the Bell Jar
Vacuum Technique and Related Topics for the Educator & Amateur Investigator

Notes from the Vacuum Shack No. 12 November 2020

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The AVS *Classics in Vacuum Science and Technology* Series

In the past I have promoted the American Vacuum Society's Classics series of books. These are paperback reprints of texts that were published in the 1960s but which still have very valid information, some of which is hard to get from other sources.

The books had been published by the American Institute of Physics (AIP) but they are currently from Springer. When I purchased my copies in the 1990s, the prices were on the order of $30 to $45 with a small discount to members of AIP affiliated societies. The prices have risen to the $100 range which makes purchase a little less trivial.

To check on the status with the publisher, I went to the Springer web page at https://www.springer.com/series/3750?detailsPage=titles. Here I found an ominous warning:

Discontinued Series - Although this series no longer publishes new content, the published titles listed below may be still available on-line (e. g. via the Springer Book Archives) and in print.

I gather that this isn't an end of life notice, just that there won't be any more books in the series. The books are all readily available on Amazon.

I would consider three books to be essential for the serious amateur vacuum hobbyist. These are Alexander Roth's *Vacuum Sealing Techniques* (498 pages), Fred Rosebury's 1964 *Handbook of Electron Tube and Vacuum Techniques* (597 pages) and A. von Engel's *Ionized Gases*.

A more recently published book in the series is *Vacuum Science and Technology - Pioneers of the 20th Century* (1994). This was edited by Paul Redhead and is a must have if you are interested in the history of vacuum technology.

I have several others in the series in my library but I refer to Roth and Rosebury very frequently. Here is a list of the rest of the books in the series:

- Walter Kohl, *Handbook of Materials and Techniques for Vacuum Devices*
- P.A. Redhead, J.P. Hobson and E.V. Kornelsen, *The Physical Basis of Ultrahigh Vacuum*
- Robert Gomer *Field Emissions and Field Ionization*
- Sanborn C. Brown, *Basic Data of Plasma Physics - The Fundamental Data on Electrical Discharges in Gases*
- Peter H. Dawson, (Ed.), *Quadrupole Mass Spectrometry and Its Applications*

As stated, these are available through Amazon along with the "Look Inside" feature which permits a good glance at the contents. You may also have luck with used bookstores.

Mechanical Vacuum Gauges – the Dwyer Magnehelic®

I've gotten so used to electronic gauges over the past couple of decades that I've forgotten about simpler methods of measuring pressure. Of course, there's the Bourdon gauge, but they are (with few exceptions) made for atmospheric pressure referenced measurements and are fairly coarse in their ranges and generally lacking in accuracy.

I was browsing through one of my compilations and found an article from the Autumn 1996 issue of *the Bell Jar* (This article is currently in the *First Five Years* compilation). The article focused on the Dwyer Magnehelic gauges and some applications in vacuum apparatus.

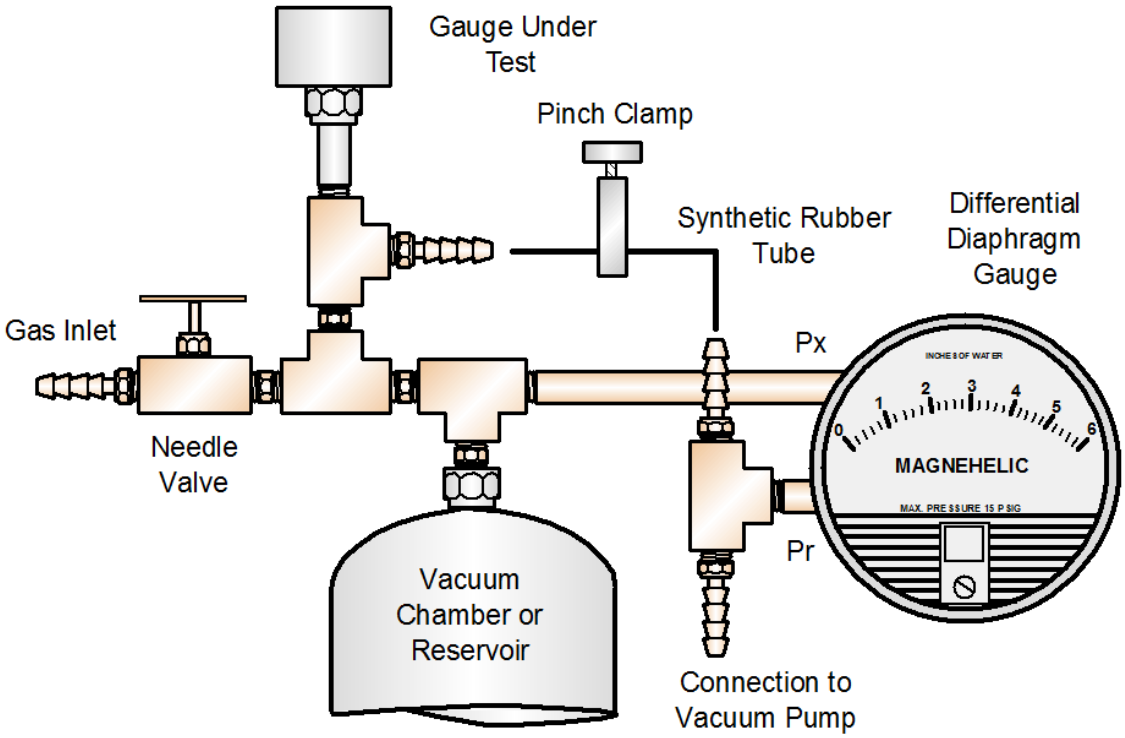
Magnehelic gauges are usually found in HVAC applications: monitoring pressure drops across air filters, determining air flows or static pressures, etc. The gauge mechanism consists of a diaphragm that transmits its position to the indicator needle by means of a magnetic linkage. The diaphragm is mechanically connected to a magnet via a spring lever. The needle pointer is connected to a helix of magnetic material that simply follows the magnet. This mechanism avoids the frictional losses associated with gears, improving sensitivity and lessening the side effects of moderate overpressures (such as bent needles).

Somewhere in my basement pile of stuff I'm sure I still have one or two of these and I found them to be quite useful, especially when the reference port was connected to a vacuum pump in order to turn the gauge into an absolute reading instrument.

The gauges that I obtained were from a surplus outlet and, at that time, there was no such thing as a Dwyer web site. As a result I didn't have much for specifications.

I built a system for measuring absolute pressure using a gauge with a full scale of 6 inches of water. This corresponds to 11.2 Torr. The application was to calibrate a homemade Pirani gauge with a couple of inert gases over the range of about 1 to 10 Torr. This is necessary as Pirani gauges are gas-type sensitive. At the time I didn't have access to such nice stuff as capacitance diaphragm gauges.

The illustration below shows the set up.



The manifold was constructed using ¼" brass threaded pipe fittings between the pump fittings and the chamber. Other fittings, such as the gauge ports and the needle valve, had 1/8" fittings so adapters had to be used at these points. The valve that served to isolate the reservoir and measurement side from the reference side and pump was a short length of ¼" id synthetic rubber tubing with a pinch clamp.

The prototype unit that I built used an aluminum tank as the reservoir. I believe the tank once served as a Freon container. The volume of this reservoir was about 4½ liters..

The process was started by pumping the entire system down to its base pressure with the needle valve closed and the pinch clamp open. Once the pressure had stabilized (a minimum reading on the test gauge), the pinch clamp was closed. Since the pump was now attached to just the gauge's reference port (Pr), the reference pressure dropped a little more.

At this point, gas was admitted through the needle valve. The Magnehelic needle would then begin to rise as did the indication from the test gauge. By opening and closing the needle valve, it was possible to settle at a sufficient number of intermediate pressures to allow a calibration curve to be developed.

One suspected problem was that the innards of the gauge are rather cluttered. However, things seemed to work well as long as the reference port was pumped.

Moving to the present, I paid the Dwyer Instruments web site a visit. This may be found at

https://www.dwyer-inst.com.

The gauges I used are in their 2000 series. Pressure ranges are noted in inches of water, Pascal and kiloPascal. At the low end, there is a 0-30 Pa gauge. This corresponds to 0.225 Torr and the minor scale divisions are at 1.0 Pa or 7.5 milliTorr. Not bad. Accuracy specs for the instruments are stated as percent of full scale (%FS) and lie in the general range of ±2-4%.

There is a caution on the diaphragm. The standard diaphragm is made of silicone rubber which is (for vacuum use) quite permeable and it is recommended not to use the standard diaphragm with hydrogen, methane or other flammable gases. These attack the diaphragm. Hydrogen, of course, will permeate like crazy. For these applications, Dwyer offers a Buna-N diaphragm upgrade for about $20.

The other comment in the specifications is that the minimum recommended pressure is -20 inHg or about 1/3 of an atmosphere. Per the FAQ, this is because of seal leakage. Based on my experience from years ago, this didn't seem to be an issue but perhaps there's also an element of safety factored in for industrial applications.

As far as how these gauges can be used in vacuum applications, one idea that came to mind was to monitor the high voltage hollow cathode at the top of my pseudospark electron beam source. This is not a convenient place to mount an electronic vacuum gauge. Since gas is fed to the hollow cathode and there are multiple small apertures between the cathode and the chamber, there will be a pressure drop. The gauge on the apparatus is on the chamber. I figure I could get a decent enough measurement of the cathode pressure by attaching a differential gauge between the chamber and the cathode with insulating tubing. The chamber pressure plus the differential pressure would provide the pressure at the cathode.

A Magnehelic could also be used to monitor the pressure differential across an orifice in the gas feed.

A new 2000 series Magnehelic will run about $80. These gauges are also readily available on eBay for a fraction of the new prices. My next step will be to get a low range Magnehelic (30-60 Pa) and conduct some more tests, especially with regard to upleak rates.

If anyone has experience with the Magnehelic gauges with vacuum apparatus, I'd appreciate hearing about it.

YouTube Channel Review – Applied Science
Submitted by Mark Atherton

Rising to YouTube fame through the development of a home-made scanning electron microscope (almost 10 years ago), Ben Krasnow is the owner of the YouTube channel 'Applied Science'.

Ben has created many interesting videos, possibly the most astonishing one being the duplication of a white-light hologram using tempered chocolate.

Many of his projects are vacuum related. He documents his early foray into the technology using a diffusion-pump. Later he upgrades his pumping-station by migrating to a turbo-pump. Trials and tribulations are included along the way, and there are some life-saving gems there.

One his most recent successes is the projection of a 25 keV electron beam a few millimetres into the atmosphere through a silicon nitride window.

Another favourite of mine is the demonstration of an LPG heated glass diffusion-pump.

Many hours of interesting viewing to be had here, see
https://www.youtube.com/c/AppliedScience/videos

Articles of Possible Interest in *Vacuum Technology & Coating* Magazine

November 2012
The Pursuit of Ultra High Vacuum: Are we there yet? UHV Gauging – Part 1
Hot cathode ion gauges

December 2012
The Pursuit of Ultra High Vacuum: Are we there yet? UHV Gauging – Part 2
Cold cathode gauges

January 2013
The Pursuit of Ultra High Vacuum: - Are we there yet? UHV Gauging – Part 3
This part covers several specialized UHV ion gauges

February 2013
The Pursuit of Ultra High Vacuum: The first decade of UHV
Key developments during the 1950s

March 2013
The Pursuit of Ultra High Vacuum: UHV Hardware – Manifolds, Manipulators and Loadlocks

Articles may be accessed at http://vtcmag.com/. Scroll to the bottom of the page to the back issue selection box. Look for my columns and you can probably find other articles of interest in each issue.

That's it for this month.

Steve