Encasement Fabrication and Testing: Processes and Innovations

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Acknowledgements

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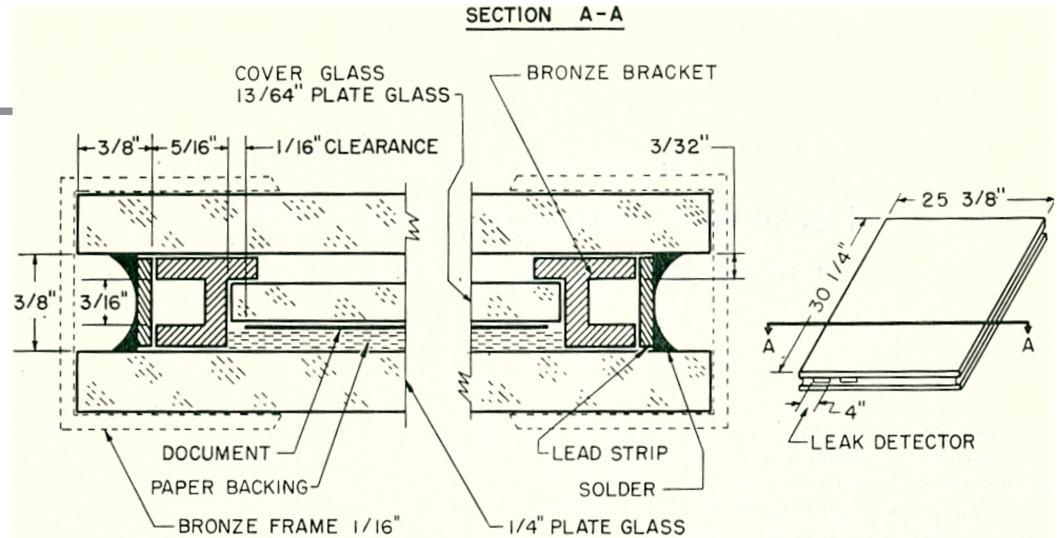
- A large number of NIST employees—far to many to name here—have made a recognizable contribution to this project to encase the Charters of Freedom.
- There are many vendors that have contributed and gone “the extra mile” to help us succeed with this project

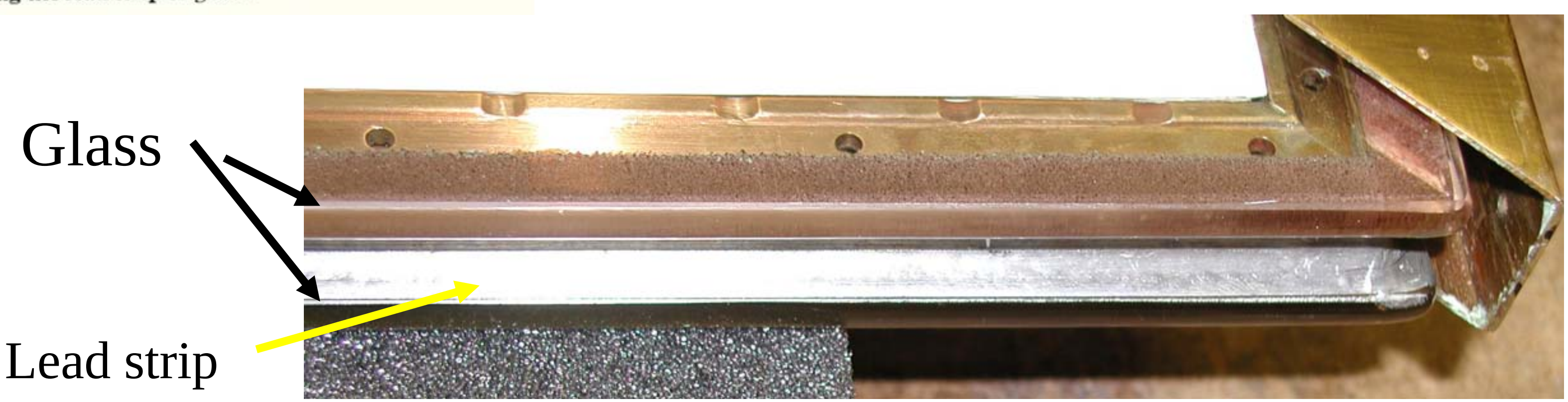
Outline

- Background-1950s encasements
- Design and fabrication challenges
- Sealing metal to glass
- Machining and fabrication
- Testing and monitoring
- Comments when “looking back”:
  - Why titanium?
  - Where are the weak spots?

The 1950s Encasements

Figure 8.—Following the assembly of all enclosure elements, the lead strip is soldered to the glass plates in one of the most critical steps of the sealing operation. In the foreground are shown the soldering accessories used in bonding the lead strip to glass.

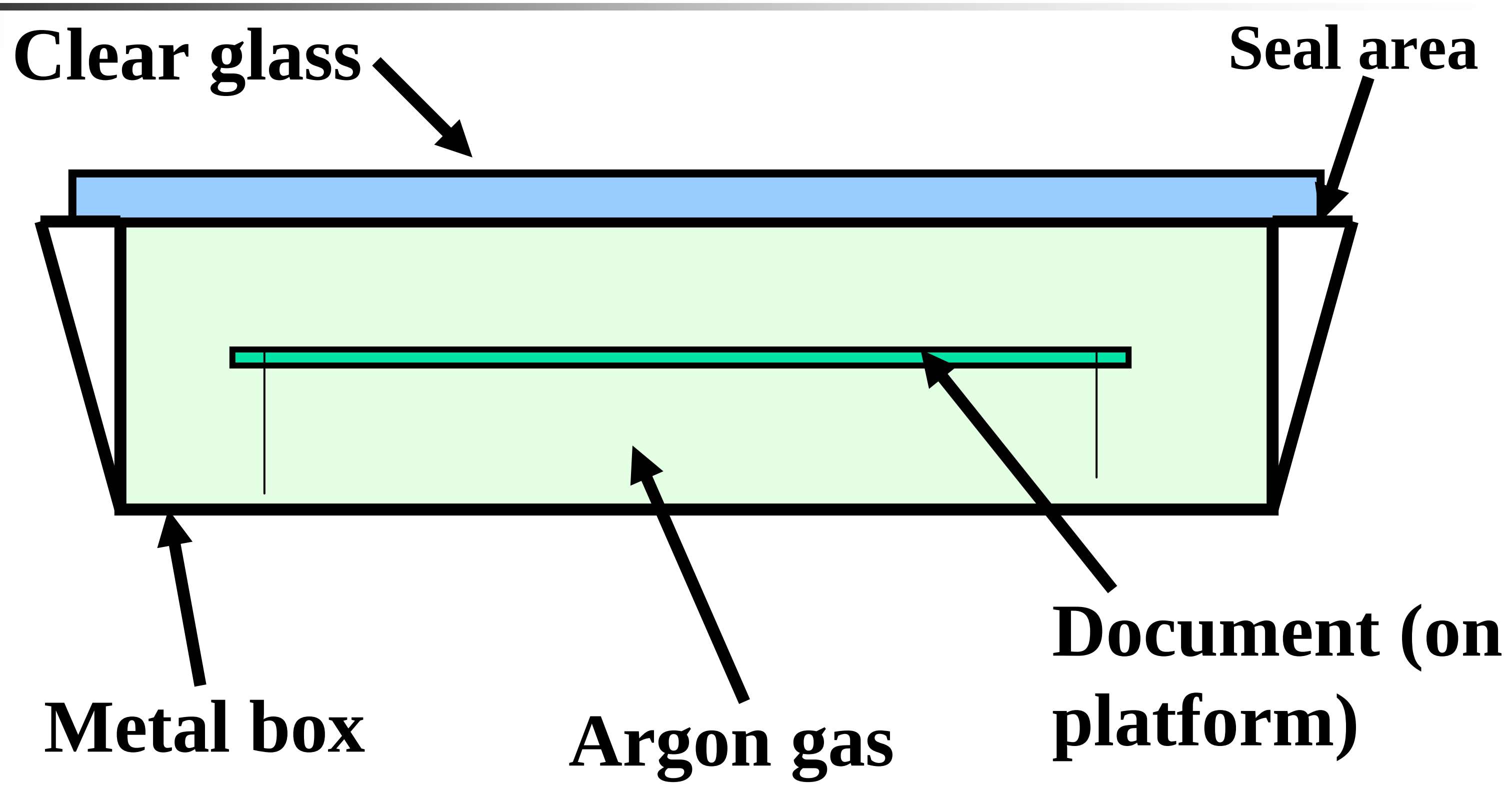




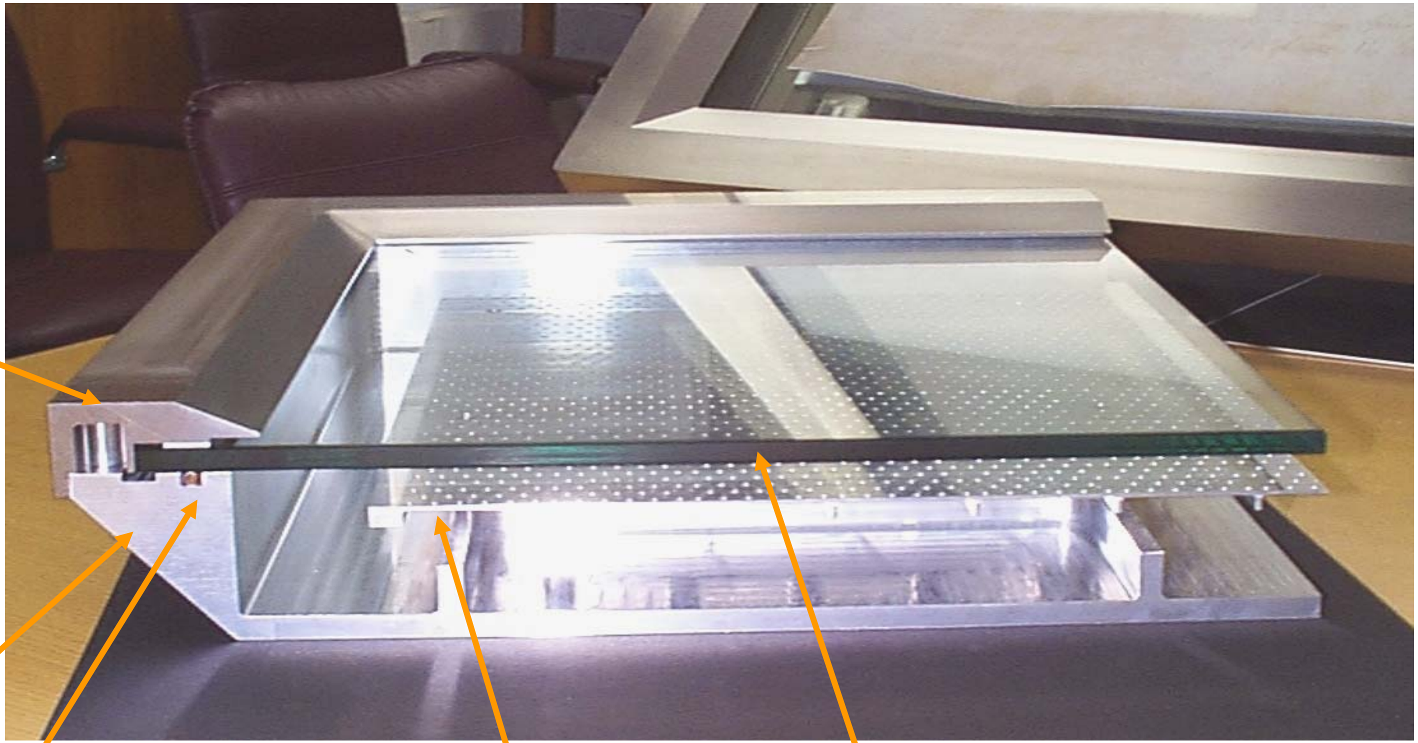
Design and fabrication challenges

- Completely sealed box—strength and deflection concerns.
- Very long term, very high quality seal.
- Means of testing and monitoring encasements needed.
- Appearance extremely important.
- Need to be able to open, encasements as light as possible.

Box with a glass front—cross section view:



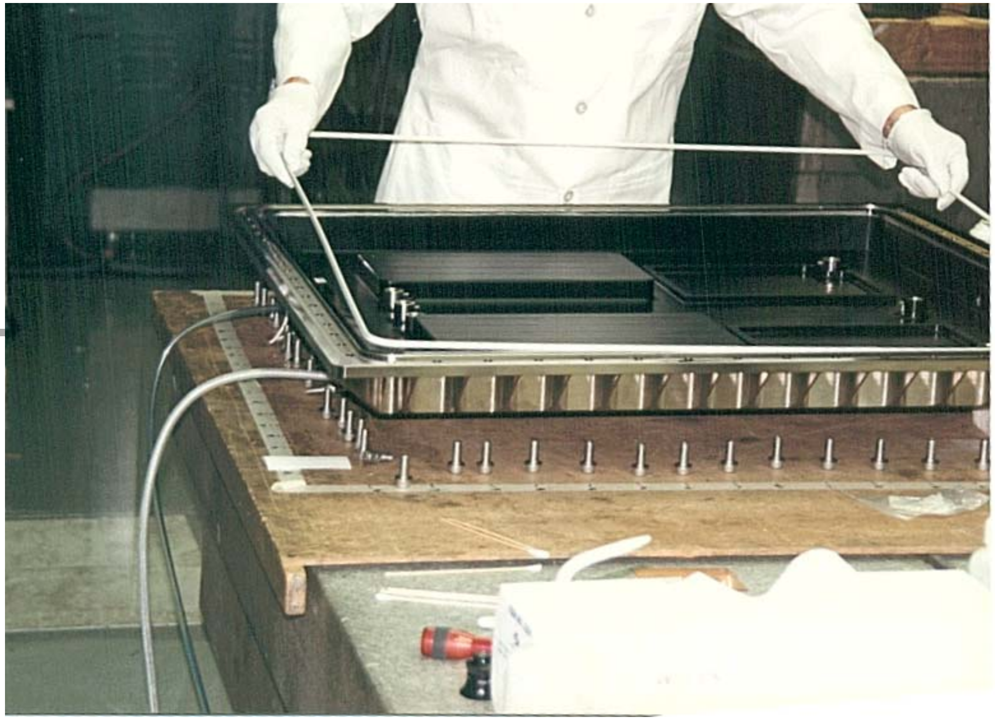
Cross Section Model of the new Charters of Freedom Encasements



Encasement design decisions

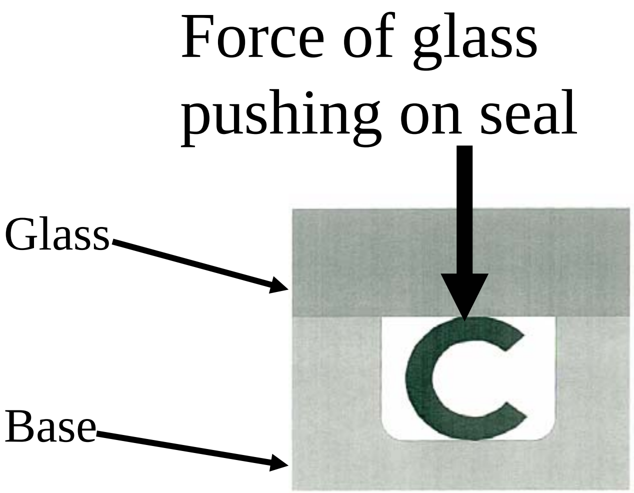
- Need for a extremely high quality seal between the glass and base structure led to an all metal “ultrahigh vacuum quality” seal.
  - Polymer seal would harden with age—time frame considered was up to 100 years
  - Diffusion through a non-metal seal would be a concern over the very long times considered.
- The metal seal dictated many of the joint design features.

Metal seal



- C-cross section metal seal--tin plated (~75um thick), inconel base metal
- Seals between the glass and the base
- Sealing pressure of approximately 80 N/mm of seal length

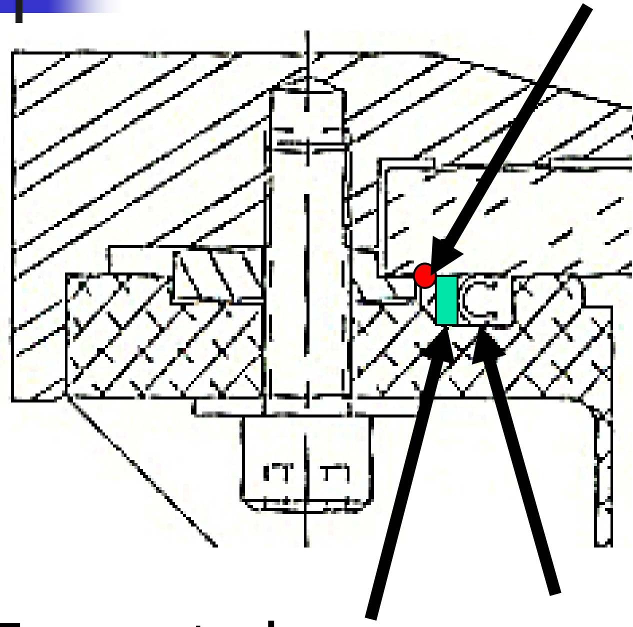
The inconel yields a small amount on closing the joint, but retains elasticity indefinitely to maintain a positive sealing pressure as the outside pressure changes slightly.

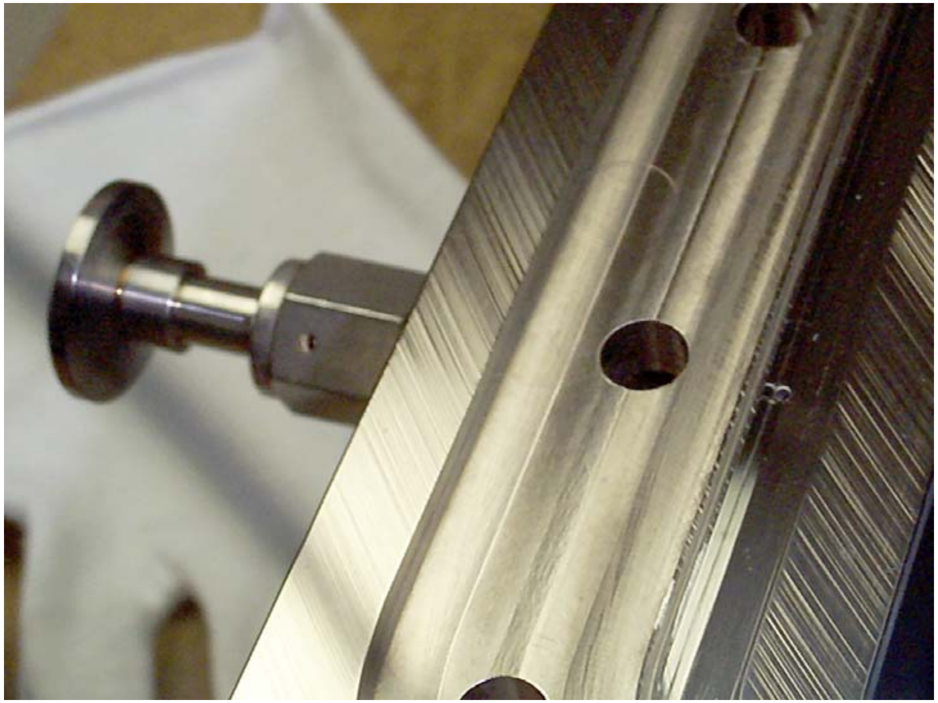


Seal requirements

- To protect documents from effects of oxygen, the seal should be so good that if there is any leak allowing the argon to be slowly replaced with air, the rate will be so small that in 100 years there would be no more than 0.5 % oxygen inside.
- Translated to technical terms:
  - **Maximum allowable leak rate: 3 x 10^{-7} cc of helium per second.**

Leak check method



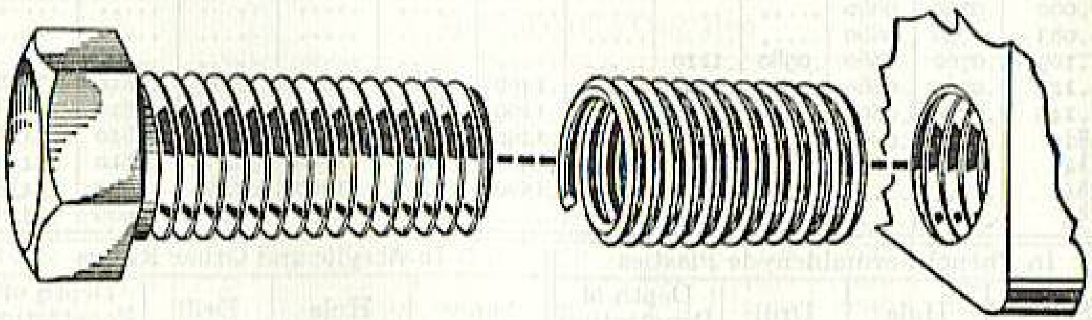


Bolted joint

- Required to apply the loading of 80 N/mm along the seal and deform the Indium wire for leak test seal.
- With a spacing of ~50 mm between bolts, every bolt needs to hold a load of at least ~4000 N (~900 pounds).
- Bolts used: 3/8-24 stainless (18-8 type).
- Smaller encasements have 66 bolts and the large encasements, 72.

Screw Thread Inserts. — Screw thread inserts are helically formed coils of diamond-shaped stainless steel or phosphor bronze wire that screw into a threaded hole to form a mating internal thread for a screw or stud. These inserts provide a convenient means of repairing stripped-out threads and are also used to provide stronger threads in soft materials such as aluminum, zinc die castings, wood, magnesium, etc. than can be obtained by direct tapping of the base metal involved.

According to the Heli-Coil Corp., conventional design practice in specifying boss diameters or edge distances can usually be applied since the major diameter of a



hole tapped to receive a thread insert is not much larger than the major diameter of thread the insert provides. For example, the major diameter of the tapped hole to receive a ¼-28 cap screw is 0.2904 inch while a conventional tapped hole for a ¼-28 cap screw has a major diameter of 0.250 inch.

Screw thread inserts are available in thread sizes from 4-40 to 1½-6 inch National and Unified Coarse Thread Series and in 6-40 to 1½-12 sizes in the fine-thread series. When used in conjunction with appropriate taps and gages, screw thread inserts will meet requirements of 2, 2B, 3 and 3B thread classes.

Page 1086, Machinery’s Handbook, 17th Ed., The Industrial Press, 1964

Machining Titanium Frames for New Encasements at NIST

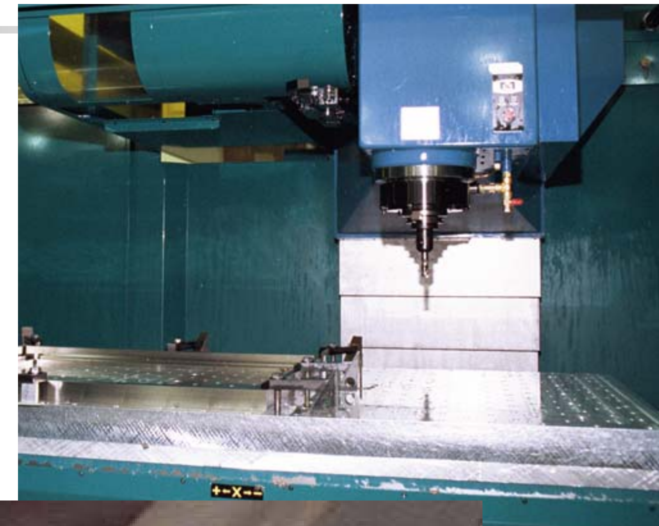
• Commercially pure (CP) Grade 2 Titanium

• Plate, approximately one meter square, 50 mm thick (40 x 40 x 2 inch plate)

•Machining parameters:

-- roughing with high speed steel, titanium nitride coated end mills

-- finishing bevel area with tungsten carbide ball end mills, 5500 rpm, 35 inch per minute feed



Testing the New Encasement Design

Thermal shock test

Results: glass did not break and seal did not leak!

Pressure test to failure

Results: four times the extreme service pressure to break the glass !

Why Titanium?

- Strong, light, relatively easy to machine.
- Excellent corrosion resistance.
- Can be gold plated.
- Was free, donated for project.

Are there weak spots?

When looking back after a couple of years, the design and fabrication appear to be excellent. If we were to “do it again” I’d change the following:

- Coarse thread on bolts, more bolts.
- Two metal seals to allow a leak test years into the future.