SLAC-TN-67-23
B. Sukiennicki
July 1967

BEHAVIOR OF THE FIRST SUIT OF SCOTCHLITE IN THE 40" SLAC HYDROGEN BUBBLE CHAMBER

A. INTRODUCTION

A retrodirector consisting of SPR 704 (lot 32A) Scotchlite* glued to fiberglass liners was installed in the 40" HBC for the first engineering run. The chamber was full of LH_2 for twenty-six days, and approximately 190,000 expansion cycles took place. The run was discontinued as the piston liner clamping ring came loose and the optics window was in danger of being damaged. The retrodirector produced good photographs and the adhesion of Scotchlite proved to be very good. The piston liner in particular emerged from the warmup in almost as good a condition as when it was originally installed.

The purpose of this note is to describe our experience with this first suit especially with reference to Scotchlite mounting problems. It does not describe the alternative mounting methods tried experimentally before the run. These concentrated on FE 582, exposed bead Scotchlite, as it was originally intended to be used in the chamber. At the last moment, however, tests showed that reflectivity of FE 582 dropped drastically with angle of incidence when tested in LH_2, an effect not noted in air. A change to SPR 704 had to be made therefore a few days before the chamber was to be closed. The mounting methods described are therefore probably not the best possible. Nevertheless they worked reasonably well. The note concludes with our plans regarding mounting of Scotchlite for the next run.

*Scotchlite is a registered trade mark of 3M Company.

B. MOUNTING DETAILS OF SCOTCHLITE COMPONENTS

SPR 704 Scotchlite was used in the chamber in several locations: on the two parts of the retrodirector, on the chamber body fiducials, and as "stuck on" fiducials on the vacuum side of the optics window.

The retrodirector components shown in Figures 1 and 2 have been referred to as the piston liner and the skirt. Description of their construction follows.

The Piston Liner

The liner base consisted of a 41.50" diameter dish of 95" spherical radius, nominally 1/8" thick. It was molded of glass fabric with Volan A finish and United Carbide ERL 2256 epoxy M.P.D.A.* hardener (100 parts of ERL to 14 of M.P.D.A. by weight). The liners were manufactured by U.T.C. of Sunnyvale, California. The bubble chamber piston was used as the female portion of the mold, with a male plug provided by U.T.C.. The fiberglass dish was lightly sanded, perforated with 0.02" diameter holes on approximately 2" spacing and placed in the fixture. Just prior to gluing on of the Scotchlite it was cleaned with acetone and baked out for several hours with heat lamps. A square sheet of Scotchlite was prepared by joining together four 12" strips of SPR 704 with about 1" overlap using Scotchlite's own adhesive. The joints were pressed down to obtain a good bond. It was very important to produce a sheet free of folds.

ERL 2256 epoxy was mixed with M.P.D.A. hardener (100 parts to 14 by weight) and outgassed in a vacuum oven at room temperature until frothing subsided (approximately 1/2 hour). The epoxy was then painted onto the dish and almost completely wiped off using a piece of soft rubber. This technique was necessary to reduce the "cratering effect" due to the epoxy not wetting certain spots on the liner, (Fig. 4). We learned how to produce craters,for example, by leaving fingerprints on the liner base, but we found no method of eliminating them completely.

---

*M.P.D.A. stands for Metaphenylediamine.

A very thin epoxy layer made the craters very shallow and virtually unnoticeable. The Scotchlite sheet was stretched over the dish with the joints perpendicular to beam direction, and sealed to the edges of the fixture with its own adhesive. This operation required a number of helpers as the sheet had to be completely free of wrinkles when installed. At this point heat lamps (approximately ten 300 watt lamps at 3 feet from the dish) were turned on and vacuum valves opened slowly. About ten minutes were allowed for the Scotchlite to pull down gradually to the dish. This time was controlled with a vacuum valve; a water manometer being used for reference. Any air bubbles trapped under the Scotchlite were moved to the nearest pump-out hole with gloved fingers. The holes were visible as small depressions in the surface of Scotchlite when under vacuum. Some sliding in the overlaping joints (about 1/16" in most cases) did occur during pull-down, but was not objectionable. The liner was allowed to cure under the heat lamps for approximately 24 hours. Vacuum in the fixture was maintained for the first two hours or so. After curing the liner was trimmed around the edges and the pump-out holes were filled from the back with ERL epoxy using a syringe. When the droplets of epoxy were dry, they were sanded to conform to the liner profile.

The piston liner was clamped in place on the piston with a total of twenty-four #10-24 screws holding the two clamping half rings. It was these rings which became loose during the run and forced its termination.

The Skirt

The skirt was manufactured at SLAC from fiberglass by hand layup on a plywood male mold. Glass cloth sections about three feet long were laid continuously with about three inch overlap. Each piece in turn was saturated with a mixture of Shell EPON 815 Epoxy and Versomin V40 hardner (100 parts of 815 to 50 of V40 by weight). This epoxy was chosen as it allowed room temperature cure and would not run as easily as ERL 2256. The layout process was continued using a roller to drive out air bubbles, until a 1/8" thickness was obtained. After twenty-four hour cure at 70°F, the skirt was sanded to its final shape.

Scotchlite was applied in 12" sections precut to shape. Outgassed EPON 815 with V40 (100 to 50) was again used. A thin layer was obtained by wiping with a piece of soft rubber. As no vacuum was used to pull the Scotchlite down, air bubbles had to be rolled out by hand. Pin holes were made in the Scotchlite where necessary to remove stubborn bubbles. In a few cases traces of epoxy oozed out of the holes. This uncured epoxy was removed by washing with acetone. The exposed edge of Scotchlite on lower end of the skirt was held down with short section of masking tape and twenty-four hour 70° cure was repeated. When cured the bottom of the skirt was trimmed where necessary and a sealing bead of epoxy was put on the top edge. The skirt was introduced into the chamber through the optics window opening. It was mounted with acorn nuts to studs welded to the chamber heat exchangers.

Chamber Body Fiducials

Five chamber body fiducials were pinned and bolted within the visible volume of the chamber. The stainless steel fiducial had a 3/4" diameter disc of Scotchlite epoxied with ERL 2256 and M.P.D.A. in a sandblasted recess in the stainless steel body. The fiducial pattern itself, a cross of 0.02" lines in a circle, was silk screened directly onto Scotchlite with black epoxy ink.

Window Fiducials - Vacuum Side

In order not to weaken the glass of the optical window, three fiducials on the tension (vacuum) side were applied as 1/2" diameter discs of SPR 704 Scotchlite. Fiducial cross was made by sandblasting 0.015" wide lines on the mylar overcoat of SPR 704. The fiducials were applied to the glass using Scotchlite's own adhesive.

C. BEHAVIOR OF SCOTCHLITE DURING THE LH_2 RUN

All Scotchlite components were installed in the chamber and the vacuum tank pumped out. First sign of trouble was observed a few hours after the chamber itself was evacuated. Irregular blotches appeared on the chamber skirt. The blotches continued to spread, attaining their maximum size in about 48 hours. The resulting loss of Scotchlite's reflectivity gave the photographs from the first run of the 40" HBC their distinctive 'mod' appearance (Fig. 5). No defects were observed on the piston liner, however.

The chamber cool-down was intended to proceed at an average of $2^{o}K$/hour. Due to various circumstances however, the actual cool-down rate averaged $1.3^{o}K$/hour. On June 4th the chamber was full of liquid hydrogen at a working temperature between $27^{o}K$ and $28^{o}K$. Tuning of the chamber then began. It was concluded that the chamber was rather "soft". There was excessive bubble formation somewhere in the invisible region of the chamber giving us spongy expansion pulses and excessively large expansion ratios. This point is of interest as it caused us to redesign the retrodirector mounting for the subsequent run.

Soon a further defect occurred which deteriorated the quality of the photographs. The superinsulation in the vacuum tank rotated, moved slightly in front of the vacuum tank ports, and reflected light directly into the camera lens with resulting flares. We were also getting unexpectedly strong flare from the polished edges of the vacuum tank ports. These factors, especially the reflections from the superinsulation, resulted in large amounts of stray light in the chamber with correspondingly lower contrast. The tracks, however, when viewed on a scanning table, were judged to be of quality acceptable for physics experiments. Good polaroid photographs were also obtained. Eight days after the chamber was full of LH_2 and after about 60,000 expansion cycles a 5" long dark streak appeared in the center of the piston liner (see Fig. 5). This was judged to be a tear but it turned out to be a small, 1", tear combined with a dirt streak. This tear , further discussed in the following section, was the only defect in the piston liner that was caused by normal operation of the chamber. On June 23rd, the upper portion of the Scotchlite clamping ring was seen to drop into the visible volume of the chamber. Although the chamber could be pulsed in this condition, an attempt at obtaining some useful experimental photographs with a photon beam was terminated since the loose clamping ring was slightly magnetic; and, if it broke loose completely, there was fear it could damage the optics window. Warmup was started on June 29th after 25 days operation and 190,000 exposures. The chamber was warmed up at $3^{O}K$/hour.

D. CONDITION OF SCOTCHLITE COMPONENTS AFTER WARMUP

Following the 4-day warmup the chamber was opened. The optics window, which remained remarkably clean during the run, had a considerable amount of oil deposited on it during the final stages of warmup. This was removed by washing with a xylene/acetone mixture. The Scotchlite fiducials on the vacuum side of the window remained securely in place and were left on.

The skirt was found to be loose, held only by 4 out of 11 nuts on the bottom and 6 out of 11 on the top. Most of the mounting holes in the skirt were badly enlarged and elongated. No dirt was found on the skirt. The blotches were due to the mylar outer layer of the Scotchlite which locally separated, but the base layer remained firmly attached to the fiberglass base. Some of the blisters formed had broken open, but no reasonfor blistering (such as association with pin holes or craters) could be found. The upper Scotchlite clamp ring was found to be held by a single screw and the lower by 4 screws. The lower clamp ring had struck and broken off one of the chamber body fiducials. The chamber body fiducials, incidentally remained undamaged, except for mechanical damage caused by the clamp rings. The piston liner was taken out of the chamber and carefully examined. It sustained some mechanical damage and had considerable dirt streaks. The only serious damage, however, associated with the normal run was the small 1" tear in the center of the liner (see Fig. 6). This tear was at the edge of an overlap joint and was due to insufficient epoxy being present to form a filet where the Scotchlite layers overlapped. The remaining 4" of the central dark streak proved to be steel and fiberglass dust which fell from the top of the skirt where it was rubbed by the loose clamp ring. Additional dirt spots in the form of characteristic "trees" were found at the lower edges of the liner (see Fig. 7). Where-ever dirt streaks were present, considerable residual electrostatic change was found in the mylar outer layer of Scotchlite.

The conclusion drawn from examination of the piston liner was that, had the clamping ring not come loose, the liner would have come out of the run in the same condition as it went in, except for the 1" central tear.

E. SIMULATION OF SKIRT BLOTCHES

Small 9" samples of the skirt were prepared Scotchlite being glued in place by various methods. The samples were then placed in a bell jar and evacuated. Samples (made in the same way as the skirt proper, i.e., with EPON 815/Versomat V40 epoxy) all blistered. Pinholes, acetone washing, length of cure made no difference. Samples on which ERL 2256/M.P.D.A. epoxy was used (following the method used in making the piston liner, but without the vacuum fixture) none blistered. The problem was thus considered solved: the epoxy was inexplicably at fault.

F. MODIFICATION OF SCOTCHLITE COMPONENTS FOR THE SECOND RUN

A second run of the 40" HBC is planned for mid-August 1967. As a result of our experiences from the first run the following changes will be made:

(a) Vacuum side window fiducials
Window fiducials on the vacuum side will be replaced without change.

(b) The chamber body fiducials will be unchanged, except that sandblasted cross will replace the silk screened pattern used.

(c) The skirt will have Scotchlite glued to the fiberglass base using ERL 2256 epoxy with M.P.D.A. hardener. In order to allow examination of bubble formation associated with attempts to reduce the softness of the chamber, 90° segments of the skirt at top and bottom of the chamber will be removed.

(c) The remaining skirt segments will be mounted to chamber walls with suitable brackets. (This is a temporary reduction of the skirt size.)

(d) The piston liner will no longer be truncated. It will be reduced slightly in diameter and bent sufficiently to allow entrance into the chamber through the window opening. The liner will be held in place by a one-piece steel clamp ring equipped with indium sealing wires (see Fig. 8). The ring will also be distorted to allow entry into the chamber. Bolts holding the ring will be tack welded to prevent loosening.

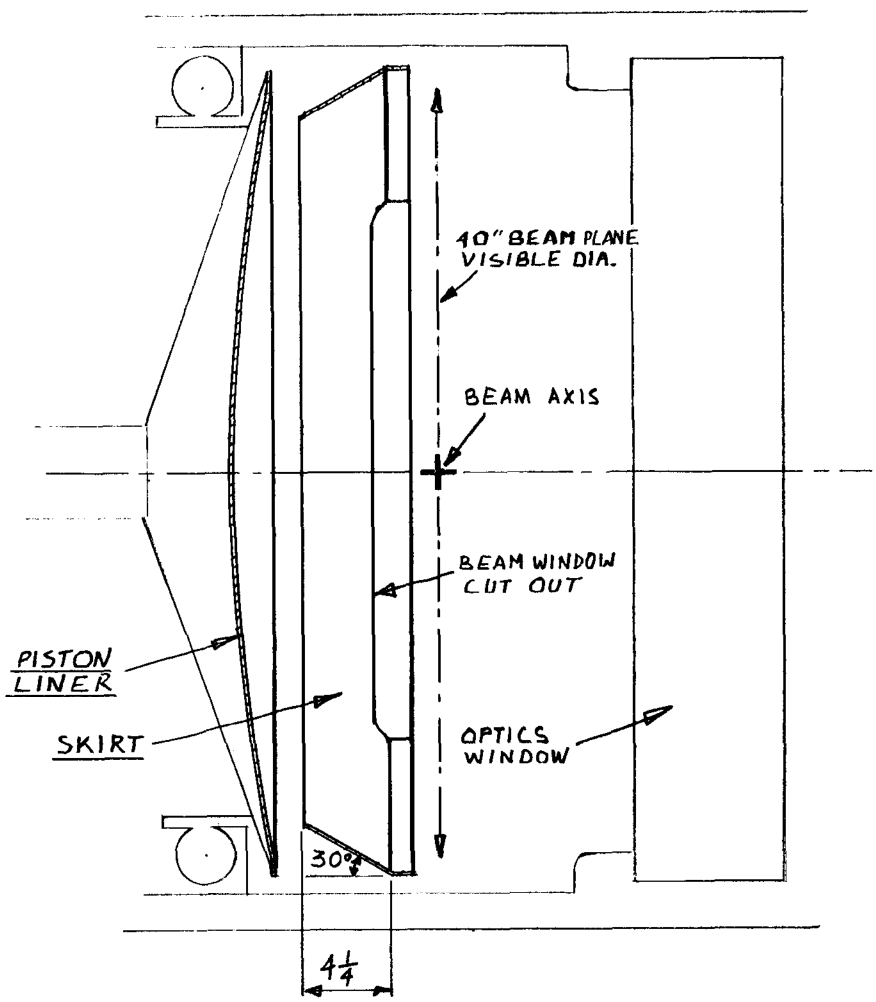

FIG. 1.

RETRODIRECTOR MOUNTING IN THE 40" H.B.C.

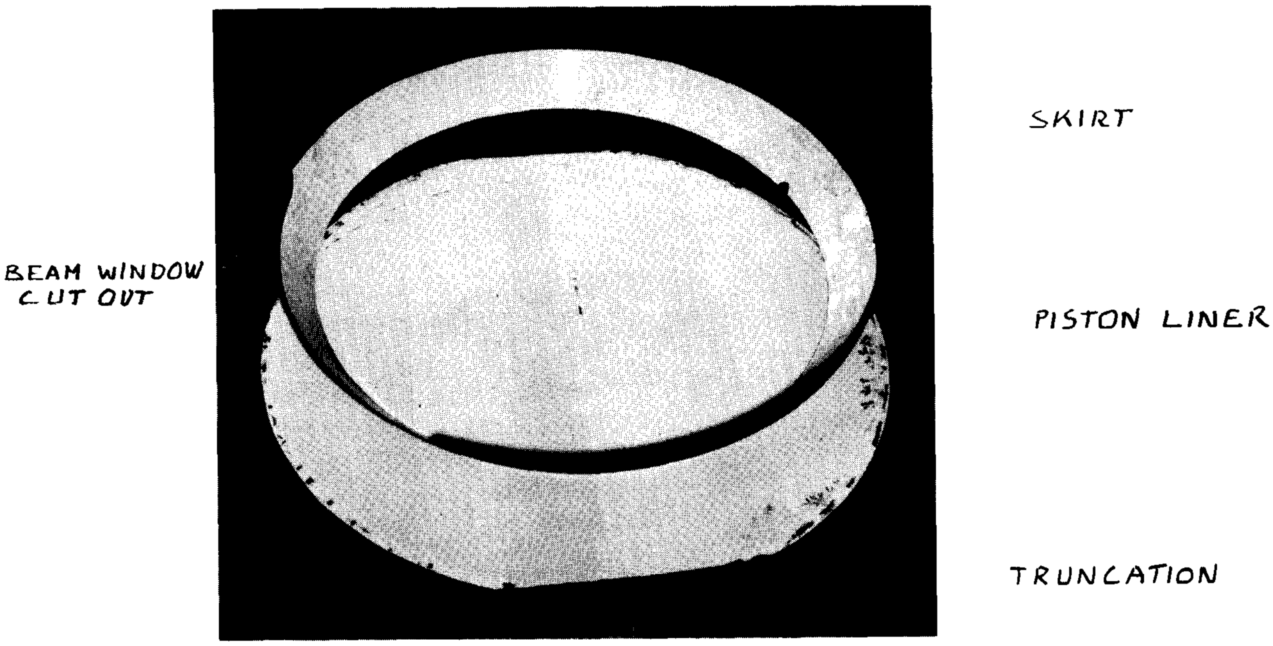

FIG. 2.

SCOTCHLITE RETRODIRECTOR AS REMOVED FROM 40" H.B.C.

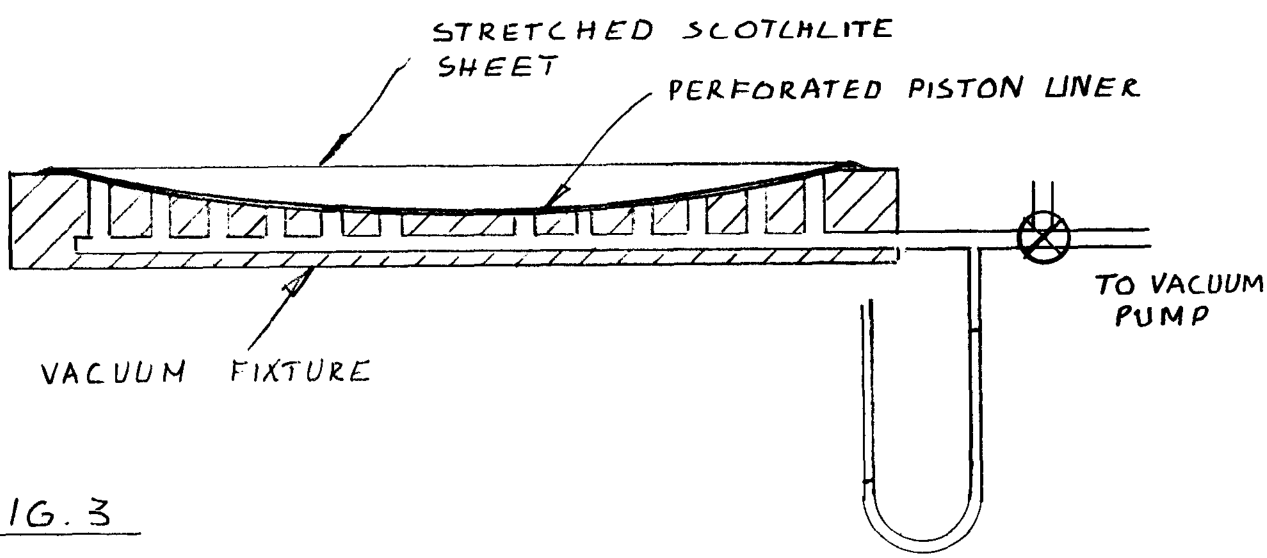

FIG. 3

SCOTCHLITE VACUUM FORMING FIXTURE.

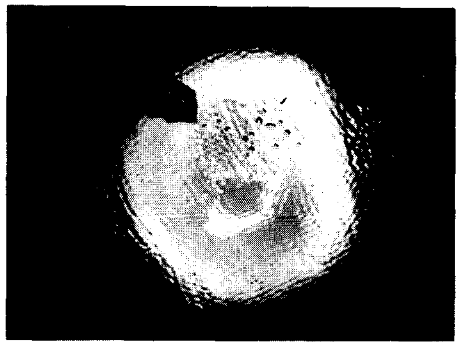

FIG. 4--Typical crater in piston liner.

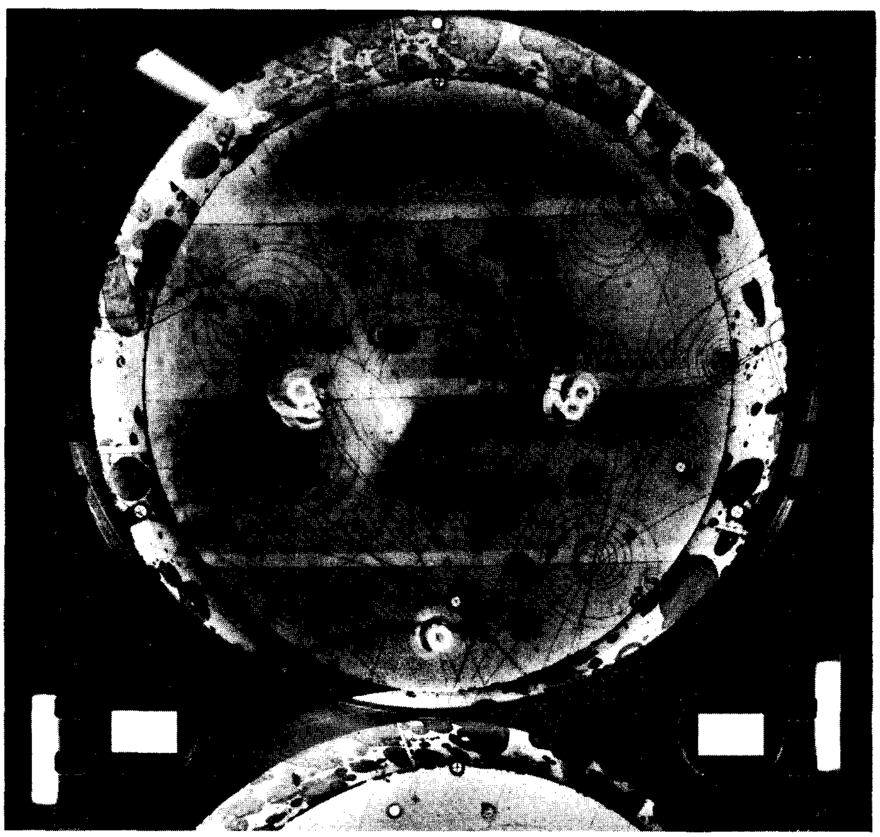

FIG. 5--Typical photograph from 40"HBC.

FIG. 6--Detail of Scotchlite tear.

FIG. 7--Detail of dirt "tree."

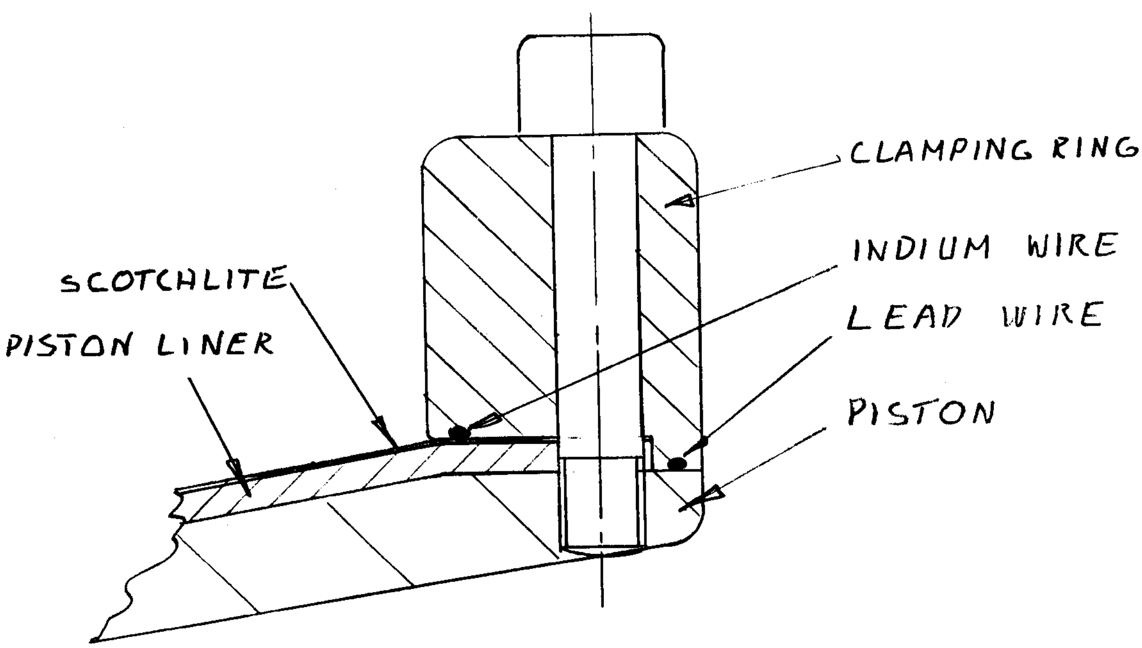

FIG. 8
PISTON LINER CLAMPING ARRANGEMENT.