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AN ALL METAL VACUUM SEAL FOR QUICK ACCESS IN THE RESEARCH AREA

INTRODUCTION:

This is not meant to be a scientific exposition on an exotic subject. Instead you are reading a simple explanation of a vacuum technique developed in a rather off-hand fashion. Not a small amount of interest has been expressed by several parties, and we are compelled to put a simple design into interested hands and to make a few obvious observations.

THE NEED:

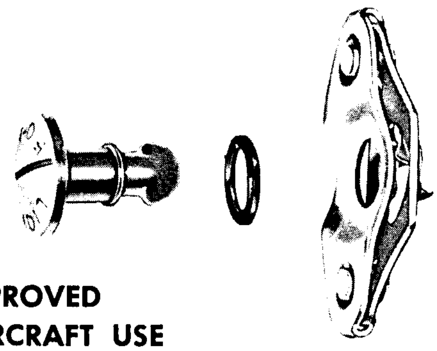
Radiation levels at SLAC will leave residual radiation on apparatuses on the beam line in the research area. These devices will require routine and emergency servicing, meaning that vacuum will have to be broken and components changed or adjusted through ports on the vacuum chamber. Beam monitoring instruments often will be emplaced or removed, and personnel time near a recently irradiated beam pipe should be minimized. Our optimum base pressure is not demanding, perhaps 10^{-6} torr.

The technique we will describe is not always useful for connecting sections of beam pipe together, but in certain cases the technique is acceptable.

SOLUTION:

R. Taylor suggested the use of quarter-turn fasteners to perform the initial clamping action. These fasteners (see Fig. 1) are commonly used in aircraft (and in English sports cars, by the way). The fasteners have been found quite acceptable when sealing indium to grooved flanges of the type explained in description below.

Locking a vacuum port typically takes 30 seconds with this technique, pumps to the base pressure of our pumping station, which is 1×10^{-7} torr, and a leak checker shows no leaks present. The fasteners are set into the lock position easily. Several seals have been broken and remade with the same indium as many as 10 times with no trouble. We have used aluminum, stainless steel and brass flanges and/or a combination of these for flange materials.



APPROVED
FOR AIRCRAFT USE

The Lion fastener conforms to Army-Navy-Air Force Specifications MIL-F-5591A (ASG) and has F. A. A. Approval for Civilian aircraft.

Fig. 1

DESCRIPTION:

A typical flange pair is shown in Figs. 2 and 3. The flange grooves are of 0.062 inch radius which is the radius of the 1/8th inch indium sealing wire. However, the groove center of radius is not at the flange surface, but is offset to provide a maximum groove penetration of 0.045 inch.

JUSTIFICATION OF DESIGN:

The reader may find some unjustifiable assumptions implicit in this section. However, we will outline the rudimentary notions which led to the flange configuration, and hope any reader's objections will be assuaged by the fact that the configuration seals quite to our satisfaction. We varied the dimensions a few times but always with less satisfactory results.

Indium is usually sealed into a square groove in one flange and is opposed by a flat facing flange (Fig. 4). We rejected this approach for reasons to be mentioned, and chose two opposing nearly half circular grooves (Fig. 5).

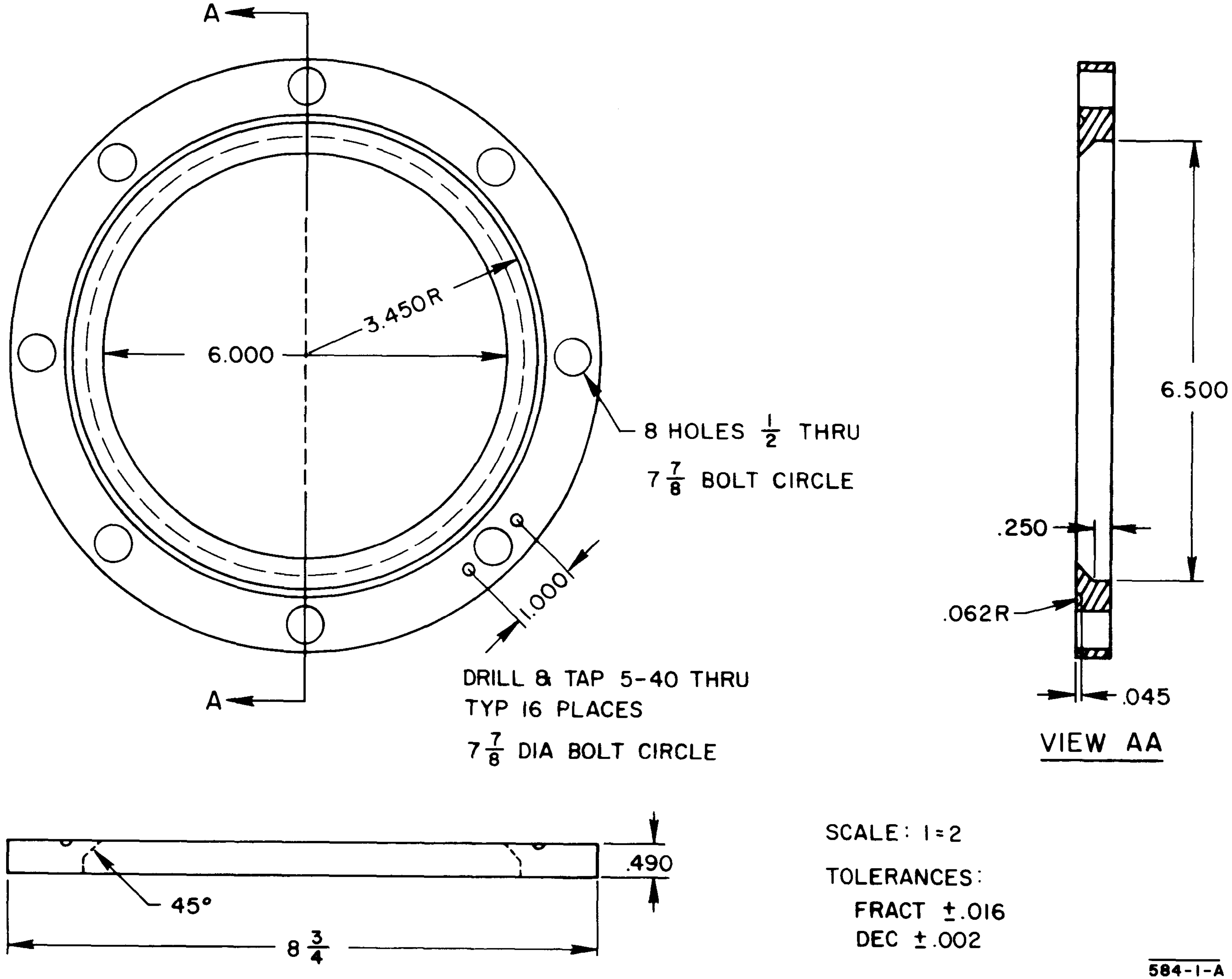


FIG. 2 -- RECEPTACLE FLANGE

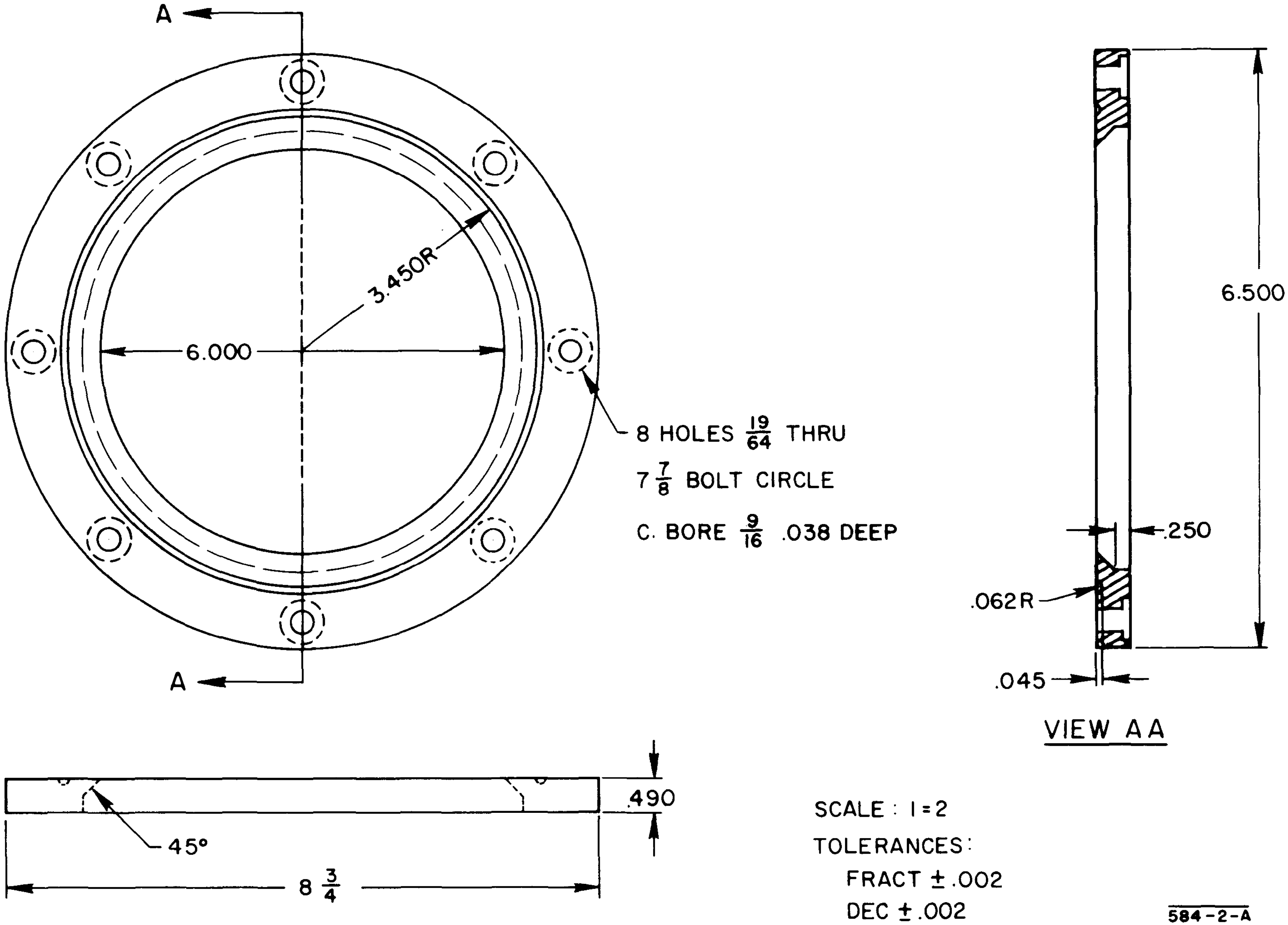


FIG. 3 -- VAC STUD FLANGE

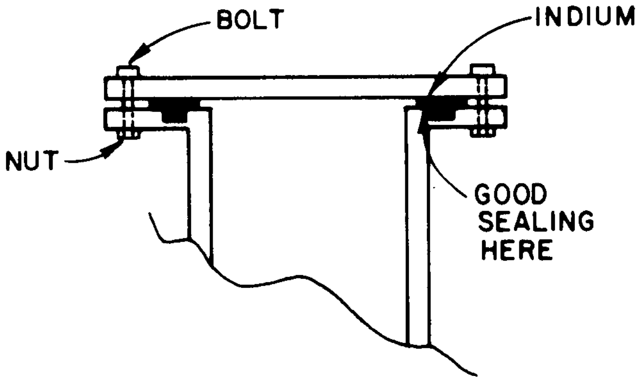


Fig. 4

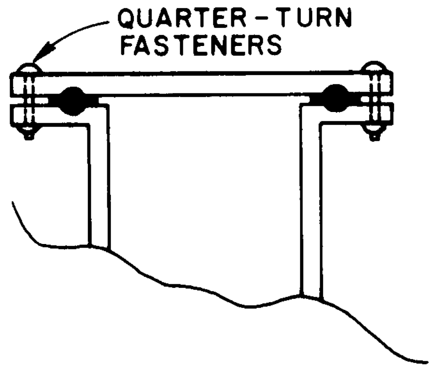


Fig. 5

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Indium wire is readily available in 1/8th inch diameter circular cross-section. If one reshapes the indium into a square groove, it would be best to use bolts because work must be done on the indium first to fill the square groove and then to force the excess indium to flow laterally as shown in Fig. 4.

When one inspects a used seal after the indium wire is removed from the groove, he will note that the indium is quite mirror-like at the square concave corner (labelled "good sealing here" in Fig. 4). Hence one might be justified in assuming that sealing is optimized when indium is forced to flow over a nearly right angle groove corner.

Since only about 40 pounds of force are available per quarter-turn fastener, one should induce the indium to flow over a corner most efficiently. Hence with nearly half-circular grooves, most of the work goes into making the seal, and no work is wasted on reshaping the indium cross section.

Actually of course, it may be that the quarter-turn fasteners just allow the pump-down to begin and that atmospheric pressure then provides ample force to maintain the seal. A particularly enthusiastic observer might note that the use of quarter-turn fasteners is even better than bolts as usually employed, because the fasteners always maintain a relatively constant force on the flange, even after the indium has crept farther away from the groove and closed the flange-to-flange gap for up to 0.025 inches. Bolts without spring washers do not automatically provide constant flange-to-flange compression as the gap shortens. Of course enthusiasm has little place here and one should just be satisfied that the fasteners are a great deal quicker to lock than bolts are to tighten.

A BRIEF TEST TO STRESS THE SEAL:

We loaded the vacuum seal with an offset weight as shown pictorially in Fig. 6.

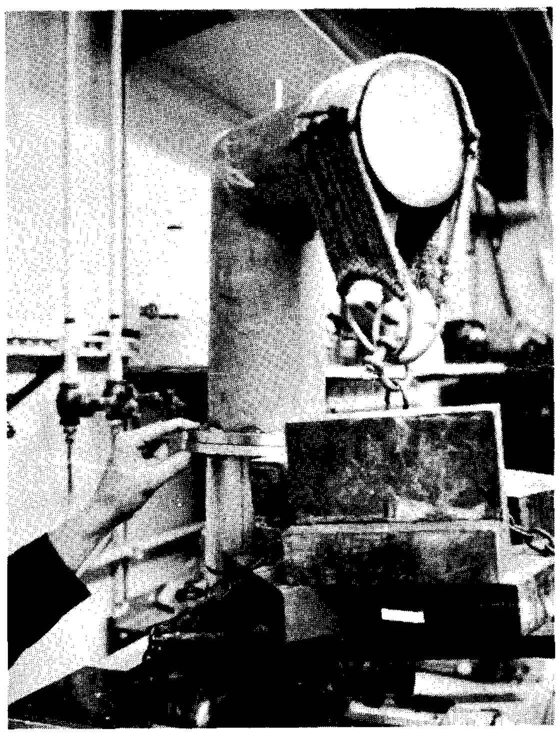

FIG. 6

By an offset load we mean that the load was applied through a fulcrum arm of about nine inches from the vertical 6" tube center. The quarter-turn fasteners might apply up to 300 pounds of force on the indium (although this can not always be verified), and atmosphere must apply 400 pounds on the seal.

We observed that a slow leak developed after about 150 to 180 pounds were loaded. A 100 liter/sec pump then took the chamber back to base pressure after the load was removed. This procedure was observed sequentially several times without having to change the seal.

Our public seems to demand some arm-waving sort of explanation for this sophisticated experiment. Reluctantly then, we suggest that the drawing at left might (with intrepid lack of rigor) be represented as shown on the right (see Fig. 7), neglecting the fastener forces.

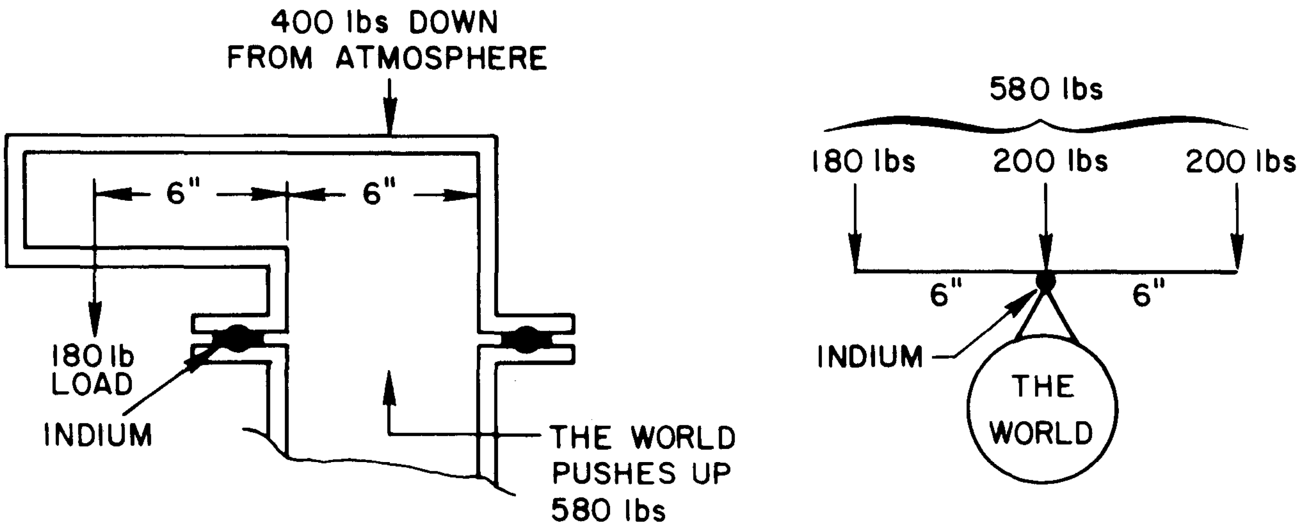

Fig. 7

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One is not surprised when a leak develops (as did happen) when the force of atmosphere is approximately relieved from part of the seal. So our little test does confirm that moderate loads on the flange are tolerable, if rather undesirable.

If one plans to connect lengths of beam pipe together end to end, we suggest that he assure himself that his vacuum system does in fact provide a constant end to end compression from atmospheric pressure on the flange, and that the flange will not be subjected to loads. Caveat emptor.

Another interesting conclusion one can draw from the test is that this vacuum configuration will seal reliably under compression of 35 pounds/linear inch on the indium sealant. One loses reliability at half that value, but some "competitive" configurations (e.g., the Parker metal "V" seal) quote a required compression of 250 pounds/linear inch.

FASTENER SPECIFICATIONS:

Specifications of the "Lion 1000" quarter-turn fasteners are:

Locking torque min 5.0 lb. in.

Locking torque max 12.0 lb. in.

Unlocking torque min 5.0 lb. in.

Unlocking torque max 15.6 lb. in.

Initial tension min 35 lbs.

Rated tensil load 500 lbs.

Locking stop strength min 60 lb. in.

The quote on SST fasteners is $1.14 each for the first 500 fasteners.

We would be happier if the fastener material were of a harder material. Some wear is evident after repeated use, but we are still using fasteners which have already made 100 seals.

CONSLUSION:

We don't propose that this is a general purpose technique, but if one needs to make or break an all metal seal routinely and quickly, this seal may be the best thing since "sticky-tape".

ACKNOWLEDGEMENTS:

J. Truher was very helpful in developing the seal, and in the preparation of this report.