# *the* Bell Jar

## Vacuum Technique and Related Topics for the Educator & Amateur Investigator

**Notes from the Vacuum Shack** **No. 19 June/July 2021**


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**The Missing June Issue**

June was not a good month for me. I started feeling ill toward the middle of the month. On the 28th I ended up in the hospital where they determined that I had a complete blockage in my small intestine. After a period of observation and stabilization I was operated on. The offending bit of intestine was removed and the cut ends were joined. My total stay was 10 days and now I'm slowly getting back to normal.

I didn't produce a June *Bell Jar* or complete my August *VT&C* article. Hopefully this will be the end of hospitalizations for quite some time

**Design and Fabrication of a Vacuum Base Plate, and Associated KF Series Fittings**

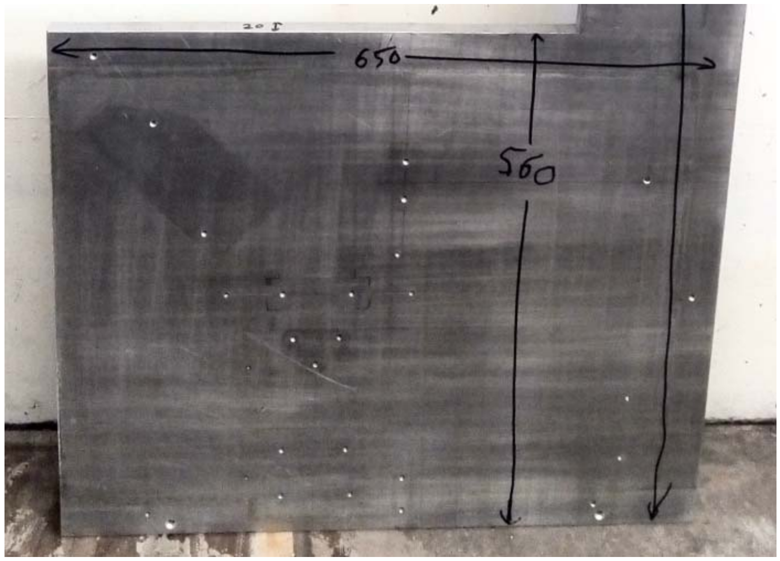

Mark Atherton, New Zealand, markaren1@xtra.co.nz


In a recent email exchange, Chuck Sherwood encouraged me to write a small piece about how a vacuum base plate was fabricated and associated KF fittings were attached without the use of a mill or other large machining tools.

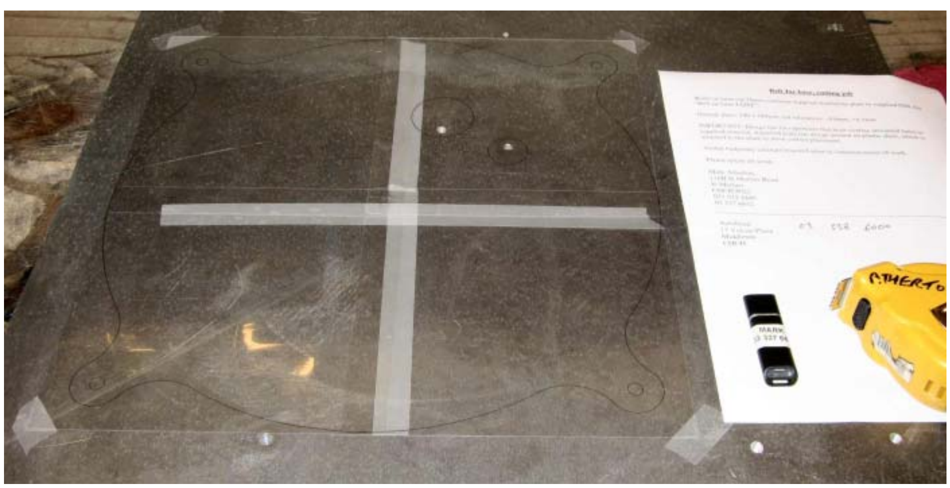
In the beginning, a moderate size (310 mm diameter) belljar had been acquired from part of a long-defunct scanning electron microscope system. A turbo-based pumping station was in-process, so a base plate for the belljar was the main piece of the puzzle missing to complete a vacuum pumping station.

After doing the maths, it was clear that the force at the centre of the base plate was going to be in the order of half a metric tonne under full vacuum. This is one of those calculations which are best done before, rather than after effort has been put into fabricating pretty much anything!

Clearly, a pretty beefy (is there a vegetarian, or PC equivalent?) plate of aluminium will be required to safely hold these kind of forces. It was with some surprise and delight that a friend phoned me up asking if I had any use for some 20 mm thick ali plate. The plate in question had previously been used as part of an optical-bench associated with a laser, so there were quite a few holes in the material, but none too large as to be prohibitive.

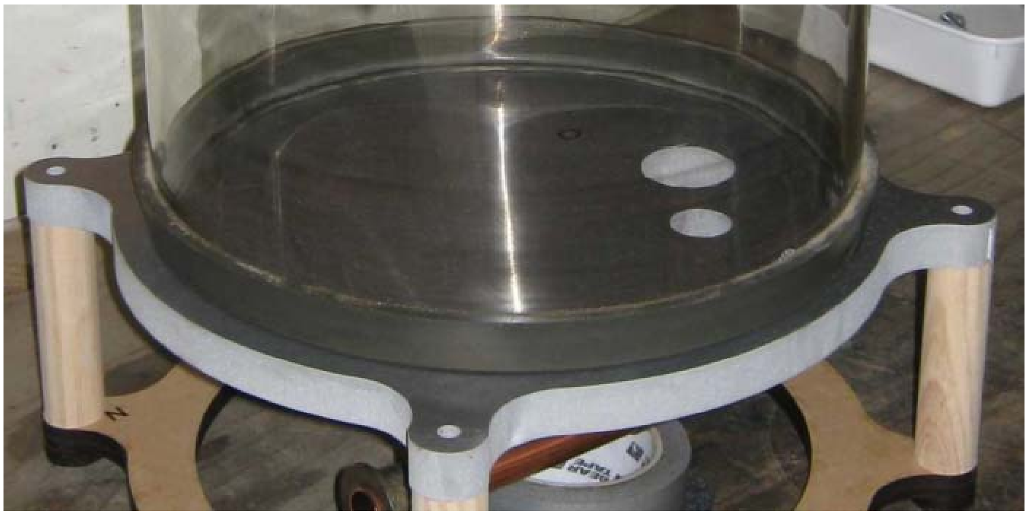



After a little contemplation, it was decided that after cutting, the plate should be mounted in each corner using M8 bolts, and should have a KF25 fitting for pumping, as well as a KF40 for electrical/gas feedthroughs. Once the required base shape had been designed, the next job was to plot it full size, and to move it around the host plate until a minimal number of holes were going to be present in the active vacuum area.



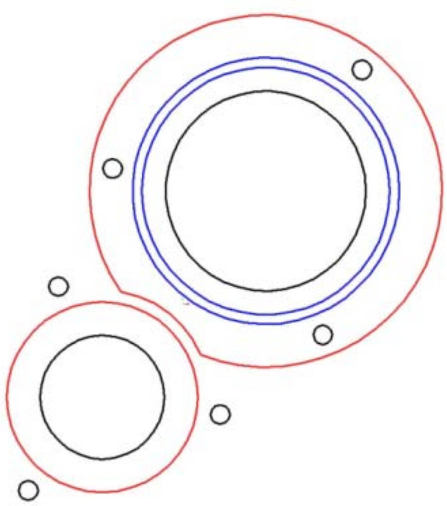
One of the other (arbitrary) design criteria was that apertures should be on a similar radius, and as far from the centre of the plate as possible - this would allow experiments to be set up in the centre of the plate.

The photo above shows the deliverables to the water-cutting house; the plate itself, a full size overlay indicating relative placement, a USB stick with a single DXF design file, and a sheet of notes associated with the job. Various water cutting speeds (and finishes) were offered by the metalworking house, the slowest (highest finish, most expensive) was chosen, with a final price in the order of NZ$180. The house in question (Autobend, Christchurch NZ) was very accommodating and easy to deal with; the finished work was as promised, was delivered on time, and per drawing.



As can be seen above, the two KF apertures are a little closer that might be preferable, but by initially engaging brain rather than metal drill, it should be possible to mount both fittings without mutual interference.

Step one in the mounting process was to see what hole patterns might work with this arrangement, and how they might be oriented for maximum clearance.



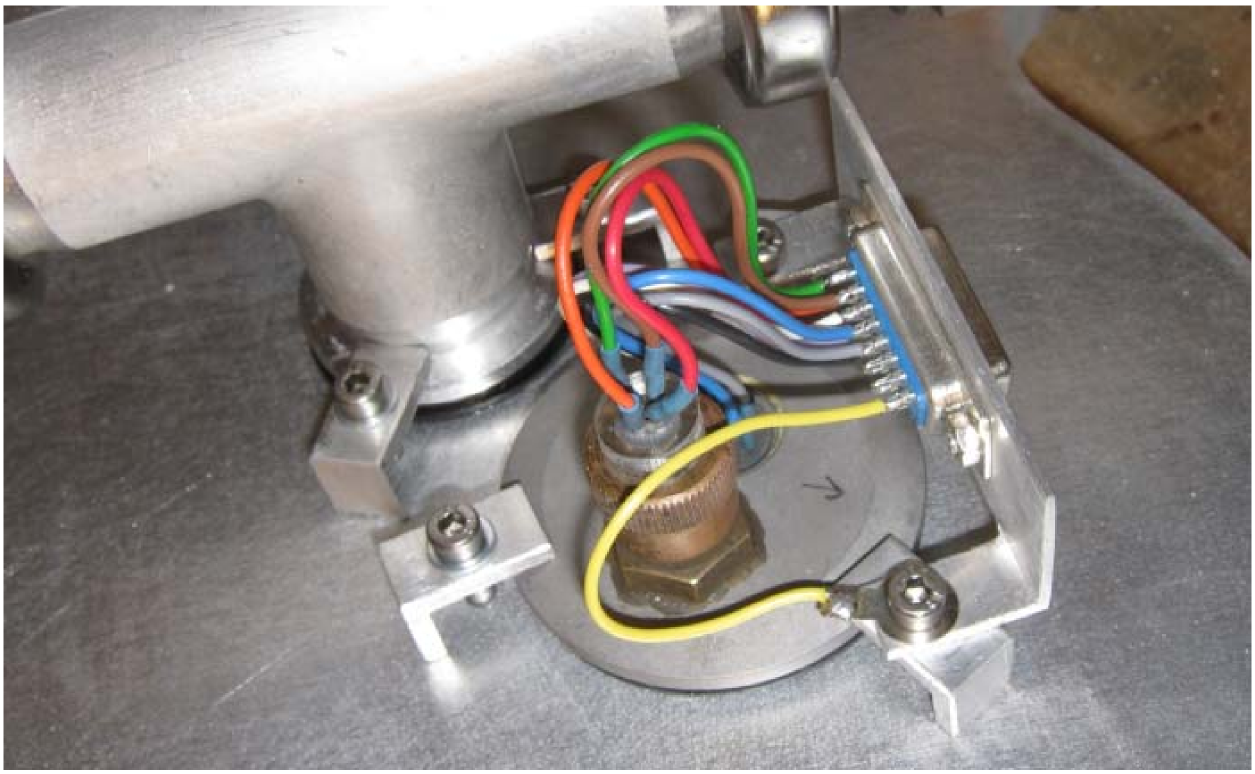
The illustration to the left shows a bottom view of standard KF25 and custom KF40 flanges. The black circles are apertures and tapped holes, red is the flange outline, blue is an O ring. The outer blue ring is also the periphery of a standard KF-40 blanking flange

From the drawing it is clear that three cantilevered brackets per fitting attached to the small (M5) holes will not interfere with each other, and that there will be reasonable clearance between flanges.

The drawing was modified to add a small cross in the centre of each hole that needed a fastener, along with a calibration graticule. This drawing then printed 100% on a transparent plastic sheet, and a ruler used to check accuracy of printed X & Y axis scales. The film was then aligned over the water-cut apertures and taped in place before a centre punch was used to mark the drill points for each hole.

Each hole was initially drilled to 1 mm before being opened up to the correct drill size for the M5 tap at a depth of around 10 mm. An M5 taper tap was followed by a bottoming tap in the usual way, with occasional stops to blow out swarf from the holes. This may appear to be quite a long-winded process but each hole landed within a few hundred microns of the target; this was more than adequate accuracy for the purpose.

Six identical cantilevered brackets were fabricated out of aluminium angle extrusion, which had been cut down to size and drilled with a single 5 mm hole.



The photograph above shows the assembled hardware. The stack up from the photograph includes:

- Water-cut aluminium base plate with 42 mm dia hole.
- KF40 aluminium centering ring, and associated O-ring
- KF40 stainless flange, with electrical feedthrough
- 3x aluminium mounting brackets, each with stainless M5 x 18 cap head screws and washers

As a side issue, the KF-40 flange already had an 8 way electrical feed-through in place as well as a 6.3 mm tube seal. The initial application required 10 electrical connections, so 4 pieces of bare copper wire were glued into a 60 mm length of 6.3 mm OD glass tubing and used to carry the remaining signals. This glass tube was inserted into the tube-seal. A small acrylic disk also had to be glued to the atmosphere side of the tube assembly to stop it being draw into the vacuum chamber.

Mark Atherton
New Zealand
27 May 2021



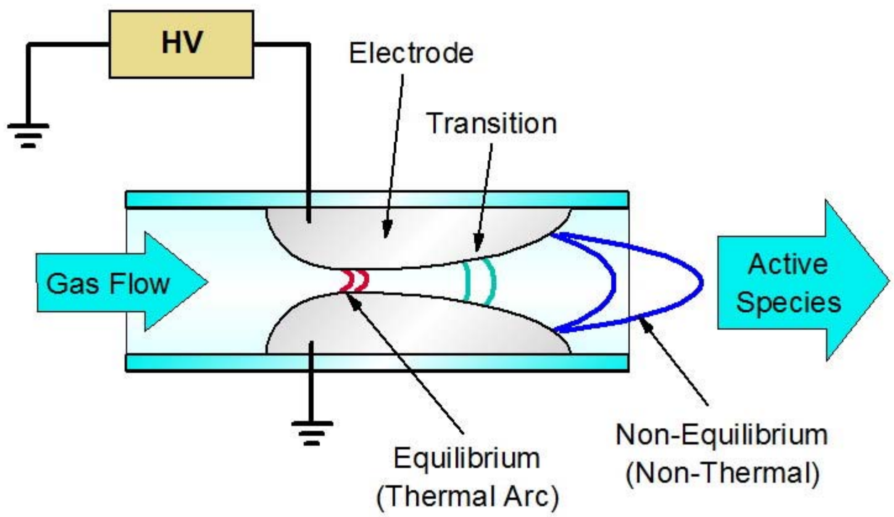
## Using Bulkhead Clamps

Chuck Sherwood sent along some photographs of a plate/KF fitting assembly he made to test some electrical feedthroughs. The connection between the plate and the KF40 fitting was secured using a bulkhead clamp set. The photographs below show (upper row from left) the plate with a recess for the center ring along with one half of the clamp and the partially assembled device with one clamp; (bottom row, left to right) clamp fully in place and, from the bottom, one feedthough. The feedthroughs are capacitors with 1/4-28 threads. He installed the feedthrough with a copper washer from a model engine spark plug. Chuck may be reached at chuck1024@wowway.com

## A Simple Gliding Arc Device for Producing Plasma Activated Water (PAW)

The May 2021 issue of this newsletter described some preliminary tests I made on producing plasma activated water (PAW) using my previously described surface micro-discharge (SMD) plasma device. I showed the pH and conductivity changes in the distilled water that was being treated.

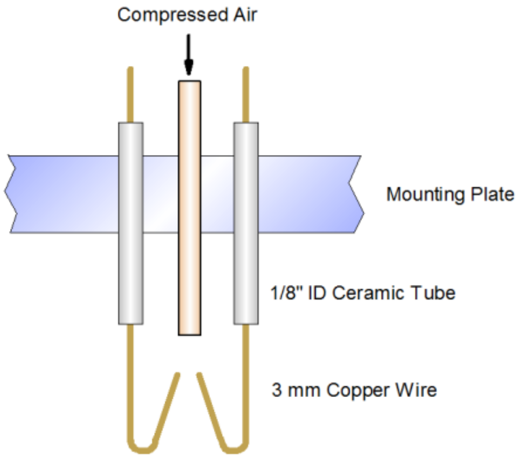
One issue, for the amateur, is that the SMD device is fairly complex. The same would be true of a plasma jet or dielectric barrier discharge, any of which could be used for producing PAW. A simpler option would be to use a gliding arc discharge (GAD) to activate the water. GAD was briefly discussed in the October 2020 issue. The figure below from that issue describes the configuration. The end state of the blown arc is a non-thermal plasma which will be rich in gaseous active species.




For a GAD device, you will need a high voltage, current limited power supply, a small diaphragm or dry vane air compressor capable of 20-40 liters/minute and a pair of divergent electrodes. Some GAD devices in the literature have power supplies on the order of 15 kV capable of 500-1000 watts. This is rather large and lethal. Others use supplies more on the order of 15 kV at 60 mA. My proto unit uses an electronic oil burner transformer (OBT) rated at 15 kV and 35 mA. An iron core OBT could also be used.

I made a very simple mock up using some #14 copper wire inelegantly bent into an approximation of the correct shape. The narrow gap was about 1/8 inch with the wires diverging to a ½ inch gap. Total length was about 1 inch. The photograph below shows the blown discharge. The air supply was provided by a Thomas diaphragm compressor rated at 1.3 cfm (about 37 liters/min). This was delivered by a 1/8" ID tube positioned about 2 inches above the electrodes. At this time I have not measured the actual air flow.

The figure below shows what I envision as the “final” electrode structure. I will use 3 mm copper wire which slides into the 1/8 inch ID alumina tubing that I purchased for my saddle field ion source. The GAD electrodes will be mounted on a PVC disk. This disk will fit on top of my 4 inch diameter acrylic vessel in the same way that the SMD device did.




This GAD device would be suitable for producing PAW as well as for conducting other experiments such as disinfection studies.

Some relevant papers follow. All of these are freely available in the internet.

1. M. Moreau, M. G. J. Feuilloley, N. Orange, J-L Brisset, *Lethal effect of the gliding arc discharges on Erwinia spp*, J Appl Microbiol. 2005;98(5):1039-46. doi: 10.1111/j.1365-2672.2004.02535.x. https://pubmed.ncbi.nlm.nih.gov/15836472/
2. J.O. Kamgang, R. Briandet, J.M. Herry, J.L. Brisset and M. Naïtali, *Destruction of planktonic, adherent and biofilm cells of Staphylococcus epidermidis using a gliding discharge in humid air*, Journal of Applied Microbiology 103 (2007) 621–628 https://www.academia.edu/17502336/Destruction_of_planktonic_adherent_and_biofilm_cells_of_Staphylococcus_epidermidis_using_a_gliding_discharge_in_humid_air?email_work_card=view-paper

3. Renwu Zhou, Rusen Zhou, Peiyu Wang, Yubin Xian, Anne Mai-Prochnow, Xinpei Lu, P. J. Cullen, Kostya (Ken) Ostrikov and Kateryna Bazaka, *Plasma activated water (PAW): generation, origin of reactive species and biological applications*, Journal of Physics D Applied Physics · March 2020. DOI: 10.1088/1361-6463/ab81cf
   Author submitted manuscript:
   https://www.researchgate.net/publication/340068059_Plasma_activated_water_PAW_generation_origin_of_reactive_species_and_biological_applications
4. Brendan A. Niemira and Joseph Sites, *Cold Plasma Inactivates Salmonella Stanley and Escherichia coli O157:H7 Inoculated on Golden Delicious Apples*, Journal of Food Protection, Vol. 71, No. 7, 2008, Pages 1357–1365.
   https://www.academia.edu/40757952/Cold_Plasma_Inactivates_Salmonella_Stanley_and_Escherichia_coli_O157_H7_Inoculated_on_Golden_Delicious_Apples?email_work_card=view-paper
5. G.M.El-Aragi, *Gliding Arc Discharge (GAD) Experiment*, Plasma Physics and Nuclear Fusion Dept., Nuclear Research Center, AEA, PO 13759 Cairo, Egypt
   https://www.ispc-conference.org/ispcproc/papers/3.pdf
6. Jiajian Zhu, Zhiwei Sun, Zhongshan Li, Andreas Ehn, Marcus Aldén, Mirko Salewski, Frank Leipold and Yukihiro Kusano, *Dynamics, OH distributions and UV emission of a gliding arc at various flow-rates investigated by optical measurements*, J. Phys. D: Appl. Phys. 47 (2014) 295203 (11pp). doi:10.1088/0022-3727/47/29/295203
   https://www.academia.edu/13782936/Dynamics_OH_distributions_and_UV_emission_of_a_gliding_arc_at_various_flow_rates_investigated_by_optical_measurements?email_work_card=view-paper

**PEM Cells for Deuterium Production**
Richard Hull

Many have been using tanked deuterium since 1998 in our fusors. (about $350 for 50 liters in a lecture bottle.)

For some time now, many are buying heavy water and electrolyzing it using a “reversible” PEM (proton-exchange membrane) cell to get deuterium gas at about 1/6$^{th}$ the cost per liter.

Such a system in now used and perfected by Mark Rowley to run his fusor. This is described on fusor.net. This coup is found in the FAQs within the Construction forum.

Mark has produced three fabulous and complete videos related to his very polished and successful setup. The URLs are listed in watching order in the FAQ.

Here is the URL to the FAQ with many useful replies and additions posted by others.
https://fusor.net/board/viewtopic.php?f=24&t=19 is th3995

(*Editor’s Note: The videos are very well done and explain everything from what’s in the Horizon package to filling a 100 cc syringe with gas to connecting the syringe to the vacuum system. I’ve got some simple ideas for connecting the PEM cell directly to a vacuum chamber. Needless to* *say, while the fusor folks are interested in deuterium, these cells can be used with distilled water for producing plain old hydrogen for those desiring protons.*)

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

June 2014
***Clean Up on Tool 2! (Donuts all over the place)***
Downstream Plasma Applicators, Toroids and Chamber Cleaning

October 2015
***Degassing and Cleaning Part 1***
Bake Out and UV Assisted Clean-Up

November 2015
***Degassing and Cleaning Part 2***
Plasma Cleaning

**End Notes**

Hopefully I will get back to some of my backed up projects. Current plans for next month include a finished GAD device and a progress report on my saddle field source.

As usual, contributions of any complexity are welcome.