A Pump for Liquid Nitrogen

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On the Microscopy ListServer, a thread came up about problems with safety when loading cold traps from ladders. Working from a ladder is not a very safe proposition and being up there with a Dewar full of liquid nitrogen brings the safety officer to attention.

An alternative to trying to climb a ladder with a Dewar flask and pour the liquid nitrogen into the trap would be to have a pump for the liquid nitrogen in a Dewar flask on the ground that could be controlled from the top of a ladder.

Some of the older among us remember wash bottles that were made from an Erlenmeyer flask with a wet tube and a vent tube that when blown into, pushed the fluid up the wet line and out the tube to wash what ever was needed. These have been replaced by plastic squeeze bottles, but over the years I have used the principle to pump every thing from water from a test tube, to diesel fuel from a 125 gallon tank.

In most cases, a low pressure source of gas needs to be provided, but in the case of liquid nitrogen, pressure can be provided by a very small heater that boils some of the liquid nitrogen and provides the pressure to force it up the wet line. The flow is controlled with the current to the resistor and a clamp on the vent tube to release the pressure to stop the flow instantly.

The illustration is an old style wash bottle with a short hose and clamp on the vent line to seal the system and provide pressure relief. A small electrical resistor attached near the end of the wet line the extends near the bottom of the flask. A small wattage resistor will heat up rapidly and cool off rapidly giving very fine control over the pressure. If a 12 Volt system is used, a 0.25 watt 51 Ohm resistor would work well or a 0.25 watt 25 Ohm resistor for a 6 Volt system. Any lab that doesn't have a lot of 6 Volt power supplies around gathering dust is either very new or has a very good surplus disposal officer.

In the working model, the Erlenmeyer flask would be replaced with a Dewar flask and a lid to hold the pressure in the Dewar flask. The wet line, vent line, fitting for the heating resistor and some type of fail-safe pressure relief valve would be built into the device that sealed the Dewar flask. The fail-safe pressure relief valve is to insure no serious accidents if the heater were left on, the vent left closed, or the wet line kinked resulting in a build up in pressure.

There are three choices to control the heat to the resistor: using the voltage or current and by a variable or a simple on/off switch. If the on/off switch is used make sure a current limiting resistor of about 300 Ohm for a 12 Volt system or 150 Ohms for a 6 Volt system is in series with the heating resistor to limit the current to it. An adjustable resistor would be handy for fine tuning the delivery of the pump. In all cases, a properly sized fuse should be in line with the heating element and as near the power supply as possible, to make sure the current is shut off in case of an electrical short.

With a control head made up of an on/off switch and pressure relief valve (so the pump can be stopped abruptly), the pump is used by placing the Dewar flask to be pressurized as high as possible so there is little head pressure to overcome and get in a safe position so that the flask to be filled can be observed. The wet line that will carry the liquid nitrogen is placed in the flask to receive the liquid nitrogen and the heater control switch is turned on. When the liquid nitrogen starts to flow, the on/off switch is regulated to maintain a steady flow. As the receiving flask begins to fill up the power switch is turned off and the pressure relief valve is released to stop the pump.

To be a safe device there must be a fail-safe pressure relief valve. The vapor relief line must be sized so that regardless of the heat of the resistive heater all the pressure will escape through the vapor relief line and very little if any liquid nitrogen is pushed out the wet line.

Care must be exercised in using the pump to keep the flask to be filled above the pump. Otherwise, when the vapor relief line is released the flow will not stop because a siphon has been created.

The pump can be used as a siphon with the heater just providing the necessary pressure to prime the siphon and then the heater is turned off and the vapor relief line used to control the flow of the liquid nitrogen.

The same principle can be use to pump fluids form many containers. Vacuum oil form drums is one that comes to mind. The pressure should be kept very low in containers not designed to be pressure vessels. Four or five pounds per square inch has been safe on everything I have encountered. In building a pump for things liquid at room temperature, a regulated source of gas has to be provided and a fail safe pressure relief system. Normally air would be the choice, but in the lab nitrogen, helium or CO_2 might be more available and more portable. Do not use oxygen to pump anything. The least bit of oil or other fuel in the system can result in a violent explosion.

While it would give the safety officer nightmares, I have used the natural gas line more than once for this kind of pump.

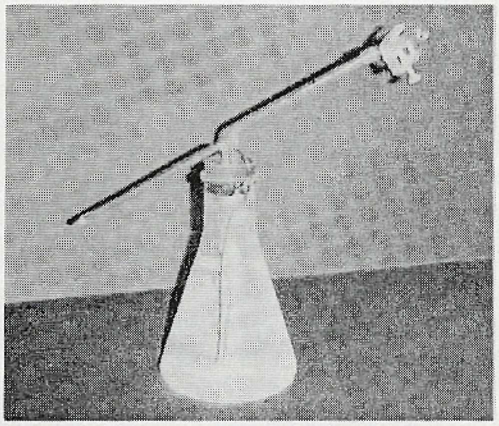

Figure 1: Pump model made using an Erlenmeyer flask. A full-scale pump would be arranged in the same manner, using a Dewar for the liquid nitrogen

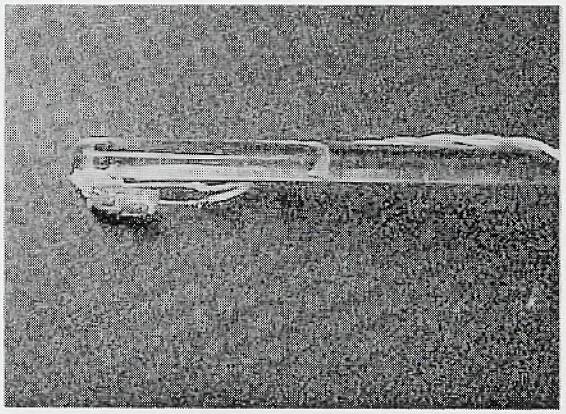

Figure 2: Detail of the heater wire for generating gas pressure