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INFLATABLE TRAVERSING PROBE SEAL

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ABSTRACT

An inflatable seal acts as a pressure-tight zipper to provide traversing capability for instrumentation rakes & probes. A specially designed probe segment with a teardrop cross-section in the vicinity of the inflatable seal minimizes leakage at the interface. The probe is able to travel through a lengthwise slot in a pressure vessel or wind tunnel section, while still maintaining pressure integrity. The design uses two commercially available inflatable seals, opposing each other, to cover the probe slot in a wind tunnel wall. Proof-of-Concept tests were conducted at vessel pressures up to 30 psig, with seals inflated to 50 psig, showing no measurable leakage along the seal's length or around the probe teardrop cross-section. This seal concept can replace the existing technology of sliding face-plate / O-ring systems in applications where lengthwise space is limited.

INTRODUCTION

This seal was conceived for a pressurized wind tunnel into which sensor probes are to be inserted and positioned from the outside. With the proposed seal, a probe can penetrate and move along a wind tunnel wall without causing an air leak at the wall. The probe can also be moved in and out through the seal, if desired.

A pair of opposed inflatable rubber seals (or tubes) form the airtight seal across a slot in a wind tunnel wall. The probe which penetrates this seal has a special double-teardrop cross section which allows the inflatable seal to deform and mold itself around the probe. (See Fig. 1). The probe can be traversed from one end of the seal to the other while differential pressure is maintained across the wall of the wind tunnel.

Current technology for commercial sealed traversing actuators utilizes sliding plates with face seals. Unfortunately, this method is very bulky, and the actuator/seal assembly must be at least twice as long as the desired probe travel (in order to keep the probe slot completely covered even when the probe is at the extreme ends of the slot). However, the new Inflatable Traversing Probe Seal assembly takes up only half as much length as commercially available actuators. Seal lengths only slightly longer than the desired probe travel are possible. This size advantage can make a tremendous difference when space is cramped, and will allow the probe to travel very close to an obstruction or flange.

This work was done by NASA-Lewis Research Center Engineering Directorate for the Aerodynamics Branch in support of the Supersonic Shear Flow Research Rig. A prototype seal test apparatus was constructed and tested, and preliminary design of a new spoolpiece and inflatable seal was completed in 1990. Tests proved that the concept will create an airtight seal while still allowing probe movement. Fabrication of actual wind-tunnel hardware has been postponed, however, due to a temporary lack of program funds to build the proposed spoolpiece for the Shear Flow Rig.

TESTING

The prototype model consisted of a 4" x 4" x 22" long square tube "pressure vessel" with an 18" long opposed inflatable seal assembly attached to one face. (See Fig. 2). The seal assembly was assembled from commercially available inflatable seals and extruded aluminum seal retainers. Both the square pressure vessel and the inflatable seal were pressurized with shop air through two separate regulators. The prototype

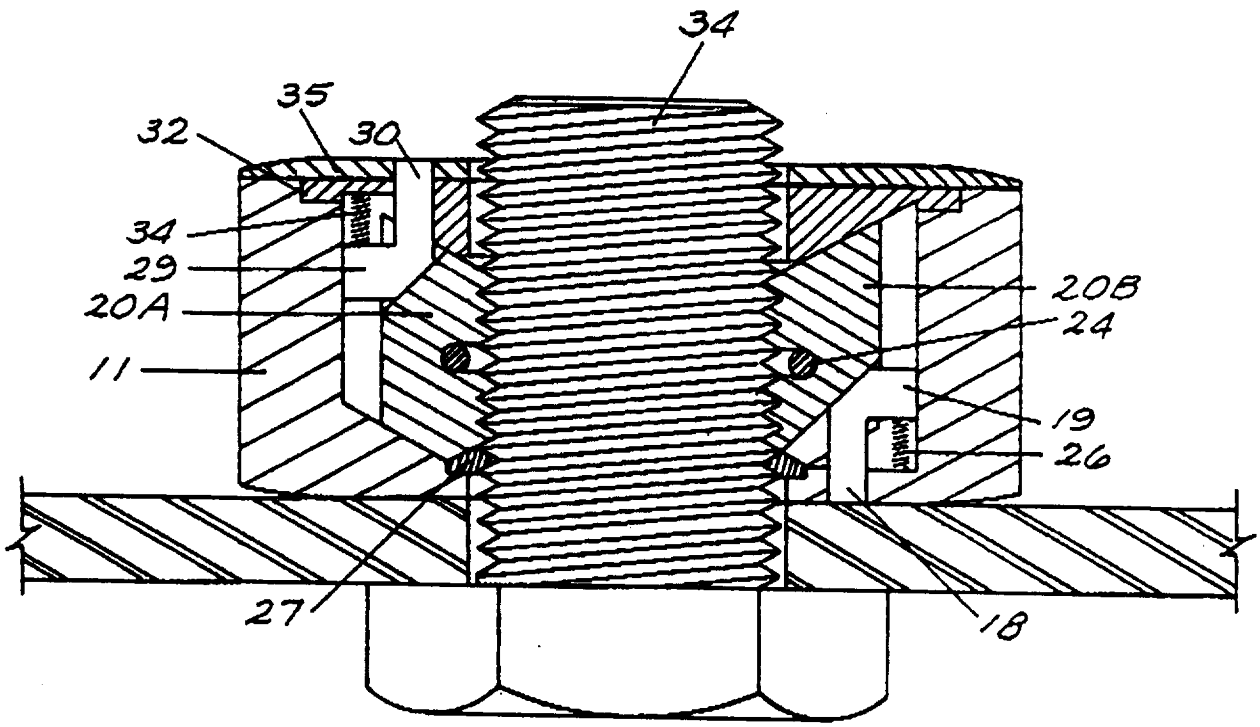

FIG. 7 is a sectional view, in longitudinal central section with a bolt or threaded shaft or spindle inserted from one side of the nut.

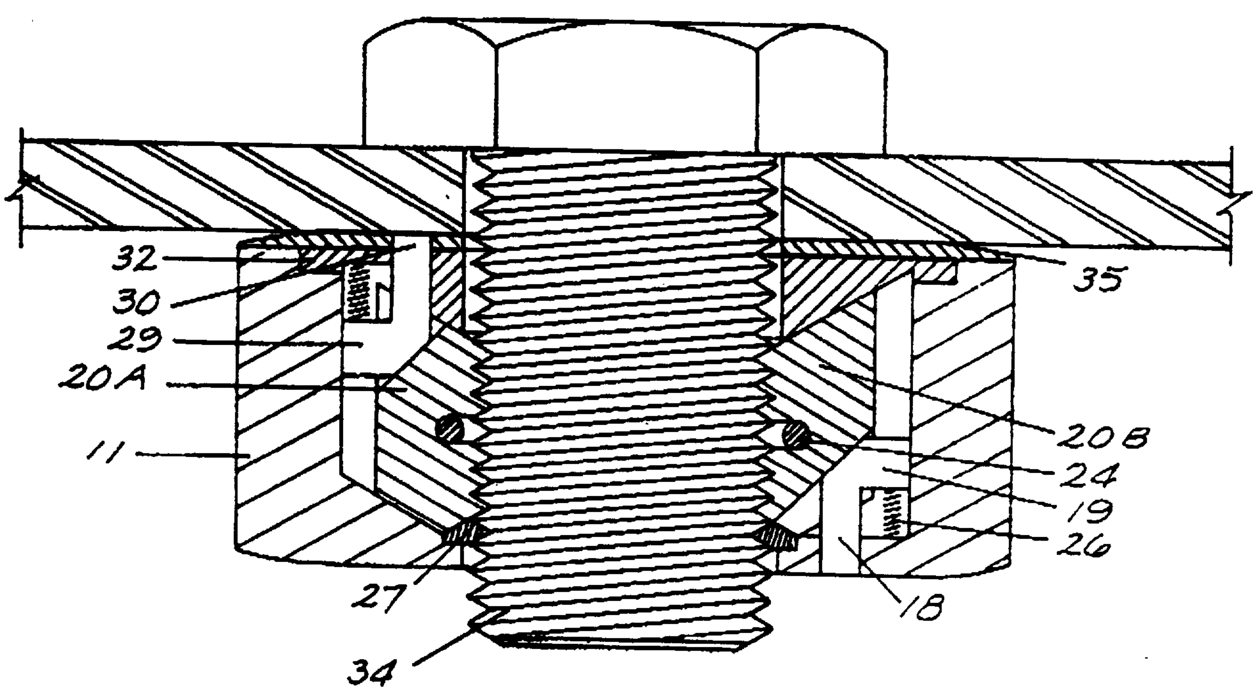

FIG. 8 is a sectional view, in longitudinal central section with a bolt or threaded shaft or a spindle inserted from another side of the nut.

seal was tested at a vessel pressure of 30 psi, with the seal inflated to 50 psi. No leakage past the seal was measured, either with the probe stationary or in motion.

Force measurements were also recorded when the probe was in motion. The actuation force necessary to drive the probe through the inflatable seal was provided by mounting the teardrop-shaped dummy probe to the movable arm of a Tensile Test Machine. (See Fig. 3). Probe actuation forces of approx. 75 lbs. were measured with the seal lubricated with silicone O-ring grease. After the probe was stroked the length of the seal several times, actuation forces began to rise rapidly. Forces of up to 130 lbs. were measured after two strokes. The rise in actuation force was attributed to the silicone grease being wiped free after several strokes of the probe, causing a significant increase in friction.

Seal lubrication is required with such frequency that an active lubrication system was devised to bleed grease from the teardrop-shaped portion of the probe. Pressurized grease is fed from a reservoir, through a solenoid valve, down to the seal/probe interface. Tiny bleed holes on the teardrop-shaped probe section weep grease into the interface. The solenoid valve is controlled on demand by a load-sensing system which causes grease to bleed whenever the actuation force exceeds 100 lbs. The grease ceases to bleed once the actuation force drops below 80 lbs.

Another interesting observation noted during prototype testing was that the actuation force required to move the probe did not vary in proportion to the seal inflation pressure. Since the seal inflation pressure creates a frictional load on the teardrop-shaped dummy probe, it was assumed that probe actuation forces would rise with higher seal inflation pressures. However, testing indicated that probe actuation force did not vary measurably with seal inflation pressure. Actuation force was more dependent on the amount of lubrication remaining on the seal interface.

End termination method is an important aspect of this inflatable seal. The prototype utilized the Presray "Inflato-Boot™ " seal end configuration. (See Fig. 4). A specially made plexiglas wedge was mounted on either end of the seal holder to fill in the gap and give the boot something to seal against. (The wedge is visible in Fig. 3). Unfortunately, it was very difficult to achieve a leak-free seal junction using this method. Strategic injections of silicone rubber sealant during assembly finally solved the leakage problem. The Inflato-Boot™ is a unique option which is probably better suited to more conventional applications of inflatable seals. For NASA's application, it now appears that a standard end configuration utilizing a solid non-expanding portion, cast to the inflated configuration (rather than the usual relaxed configuration) would be easier to seal and less likely to leak. (See Fig. 5). It would also be less complicated, requiring no custom-machined wedge to bear against. This second method (standard end, inflated configuration) is the one which has been baselined for the NASA Shear Flow Research Rig application.

CONCLUDING REMARKS

This seal concept utilizes commercially available components to provide a dramatic improvement to the capabilities of sealed actuator systems. The concept is adaptable to other situations in which objects must penetrate pressure walls and move along them. It should work for vacuum chambers as well as pressure vessels. The concept may also be used for dust seals, regardless of differential pressure. A U.S. patent has been approved for the new device, with release scheduled for early 1992.

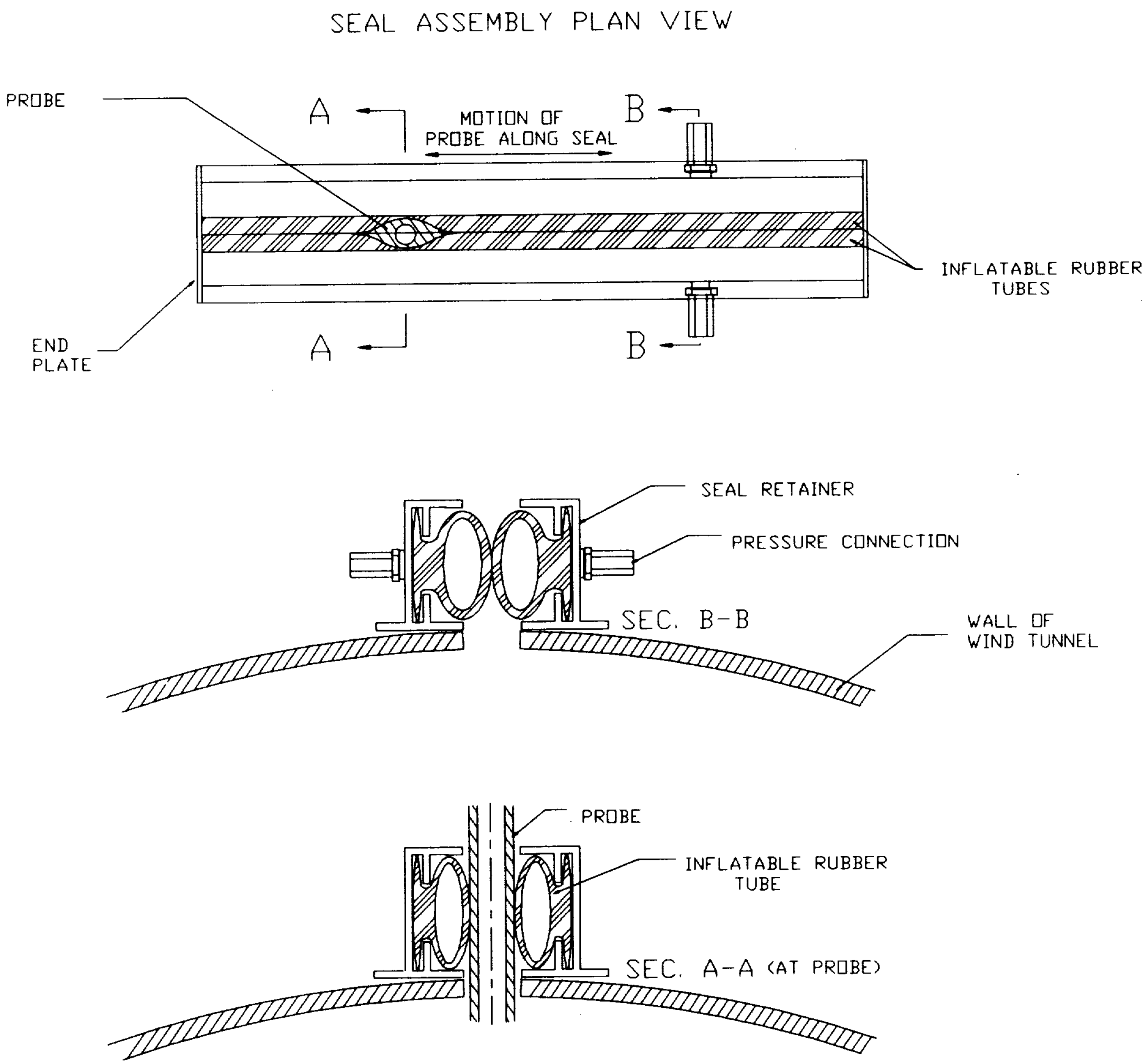
SEAL ASSEMBLY PLAN VIEW
PROBE
A
MOTION OF
PROBE ALONG SEAL
B
INFLATABLE RUBBER
TUBES
END
PLATE
A
B
SEAL RETAINER
PRESSURE CONNECTION
SEC. B-B
WALL OF
WIND TUNNEL
PROBE
INFLATABLE RUBBER
TUBE
SEC. A-A (AT PROBE)

FIGURE 1

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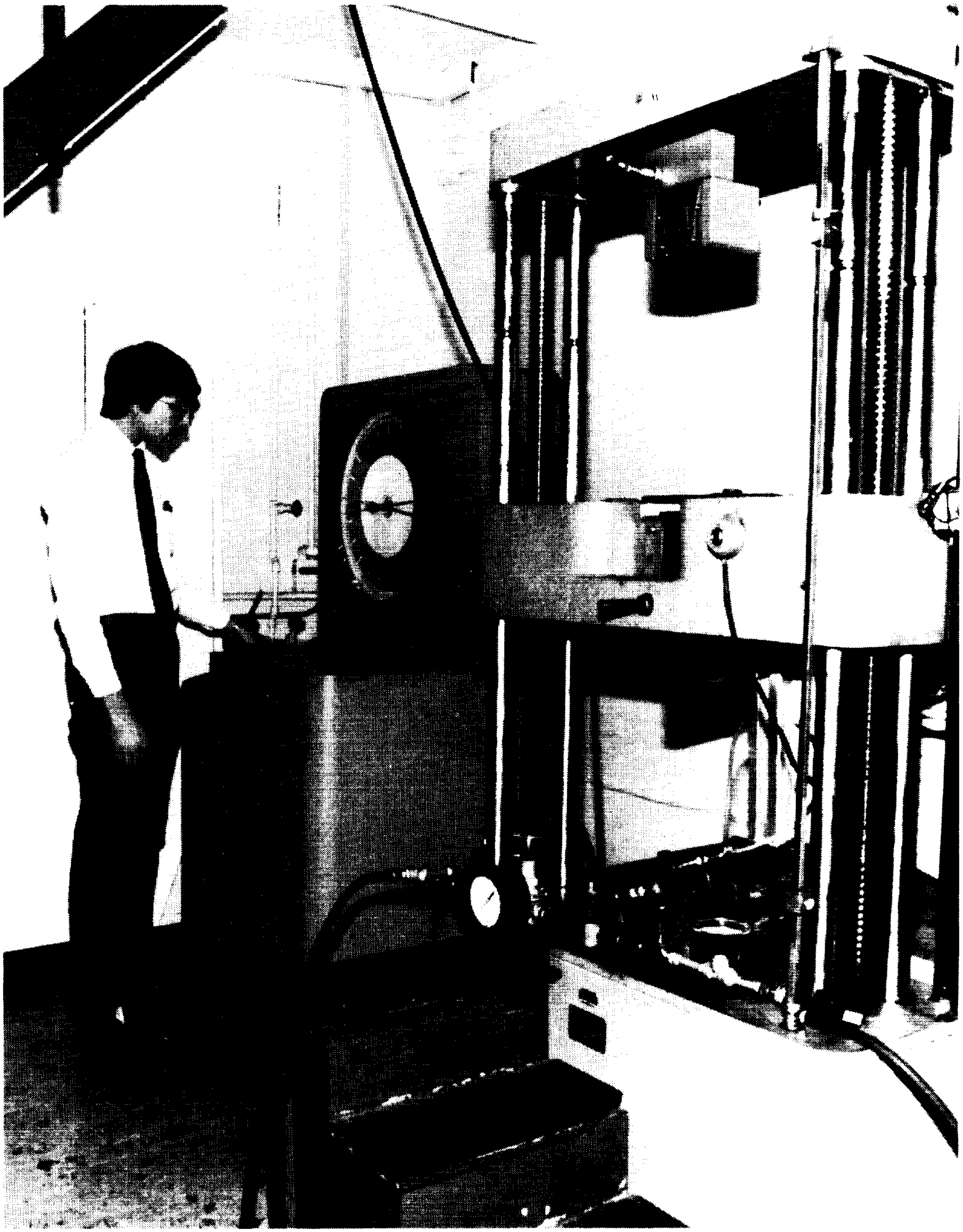

Fig. 2

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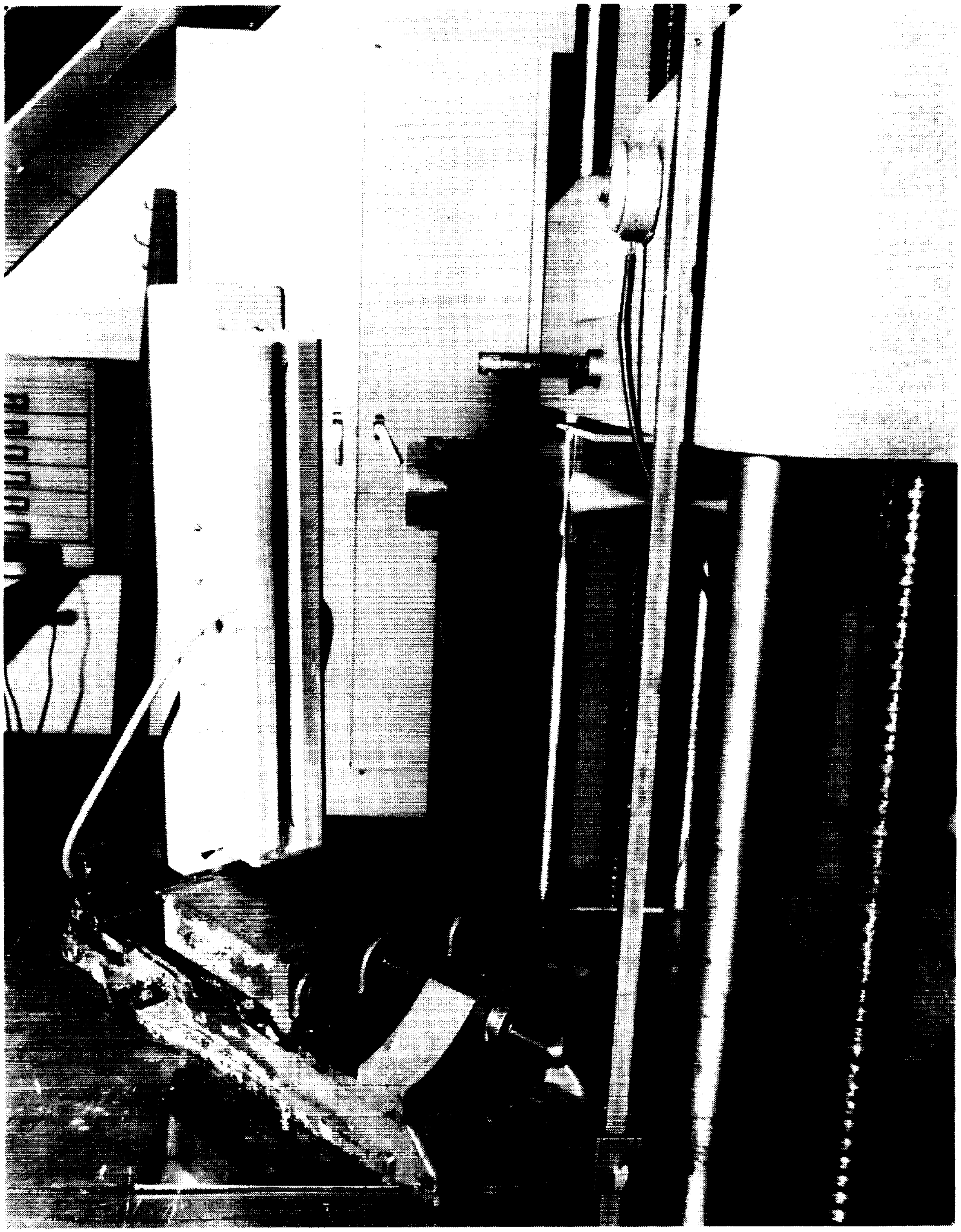

Fig. 3

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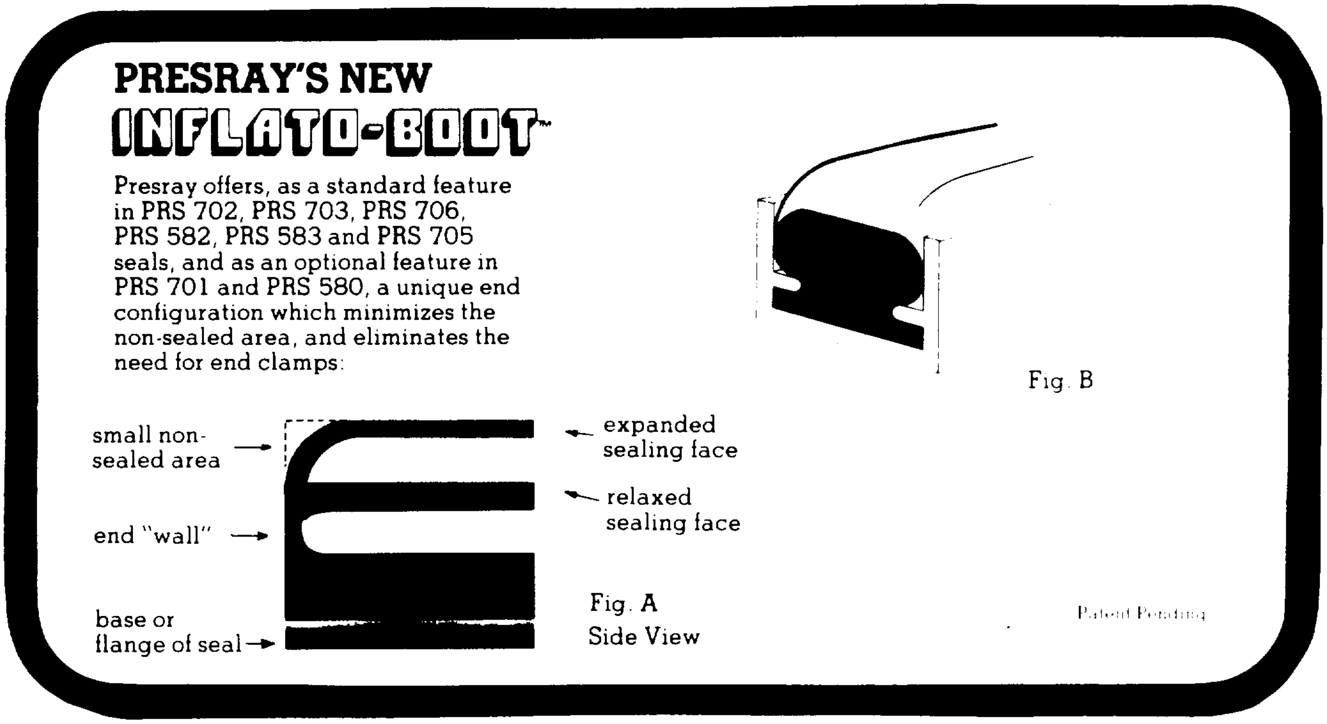
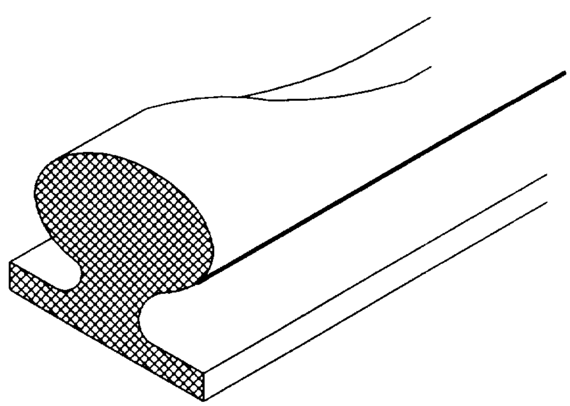
BLACK AND WHITE PHOTOGRAPH



Courtesy of Presray Corp.

Fig. 4



Standard Seal End Cast
Into Inflated Configuration

Fig. 5

ARTIFICIAL INTELLIGENCE

(Session D2/Room B1)

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