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Unsupported Area High Pressure Seal*

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ONE of the more commonly used seals for high pressure is the unsupported area seal developed by P. W. Bridgman.[1] The principle of operation is well known, and is explained in Bridgman's book, so that it does not require description here.

There is considerable variation in the method of application of this seal in different laboratories and in commercial equipment. Nevertheless, this seal depends eventually on the development of pressure in some sort of packing (rubber, leather, Teflon, copper, lead, steel) in excess of that in the fluid whose leaking is to be prevented. This excess pressure must not be too low; otherwise, sealing is unlikely. Nor must it be too high; otherwise, pinch-off[1] is liable to occur. Bridgman[1] found that sealing plug stems would pinch off when the pressure on them was approximately the maximum tensile strength of the stem material. However, when the packing is made thinner, then the heavily stressed part of the stem receives considerable support and the stem is less likely to pinch off. This cannot be carried too far, since some bearing area is required for sealing against the plug surface. Although the amount of packing pressure and the packing dimensions must be designed for the experimental situation being handled, it is of some interest to report the values of these parameters in a specific case.

Our own motive for looking at this experimental problem was a desire, in building an optical high pressure bomb, and optical plugs with apertures down their centers, to minimize the ratio of packing hole diameter to optical aperture. For a given aperture and a small experimental volume, the smaller the diameter of the packing hole in the bomb, the smaller the pressure vessel can be made. However, the excess pressure in the packing increases as the hole diameter is decreased if the stem diameter is held constant (see Fig. 1). At the suggestion of Professor Bridgman, we undertook some experiments to determine to what extent one could increase this excess packing pressure without causing rapid deterioration of the packing or pinch-off of the plug stem.

Figure 1 shows the test arrangement used. Steels and hardnesses are indicated in this figure. The pressure was introduced via stainless steel tubing as previously reported.[2]

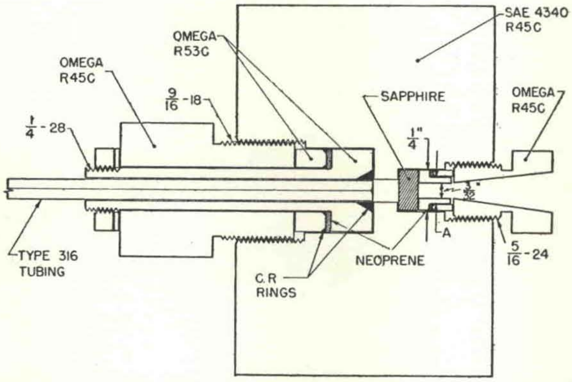

FIG. 1. Test bomb. Dimension A was $\frac{5}{32}$, $\frac{3}{16}$, and $\frac{7}{32}$ in. diam successively with the inside diameter of the push piece adjusted accordingly.

Neoprene rubber was used as the packing material on both tubing and optical plugs. The thickness of Neoprene used was in each case only $\frac{1}{64}$ in., so as to reduce the force on the stem causing pinch-off. This small thickness was successful, although the care taken in ensuring good surfaces and fits quite probably contributed to this. We have sometimes used Teflon as packing material with considerable success; similar work has been reported from another laboratory.[3] We found more difficulty with Teflon than with Neoprene in producing an *initial* pressure seal; it is often advantageous to use Teflon and Neoprene in combination to take advantage of the sealing properties at low pressures of the Neoprene and the lubricating qualities of the Teflon.

Starting from a dimension A of $\frac{5}{32}$ in., corresponding to a packing pressure to fluid pressure ratio, x, of 1.25 the usual order of value in this Laboratory, we tested the assembly to just over 10 000 kg/cm². For dimensions of A up to $\frac{7}{32}$ in., corresponding to $x=4.0$, the assembly held pressures to 10 000 kg/cm² without any evidence of leaking. The packing on disassembly showed no ill effects. The tests were not taken above 10 000 kg/cm² because it was not convenient to do so on the test apparatus at that time; the seals may well hold to higher pressures, as they do for x values of about 1.2 in our normal work. Moreover, we stopped at $x=4$ because the conical washers were then $1/128 \times 1/128$ in. triangular shape, and could not easily be reduced. There seems no reason to suppose that the same excess pressure could not be applied to larger plugs with similar success.

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[1] P. W. Bridgman, *The Physics of High Pressures* (Bell and Sons, London, 1949).

[2] W. Paul and D. M. Warschauer, Rev. Sci. Instr. **27**, 418 (1956).

[3] H. A. Bowman *et al.*, Rev. Sci. Instr. **27**, 550 (1956).

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20,000 ats
15
300,000 psi -

High Pressure Tubing*

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HARD-DRAWN, type 316, stainless steel tubing $\frac{1}{8}$ in. o.d. by 0.025 in. i.d. has been tested and found to withstand pressures of at least 20 000 atmos. Because this value already exceeds the theoretical rupture point, it would be of interest to test this tubing at even higher pressure, but facilities for this purpose are not available at the moment.

The outstanding virtues of this tubing for high pressure work are its flexibility and its low heat conductivity. Thus this tubing is ideal for connecting an experimental vessel to a pressure-producing apparatus where the vessel is to be aligned accurately in an optical beam or magnetic field or to be immersed in a constant temperature bath. Spiraling gives added flexibility to the tubing.

The main problem in applying this tubing to pressure work is to devise an effective means of connecting the ends without incurring pinch-off at the seals. Figure 1 shows a connecting plug which is satisfactory to 12 000 atmos and possibly higher. The wall of the tubing is effectively built up by the stem of the central plug. The outside of the plug is packed with a rubber washer having an excess pressure ranging between 125% and 250% and restrained by cold-rolled jam washers. The tubing is threaded and soft-soldered into a cold-rolled cone which is initially pressed into the mating plug seat with an arbor press. The inward thrust of the cold-rolled cone seals and restrains the tubing. The nut and hardened washer at the left end provide means for self-extraction of the plug. A slight modification of this design will work to at least 20 000 atmos.

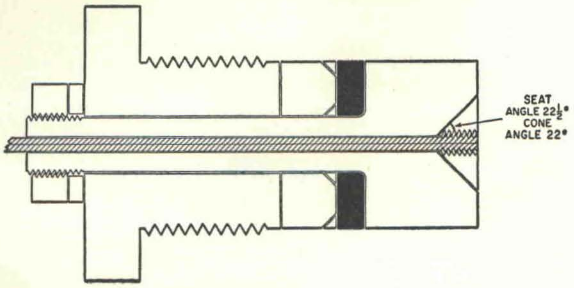

FIG. 1.

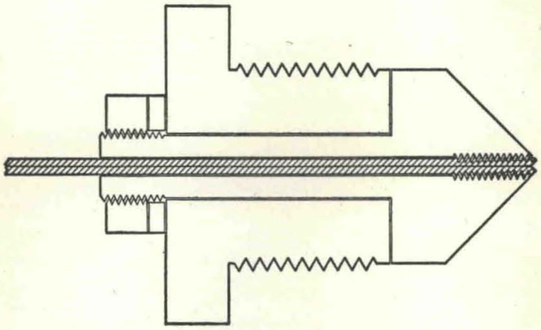

FIG. 2.

Figure 2 illustrates an even simpler plug suitable for application to 20 000 atmos, where the plug is not to be removed very frequently. Here the plug stem is simply for extraction. The tubing is threaded as shown and soldered over the length of the plug. The tubing is then flared at the tip with a center punch. The plug is somewhat softer than the pressure vessel to allow for outward expansion against the mating seat. One advantage of this plug is the all-metal construction, which allows work over a wider temperature range or with fluids deleterious to rubber packings.

We wish to thank Mr. Charles E. Chase and Mr. Fred Terrio for construction of parts and aid in these tests.

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