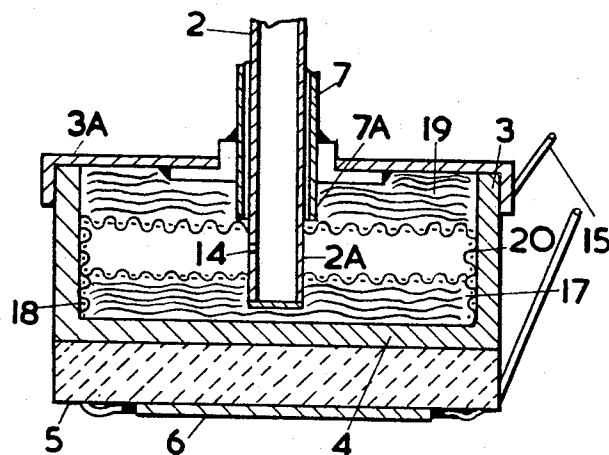


FIG. 2.

W. A. HOYES

Inventor

By *More, Hall & Pomeroy*

Attorney

1

2

3,410,110

COOLING DEVICES

William Adlard Hoyes, Malvern, England, assignor to Minister of Aviation in Her Majesty's Government of the United Kingdom of Great Britain and Northern Ireland, London, England

Filed Feb. 6, 1964, Ser. No. 343,914

Claims priority, application Great Britain, Feb. 7, 1963, 5,120/63

13 Claims. (Cl. 62—514)

This invention relates to cooling devices and has reference to those cooling devices which are used for cooling electronic photosensitive devices.

A cooling device is sometimes required to enable a photosensitive cell, for example a cell of the lead selenide or the indium antimonide type, to achieve its maximum performance in detecting small infra-red signals. For certain applications the cooling of a cell represents considerable difficulty and a device has been developed in which liquid gas refrigerant held under pressure is allowed to expand and escape to the atmosphere. The liquid gas is lost but it is possible to make an amount available which is sufficient to give a useful degree and length of time of cooling. Such a cooler is colloquially known as a "one-shot" cooler.

One difficulty which is encountered is in preventing the leakage of heat to the cooled part of the cell and that part of the cooler in close contact with it. The reservoir of liquid refrigerant is capable of holding heat because of its bulk and the holder and the connecting structure between the holder and the cooled parts tend to conduct heat to those parts.

It is an object of the invention to provide an improved cooler.

According to the invention a cooler for cooling a photosensitive cell comprises a reservoir for holding a mass of refrigerant, an expansion chamber one part at least of which constitutes the region to be cooled, inlet means for conducting refrigerant from the reservoir to the expansion chamber and exhaust means for exhausting the expansion chamber to lower pressure, the arrangement being such that the exhaust from the expansion chamber cools refrigerant entering the expansion chamber from the reservoir.

Conveniently the means conducting refrigerant between the reservoir and the expansion chamber is a tube located within a larger tube serving as the means for exhausting the chamber; together they form a heat exchanger.

In order to make the invention clearer a one-shot cooler embodying the invention will now be described by way of example, reference being made to the accompanying drawings, in which:

FIGURE 1 is a cross-sectional diagram of a one-shot cooler, and

FIGURE 2 is a cross-sectional diagram of a detail associated with the expansion chamber of a more refined version of the cooler.

In the drawings a reservoir 1 communicates by means of a cupro-nickel tube 2 to an expansion chamber 3 made of high conductivity copper. A wall 4 of the chamber 3 carries a Sintox substrate 5 on which a photosensitive layer 6 is deposited.

A cupro-nickel tube 7 concentric with and outside the tube 2 provides an exhaust from the chamber 3 to a cavity 8. A further cupro-nickel tube 9 continues the exhaust from the chamber 3 and the cavity 8, through the reservoir 1 to an output pipe 10. The tubes 2 and 7 are made of cupro-nickel to minimise heat conduction between the reservoir 1 and the chamber 3.

A skirt 11 extends at a distance from and about the tube 7 and is closed by a sapphire window 12. The space 11A thus enclosed is pumped via a pumping stem 12A to

vacuum. A mounting 13 for the cooler is provided integrally with the wall of the reservoir 1. Leads 15 are connected to the photosensitive layer 6 and terminate at a terminal block 16 in the skirt 11. A short distance from the closed end of the tube 2 a small orifice 14 provides an expansion nozzle from the tube 2 to the chamber 3.

In operation we assume first that the outlet pipe 10 is closed e.g. by a frangible high pressure seal 10A, and the reservoir 1 contains a liquid refrigerant under pressure, such as Refrigerant 22 (American Society of Refrigeration Table) inserted by means of a filling port 1A, which is sealed off after filling. Thus the whole cooler except the space 11A is filled with refrigerant, including the reservoir 1, the chamber 3, the cavity 8 and the tube 9.

To cool the photosensitive layer 6 for a spell we first break the seal 10A on the outlet pipe 10. This causes the refrigerant in the chamber 3, the tube 7, the cavity 8 and the tube 9 to expand, cooling the chamber 3. The fall in pressure in the expansion chamber 3 causes further expansion of refrigerant through the orifice 14 and consequent further cooling. Finally the liquid refrigerant in the chamber 3 evaporates causing yet further cooling. Thus the wall 4 of the chamber 3 is rapidly cooled and hence the Sintox substrate 5 and its photosensitive layer 6 are rapidly cooled also. It will be noted too that incoming liquid is cooled by heat exchange between the tubes 2 and 7.

Typically using a reservoir 1 holding 4 gms. of Refrigerant 22 a temperature of -40°C . can be attained at the layer 6 when the temperature in the neighbourhood of the mounting 13 is $+80^{\circ}\text{C}$. The running up time of a typical cooler is $2\frac{1}{2}$ secs. and it would be effective for 30 seconds in which time about half the refrigerant is used. The aim is to keep the temperature of the reservoir 1 reasonably high to ensure sufficient pressure to build up the required flow. It is sufficient for the reservoir to be at room temperature.

The cooler can be made of small size. Typically the overall length of tube is 19.65 mm., the distance of the cavity 8 from the cover 3A of the expansion chamber 3 is 9.3 mm., the distance of the hole 14 from the wall 4 of the chamber 3 is 2.5 mm., and the diameter of the hole 14 is 0.0036 in. The distance of the cavity 8 from the chamber 3 is made as large as possible within the permitted overall dimension of the cooler and the diameter of the orifice 14 is determined by the time of operation required. However, if the orifice 14 is too large a backrush may be created in the chamber 3 when outward flow ceases. This can cause an undesirable step function in the temperature of the photosensitive layer 6. It will be appreciated that, instead of attempting to cool all the refrigerant at once as a one-shot cooler would do, the present cooler operates continuously.

A typical cell is substantially free from vibration effects which would tend to cause unwanted noise in the detection circuits associated with the photosensitive layer 6. Moreover quick recovery after the shock of initial operation is obtained. These effects are attributable to the feedback principle embodied in the construction of the cooler which ensures that heat influx to the cooling expansion chamber 3 and the layer 6 is significantly reduced particularly during the initial stages of operation of the cooler. More efficient use of the liquid refrigerant is obtained in the cooler and, in fact, by the use of a suitable valve in the outlet pipe 10 the cooler may be made to be a multi-shot cooler. Repeated operation is then possible under control of the valve for as long as there is liquid in the reservoir.

A detail associated with the expansion chamber of a more refined version of the cooler is shown in FIG. 2.

The tube 2 extends further into the expansion chamber 3 nearer to the wall 4 and the hole 14 is also located nearer the wall 4. A wad of silica wool 17 held by a

cage 18 of copper gauze surrounds the end 2A of the extended tube 2, and a second wad of silica wool 19 held by another cage 20 again of copper gauze surrounds an extended end 7A of the exhaust tube 7. The hole 14 in the tube 2 is thus located between the wads 17 and 19.

This refinement serves to separate the feedback heat exchange tubes 2 and 7 so that for a whole range of fluid flows in the tubes 2 and 7 via the chamber 3, the effects of external accelerations are reduced. This avoids an undesirable step-change of temperature in the Sintox substrate 5 at a reversal of acceleration during the operation of the cooler. Another advantage is that the omnitude capability of the cooler is improved.

I claim:

1. A cooler including a reservoir for a refrigerant, wall means defining an evacuable chamber, further wall means defining an expansion chamber located within said evacuable chamber, a device to be cooled located within said evacuable chamber in heat exchanging relation to said expansion chamber, an inlet conduit connected between said reservoir and said expansion chamber, an orifice in the inlet conduit for supplying refrigerant from said reservoir to said expansion chamber via said inlet conduit, and an exhaust conduit connected to said expansion chamber in spaced relation to said inlet conduit and in heat exchanging relation with said inlet conduit, said exhaust conduit having selectively operable outlet means adapted, upon being opened, to effect a flow of refrigerant from said reservoir through said inlet conduit to said expansion chamber for cooling said device, the expanded refrigerant then passing from said expansion chamber through said exhaust conduit whereby the exhaust from said expansion chamber passing via said exhaust conduit cools refrigerant flowing toward said expansion chamber via said inlet conduit, said reservoir, expansion chamber, and conduits all containing said refrigerant at a pressure substantially higher than atmospheric pressure.

2. The combination of claim 1 in which said openable outlet means comprises an openable and closeable exit port in said exhaust conduit.

3. The cooler of claim 1 wherein said exhaust conduit comprises tube means having at least a portion thereof extending through said reservoir.

4. The cooler of claim 3 wherein said inlet conduit comprises a tube, at least a portion of said exhaust conduit tube means having a diameter greater than said inlet conduit tube and being disposed in concentric surrounding relation to said inlet conduit tube.

5. The cooler of claim 1 wherein said device to be cooled comprises a radiation sensitive cell, the wall means of said evacuable chamber including radiation permeable window means for transmitting radiation through the wall means of said evacuable chamber to said cell.

6. A cooler as claimed in claim 1 and in which said expansion chamber contains porous material separating said exhaust conduit from the connection between said inlet conduit and said expansion chamber.

7. A cooler as claimed in claim 6 and in which said porous material comprises silica wool.

8. A cooler as claimed in claim 7 and in which said openable outlet means includes a frangible seal.

9. A cooler for a photo-sensitive cell comprising first wall means defining an evacuated chamber having a window, said photo-sensitive cell being mounted within said evacuated chamber adjacent said window, second wall means defining an expansion chamber located within said evacuated chamber in heat exchanging relation to said cell, third wall means defining a reservoir containing refrigerant under a pressure substantially higher than atmospheric pressure, inlet conduit means extending from said reservoir through said first and second wall means for passing refrigerant from said reservoir through said evacuated chamber to said expansion chamber, and outlet conduit means disposed in spaced relation to said inlet conduit means and extending through said first and second wall means for exhausting expanded refrigerant from said expansion chamber through said evacuated chamber.

10. The cooler of claim 9 wherein said inlet and outlet conduit means comprise concentric tubes, said expanded refrigerant passing through an annular space defined between the exterior of said inlet tube and the interior of said outlet tube.

11. The cooler of claim 9 including closure means normally closing said outlet conduit means to prevent any flow of refrigerant from said reservoir to said expansion chamber, said closure means being selectively openable to initiate said flow of refrigerant.

12. The cooler of claim 9 wherein said evacuated chamber comprises an enclosed evacuable container having a pumping stem adapted to be connected to an evacuating pump.

13. The cooler of claim 9 wherein said first wall means defining said evacuated chamber and said third wall means defining said reservoir include wall portions cooperating with one another to define an enclosed cavity separating said reservoir and evacuated chamber from one another, said outlet conduit means comprising a first conduit portion extending from said expansion chamber to said cavity, and said outlet conduit means also comprising a further conduit portion extending from said cavity, in spaced relation to said first conduit portion, through the third wall means defining said reservoir.

References Cited

UNITED STATES PATENTS

1,057,052	3/1913	Guye	62—42
2,515,092	7/1950	Miller	67—7.1
2,818,717	1/1958	Morris	67—7.1

FOREIGN PATENTS

7,773	1898	Great Britain.
-------	------	----------------

ROBERT F. STAHL, *Primary Examiner.*