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Pyrex Glass Dewar Vessels and Metal Transfer Tubes for Liquid Helium

W. F. Giauque

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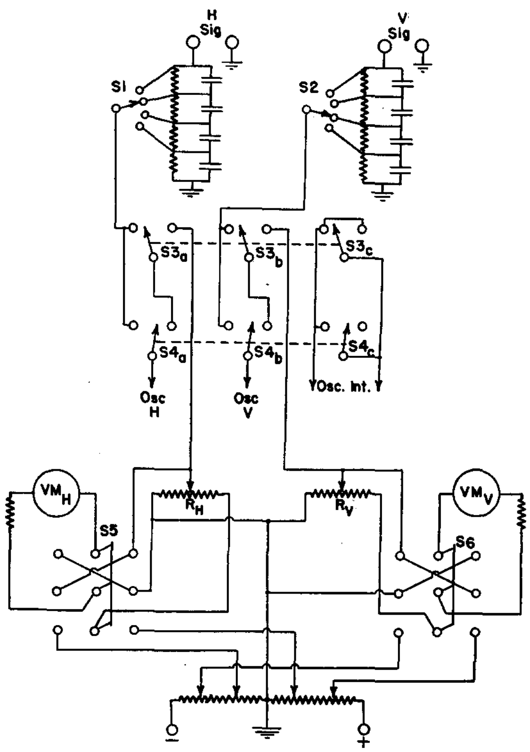

FIG. 1.

The apparatus herein described makes it possible to read directly on two meters the horizontal and vertical coordinates of any point on the screen. The meter readings are independent of the settings of the oscilloscope amplifiers. It is not necessary to calibrate the amplifiers at any time. In essence, this apparatus consists of a commutator which applies to the oscilloscope first the signals which are to be studied and second the calibrating signals. The operator sees on the screen the curve which he wishes to examine and a spot of light which he can move about the screen by means of two knobs on the control panel. To locate a point on the curve, he simply moves the spot of light to this point and then reads the coordinates on two meters.

The circuit diagram is shown in Fig. 1. The signals which are to be studied are brought in through the terminals marked *H* Sig. and *V* Sig. Calibrated compensated voltage dividers are provided so that by means of switches *S*1 and *S*2 the signals actually carried to the oscilloscope may be kept within restricted voltage ranges. D.c. voltages lying within these same restricted ranges may be brought to the oscilloscope through potentiometers R_H and R_V. The magnitudes of these d.c. voltages are indicated on voltmeters VM_H and VM_V. When the calibrating spot is adjusted, the horizontal and vertical deflecting voltages corresponding to any point on the screen are equal to the voltmeter readings multiplied by the corresponding voltage-divider ratio. A motor-driven commutator *S*3 alternately applies to the oscilloscope the external signals from the voltage dividers and the d.c. calibrating voltages from the potentiometers. Sections $S3_a$ and $S3_b$ of the commutator operate simultaneously. The contacts of $S3_c$ close after those of $S3_a$ and $S3_b$. Section $S3_c$ is connected across a resistor in the intensity control circuit of the oscilloscope. When $S3_c$ is open, the cathode-ray beam is cut off. Thus $S3_c$ blanks out any extraneous signals which may be picked up while sections $S3_a$ and $S3_b$ are open. When switch *S*4 is thrown to the left, the external signals are applied directly to the oscilloscope and the commutator *S*3 is by-passed. Switches *S*5 and *S*6 reverse the polarity of the d.c. voltages fed to the oscilloscope. For example, with *S*5 thrown to the right, operation of R_H moves the calibrating spot from the center of the screen to the right. If the position of *S*5 is reversed, the calibrating spot may be moved from the center of the screen to the left.

Because of the action of the commutator, the oscilloscope screen exhibits first the curve traced by the external signals and then the point set by the calibrating voltages. If commutation is carried out at a rate in excess of twenty operations per second, persistence of vision creates the illusion of simultaneous representation. In order to make the intensity of the curve roughly equal to that of the calibrating spot, the commutator is constructed so as to apply the external signals for a period three or four times as long as that during which the calibrating voltages are connected to the oscilloscope. The commutator may consist of three SPDT contactors operated in unison by means of a motor-driven cam, or of rotating contacts driven around split rings.

Pyrex Glass Dewar Vessels and Metal Transfer Tubes for Liquid Helium

W. F. GIAUQUE
Chemical Laboratory of the University of California, Berkeley, California
September 3, 1947

WE have noticed a recent note by Lane and Fairbank[1] on the use of Pyrex Dewar flasks for use with liquid helium and, as we have used such flasks for this purpose for some fifteen years, it occurred to us that a few remarks on experiences in this laboratory might be useful to others. Our previously published brief remarks on this subject are rather obscured by inclusion with other material as is evidenced by the fact that the above authors incorrectly state, concerning our procedure, that the Dewar is continuously pumped by an attached diffusion pump and that this makes it difficult to move a filled flask to another location. Actually, we have never found it necessary to evacuate Pyrex Dewar vessels during the period in which they contain liquid helium.

During work preliminary to the first adiabatic demagnetization experiments of D. P. MacDougall and the writer in 1933 we built a helium liquefier in a Pyrex Dewar with the inner tube 4.5 in. and the outer tube 5.5 in. in diameter. It is about 5 ft. long. After one very successful liquefaction, the Dewar vessel was allowed to stand in an atmosphere of helium for about a week and developed a large heat leak. We were unaware of the diffusion of helium through Pyrex at that time so the Dewar vessel was repumped on the assumption that a leak had occurred. The experience of successful liquefaction followed by later loss of vacuum was repeated and we learned the facts concerning the diffusion of helium through Pyrex. However, since the apparatus was ready for a liquefaction, we decided to satisfy our curiosity concerning the ability of a Pyrex Dewar to clean up the helium in the vacuum space when it was cooled to low temperatures. The outside temperature of the Dewar vessel varied from that of liquid air at the bottom to an estimated 250°K at the top. The inner temperature varied from 14°K at the bottom to about 250°K at the top. Compressed helium was sent through the Joule-Thomson effect liquefier in the usual manner. It was evident that a large heat leak remained but after a considerable period, of the order of an hour, a clean-up did occur, presumably on the coldest part of the glass, and liquid helium was then produced. While this fact is of interest and of practical importance, we certainly do not recommend such an inefficient procedure in using Pyrex Dewar vessels.

Following the above experience a diffusion pump line with a stopcock was attached to the Dewar. Concerning this arrangement Giauque and MacDougall[2] remark, "Pumping of a Dewar vessel is unnecessary during an experiment." Giauque, Stout, Egan, and Clark[3] state with respect to a double Pyrex Dewar vessel, "The two Dewar vessels have a single vacuum space which could be pumped continuously if desired." However, this was not necessary for although the Dewars were made of Pyrex, which is permeable to helium, it was found sufficient to pump a vacuum and then turn off the vacuum pumping system during the course of an experiment which usually extended over two days. Although a considerable area in the outer tube "(60 percent) was at room temperature or even warmer during this period any helium diffusing through the warm parts of the Dewar was cleaned up by adsorption on the cold portions." The above Dewar vessel was 5.5-in. o.d. and about 5 ft. long. It was located in the center of a solenoid magnet which was operated at temperatures as high as 50°C at intervals, and the outer surface of the Dewar vessel must have approximated this temperature occasionally.

It is evident that liquid helium can be transported in Pyrex Dewar vessels of almost any capacity provided that the outer wall of the Dewar vessel is cooled sufficiently to reduce heat leak and provided that the vessel has been recently evacuated at room temperature.

Since liquid helium can be transferred easily through very long metal transfer tubes which do not need external cooling, we have not had much occasion to transport it in portable Dewar vessels. However, some ten years ago we built our present laboratory helium transport vessel. It is made of Pyrex tubing with walls 6.5 in. and 5.5 in. in diameter, holds about 8 liters of liquid helium, and has a neck about 6 in. long and 1.5-in. i.d. There are no supporting plugs. Support when in a horizontal position is obtained by means of a support piece extending from the inner vessel into a short concentric tube on the bottom of the outer vessel. There is no contact of these support tubes when the Dewar is vertical. Several indentations in the outer support tube reduce clearance to such a small value that the strain on the neck is trivial when it flexes to make contact when the Dewar is not vertical. A vacuum line with a stopcock is attached to the outer side of the neck. The whole Dewar vessel is enclosed in a monel case which can be immersed in liquid air or nitrogen, in an insulated case equipped with handles for carrying it. The vacuum stopcock is outside the case and after evacuation of the Dewar the cock is closed and the line cut free.

This Dewar vessel will maintain liquid helium temperatures for several days with one filling. The longest period it has actually been kept cold after the last addition of a somewhat incomplete filling is 39 hrs. when we were cooling some spores and seeds to liquid helium temperatures at the request of Professor C. B. Lipman.[4] However, two other experiments were in progress simultaneously and more than half of the liquid helium was transferred to other apparatus some 4 hrs. after the Dewar vessel was filled. We estimate that this Pyrex Dewar vessel with the outer wall at liquid air temperature would maintain liquid helium temperatures for at least 4 days with one filling and, in any case, it should not be difficult to construct one of this type which would hold liquid helium for a week with one filling.

In general, the diffusion coefficients of gases through solids have such large temperature coefficients that the diffusion of helium through glass should be negligible at moderately low temperatures.

Except in cases where unusually great stability is desirable we regard the use of liquid hydrogen to protect liquid helium as an unnecessary complication. Under ordinary circumstances, it is much more profitable to use any liquid hydrogen available to produce a larger quantity of liquid helium which can then be protected by liquid nitrogen.

It may be of interest to remark that we also have several Jena glass Dewar vessels, which were made to order in Germany, and these vessels will resist diffusion of helium for several months of intermittent experimental work without repumping.

In transferring liquid helium we use a very thin-walled German silver tube with a vacuum jacket. Liquid helium can be transferred so rapidly that there is little time for radiation to contribute to heat leak during the operation, thus we do not consider it necessary to cool the outer jacket. However, the inner tube should be of small heat capacity so that not much liquid helium will be lost in cooling it from room temperature. It should be noted that in such cooling the heat of evaporation of the liquid helium is unimportant and the cooling effect of the gas produced by the liquid which evaporates is substantial. The heat capacity of German silver is so small at temperatures near those of liquid helium, and even considerably above, that cooling by means of the gas is essentially the only cooling required.

One of our transfer tubes is about 10 ft. long. It is used with about one-half of it at room temperature and the remainder in the temperature gradient. The inner tube is $\frac{3}{16}$ in. in diameter with a 0.005-in. wall thickness. The viscosity of liquid helium is so low that the tube diameter and thus the heat capacity could be decreased somewhat so far as the transfer of liquid helium is concerned. However, the above diameter was selected so that we could circulate a considerable flow of helium gas cooled to liquid hydrogen temperature for certain cooling purposes. Such a tube could be made much longer if necessary and should be more efficient than transporting the helium by means of a portable container. The design must provide for the decrease in tube length on cooling. For internal support we ordinarily use a few strands of loose wool yarn tied around the inner tube. As we have had numerous difficulties maintaining a vacuum for a long period in the various metal transfer tubes used for liquefied gases in this laboratory, such tubes are usually connected to a vacuum system when they are installed in non-portable apparatus. They are ordinarily pumped shortly before use, as a precaution, but are usually used with a stopcock turned off in the vacuum line. Transfer tubes for use in portable apparatus are evacuated shortly before use and are sealed off then.

[1] C. T. Lane and H. A. Fairbank, Rev. Sci. Inst. **18**, 522 (1947).
[2] Giauque and MacDougall, J. Am. Chem. Soc. **57**, 1175 (1935).
[3] Giauque, Stout, Egan, and Clark, J. Am. Chem. Soc. **63**, 405 (1941).
[4] C. B. Lipman, Plant Physiol. **11**, 201 (1936).

Fine Tungsten Wire in the Laboratory

H. A. Liebhafsky, L. B. Bronk, and E. W. Balis
Research Laboratory, General-Electric Company, Schenectady, New York
October 3, 1947

THE advantages of fine tungsten wire for various laboratory purposes, such as the suspending of floats, seem not to be generally known. We have used such wire 2 mils in diameter during the past four years to hold a 11.5-g float employed in routine density determinations required to control chlorosilane production. This wire is in turn suspended from 5-mil tungsten attached to the arm of an analytical balance. As will appear below, the 2-mil wire satisfactorily withstands strong handling, and exposure to acid and alkali.

In the course of the work, the fine wire and float unavoidably become contaminated with hydrolysis products of the chlorosilanes; namely, with a gel containing much hydrochloric acid. These products are removed from the float by dipping it in an alcohol-acetone mixture, whereupon the float is wiped dry with a towel. Several times a day, immersion of the float in strong alcoholic potash must be interspersed as an auxiliary measure. (Extending the immersion overnight shortens the useful life of the wire.) These various manipulations strain the wire considerably. Approaching failure can usually be recognized where the wire is twisted around the glass loop at the top of the float.

TABLE I. Breaking strengths of fine wires

Wire	Diameter (mils)[a]	Breaking Strength (lb.)
Tungsten	2	1.14
Molybdenum	2	0.50
Stainless steel (18–8)	2	.44
80% Platinum-20% Indium	2	.10
Tantalum	3	.68
Platinum	3	.53
Nickel	3	.50

[a] 1 mil = 0.00254 cm.

Tungsten approaches the noble metals in its inertness toward many substances at room temperature. But it has a great advantage over these and most other metals in the enormous increase that results in its tensile strength from the mechanical working required to produce fine wire.[1] What this means for the present application is clear from the following values of breaking strengths, which were determined here on a tensile strength machine.

Tungsten wire must be carefully twisted when a loop is formed, for a break is liable to occur sooner or later at a sharp bend. Nevertheless, the 2-mil wire holding the float usually survives about 100 determinations before approaching failure makes replacement desirable. The 5-mil tungsten attached to the balance arm has never been replaced.

[1] Jeffries, Trans. A.I.M.E., **60**, 588 (1919), found tungsten wire 1.14 mils in diameter to have a tensile strength of 590,000 lb./sq. in., or 33 times that of a sintered ingot.

An Automatic Guider for Astronomical Telescopes

Horace W. Babcock
Mount Wilson Observatory, Pasadena, California
September 2, 1947

IN photographic work with large astronomical telescopes, constant manual control is usually required on the part of the observer to compensate for small fluctuations in the apparent position of the star due to "seeing", and for residual errors in the driving mechanism of the telescope. This applies both to direct photography and to spectrographic work, in which the image of the star must be kept accurately on the slit. The experimental photoelectric guider of Whitford and Kron[1] worked well, but in one coordinate only, and was considered to be of doubtful usefulness in direct photography owing to the scarcity of sufficiently bright guide stars.

A guider operating on the principle of the "rotating knife-edge", working in two coordinates and employing a single multiplier-type photo-tube, was built early this year by the writer and is in regular use in guiding the 100-inch telescope for high dispersion spectrographic work. This is a type of observation well adapted to the introduction of an automatic guider, since the stars studied are generally brighter than the guide stars usually available in direct photography. A fraction of the light of the star that does not enter the spectrograph slit is reflected back by the polished slit jaws, and is normally used in manual guiding; it is equally well utilized in the automatic guider without any depletion of the light entering the slit.