Feasibility of a Super High Energy Density Battery of the Li/BrF_3 Electrochemical System

[1989]

Technical Report

Wilson Greatbatch Ltd.
10,000 Wehrle Drive
Clarence, NY 14031

Michael F. Pyszczek, Steven J. Ebel, Christine A. Frysz

To date, design and construction of a material handling and measurement system along with the apparatus required for waste material disposal has been completed. Preliminary corrosion screening of potential case materials is currently underway.

Material Handling System:

A review of the literature, along with direct communication with personnel at China Lake NWC, has led us to the use of Monel® 400 as the material of construction for the handling and measurement system. The inherent stability of this material with bromine trifluoride in its liquid state is crucial to ensure that contamination does not occur during storage and handling. For applications which require a flexible or transparent material, items fabricated from perfluoroalkyoxy polymers (Teflon® PFA) were utilized. One such application encountered was in the design of the graduated tank which allows visual inspection of the material prior to dispensing. Containers used for compatibility/corrosion testing were also constructed of PFA.

Attached is a schematic of the handling and measurement system. The system was designed to utilize a gravity flow of material wherever possible, thus reducing the need to pressurize the apparatus. The arrangement of the holding tank and graduated tank allows the latter to be used as a "site glass" for determining the level of stored material. Transfer of bromine trifluoride into the graduated tank is by gravity as the liquid levels are allowed to equalized between the tanks. The system outlet is equipped with a three-way ball valve which permits evacuation of receiving vessels prior to introduction of the liquid. The valve was specified with an internal design which eliminates the possibility of contaminating the low pressure portion of the system with bromine trifluoride. The vacuum side of the valve can also be pressurized with argon to permit the equilibration of pressure within the receiving vessel.

With respect to the hazardous nature of the material, several safety features were designed into the equipment. All lines which introduce gaseous materials into the system are protected with 1 psi check valves which eliminate back flow of material. In the event that a rapid

Future Investigations:

Additional compatibility testing will be performed for 1 and 3 month time intervals. Electrochemical corrosion testing on selected metal samples will be initiated along with the evaluation of candidate materials to be used for glass to metal seals. Materials for other components of the proposed Li/BrF_3 cell such as electrode separator and internal insulators will be examined.

degradation occurs within the system resulting in an increase of pressure, the apparatus is equipped with a 10 psi pressure relief valve. This device is also of the check valve style to eliminate the entry of atmospheric moisture into the system following a high pressure situation, as would be the case with conventional rupture disk technology.

The entire handling and measurement system is contained within a full-flow fume hood with a minimum face velocity of 100 cfm. Tempered glass safety shielding is used in addition to the transparent hood door to provide operator protection.

Prior to assembly of the equipment all valves and fittings were disassembled and thoroughly degreased. Monel tubing was deburred and cleaned to reduce the possibility of contamination or decomposition. Following final assembly, the system was purged and pressure tested with argon gas. The equipment was then evacuated and procedures to passivate the metal with a mixture of 10% fluorine in argon were initiated. The system was treated 3 times with fresh charges of the gas mixture until no signs of hydrofluoric acid vapors were seen upon release.
A final pressure test up to 65 psi with argon was performed prior to contact with the bromine trifluoride.

Material Compatibility Testing:

Ten metal samples were cleaned then weighed. They were place in conical teflon PFA vials inside a glove bag containing a teflon lined stainless steel tray. The glove bag was evacuated then filled with argon for approximately 6 cycles to ensure electrolyte pour and vial assembly takes place in an inert atmosphere. Bromine trifluoride was added to the vials which were then capped. Storage remained in the argon filled glove bag for 2 days after which the vials were opened. The metal samples were rinsed in trichlorofluoroethane, reweighed, then examined via SEM. Surface condition was compared to virgin material.

Table 1 lists the results for the metals tested. After two days of bromine trifluoride exposure, pre and post weight changes were insignificant. Mild steel, 304 and 316 L SS showed visible signs of general corrosion, see Figures 1 through 6. Surface discolorations were observed for nickel 200, Superferrit® and Shomac®, see Figures 7 through 12. The discolorations coincided with small particles retained on the surface after cleaning. It is speculated that these particles may be fluorides since elemental composition was undetectable by WGL's present EDX system. Aluminum alloy 1145-0, Hastelloy ® G30, 29-4-2, and Monel® appeared to be unaffected, Figures 13-20.

BrF_3 HANDLING AND MEASUREMENT SYSTEM

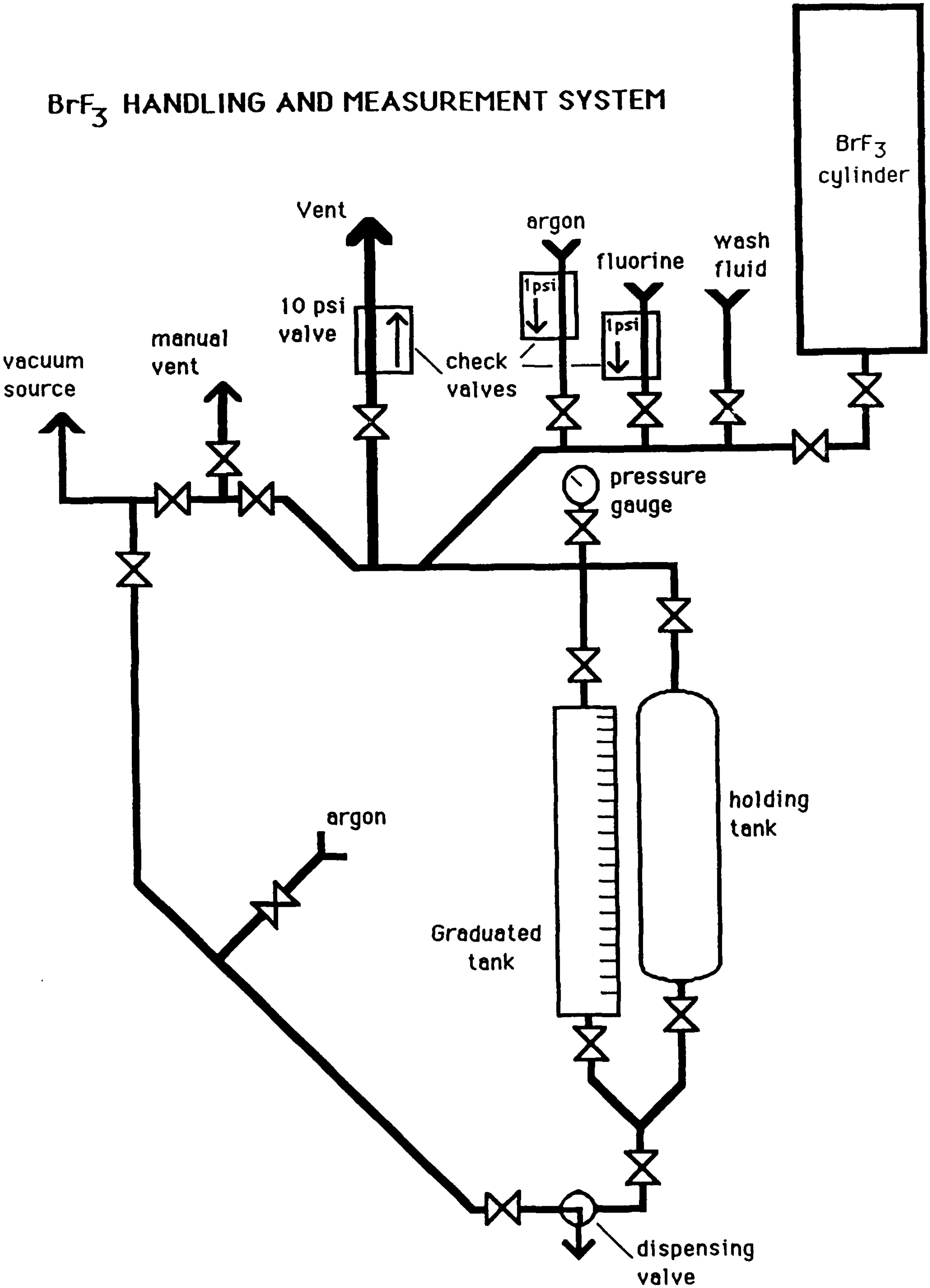

TABLE 1

SAMPLE	PRETEST WT. (g)	POST TEST WT. (g)
MILD STEEL	0.203	0.204
304 L SS	0.039	0.040
316 L SS	0.019	0.020
NICKEL 200	0.293	0.293
SUPERFERRIT	0.087	0.087
SHOMAC	0.045	0.045
ALUMINUM 1145-0	0.031	0.031
HASTELLOY G30	0.507	0.506
29-4-2	0.072	0.072
MONEL 400	0.473	0.473

FIGURE 1: VIRGIN MILD STEEL ~600X

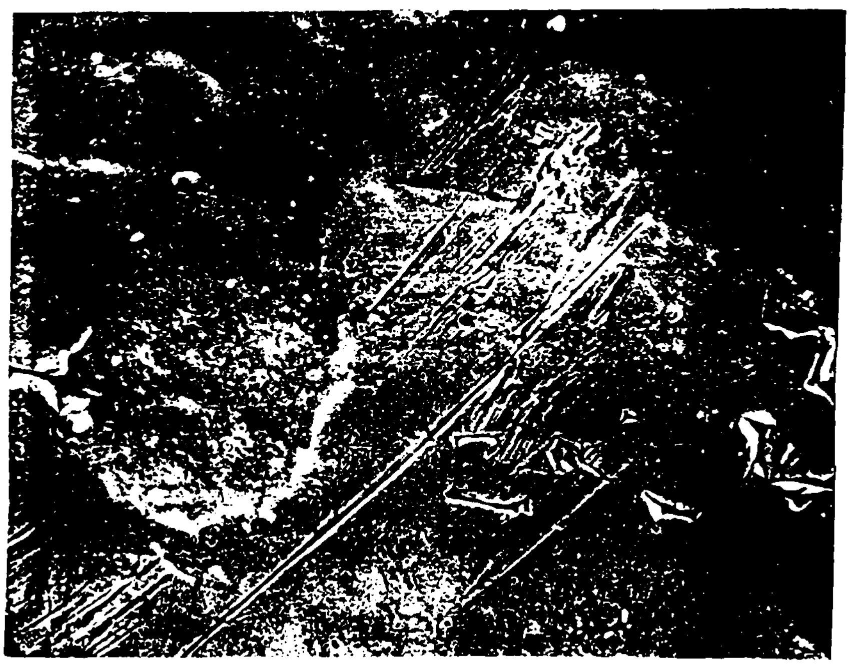

FIGURE 2: MILD STEEL - 2 DAY EXPOSURE TO BrF_3 ~600X

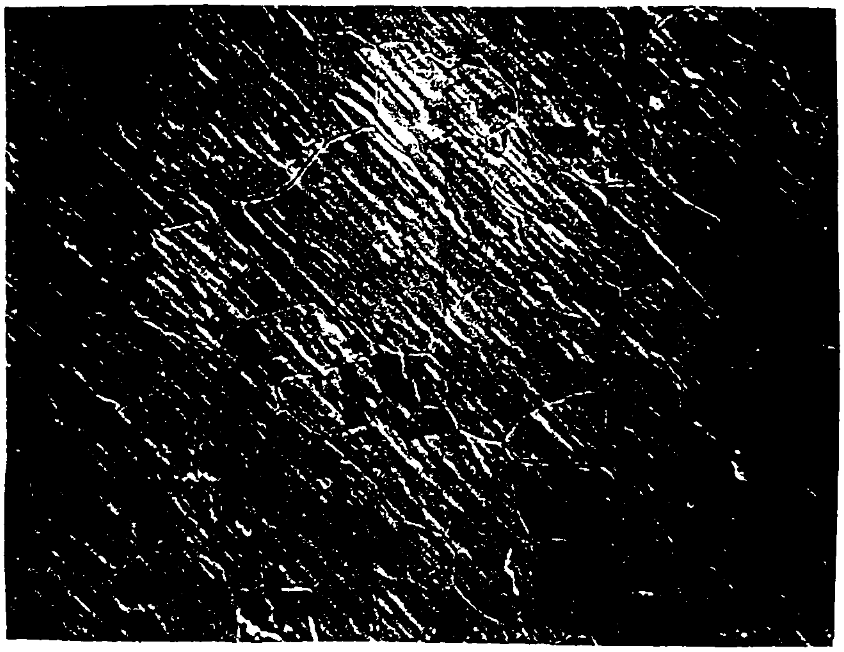

FIGURE 3: VIRGIN 304 L SS ~600X

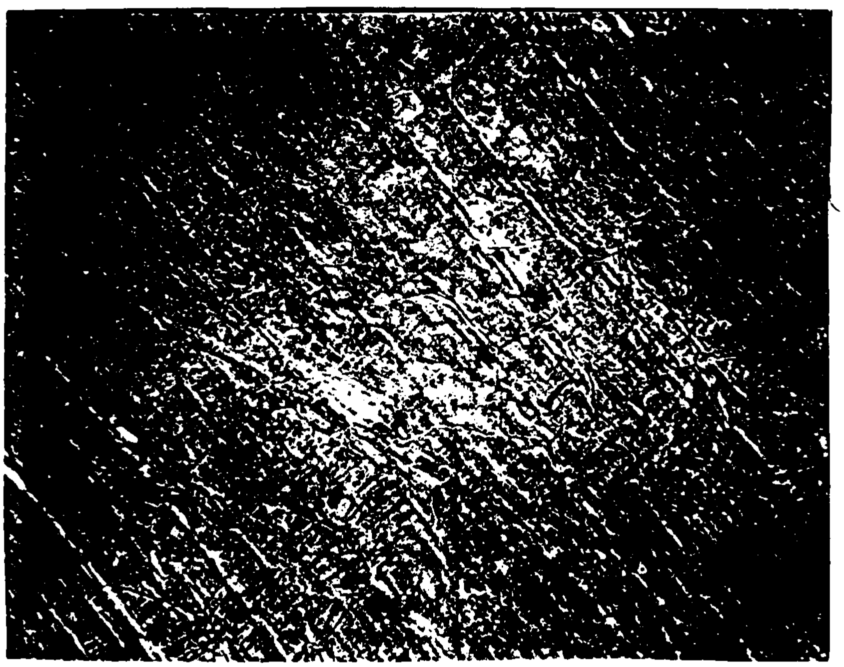

FIGURE 4: 304 L SS - 2 DAY EXPOSURE TO BrF_3 ~600X

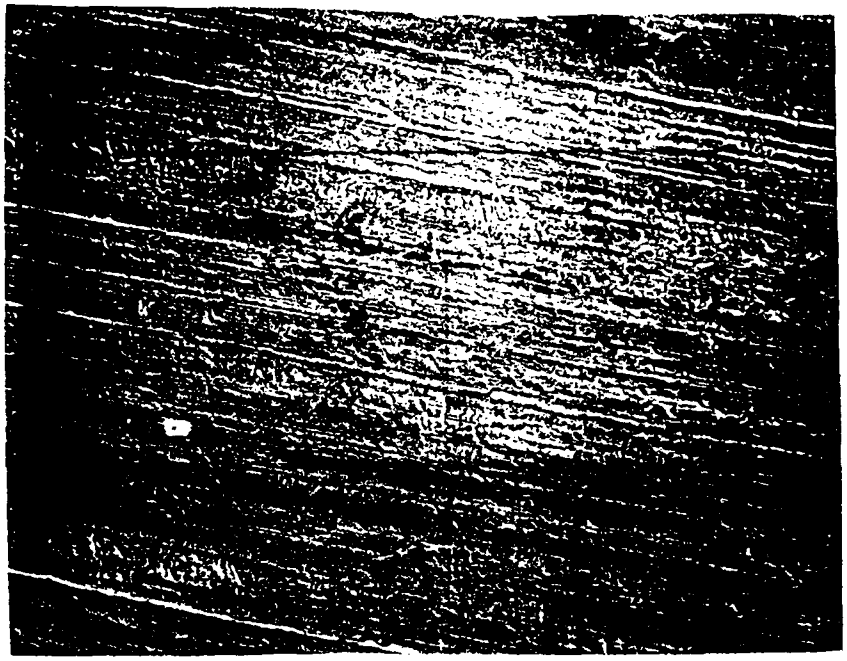

FIGURE 5: VIRGIN 316 L SS ~600X

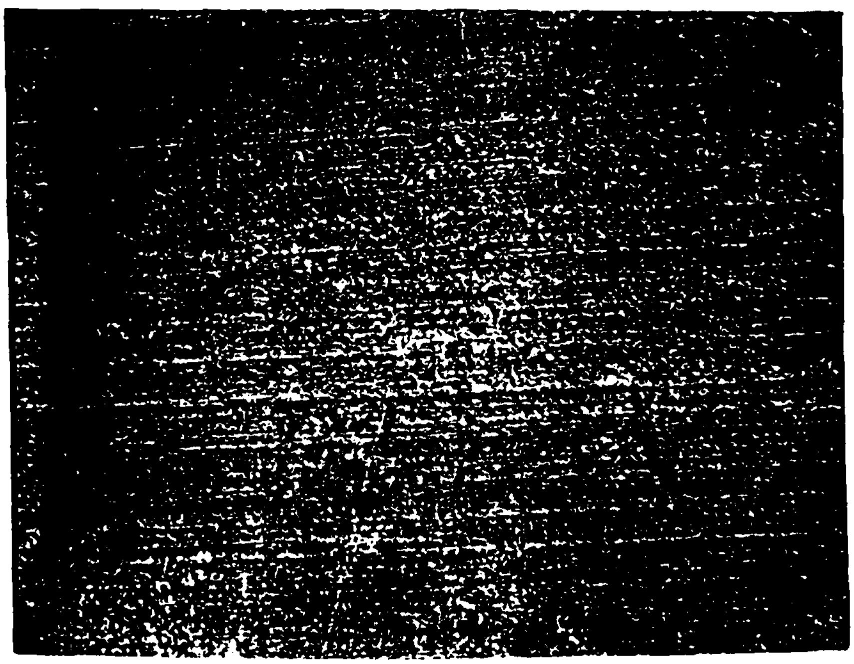

FIGURE 6: 316 L SS - 2 DAY EXPOSURE TO BrF_3 ~600X

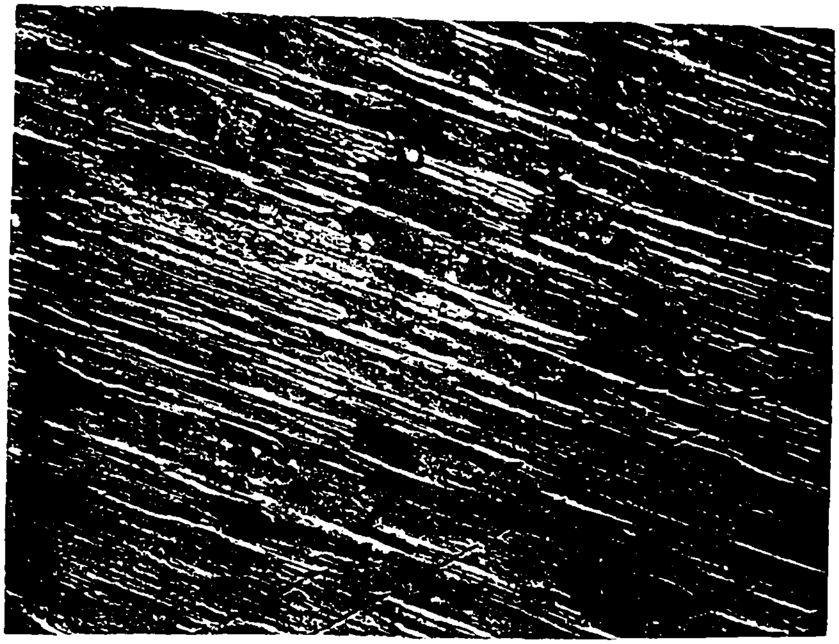

FIGURE 7: VIRGIN NICKEL 200 ~600X

FIGURE 8: NICKEL 200 - 2 DAY EXPOSURE TO BrF_3 ~600X

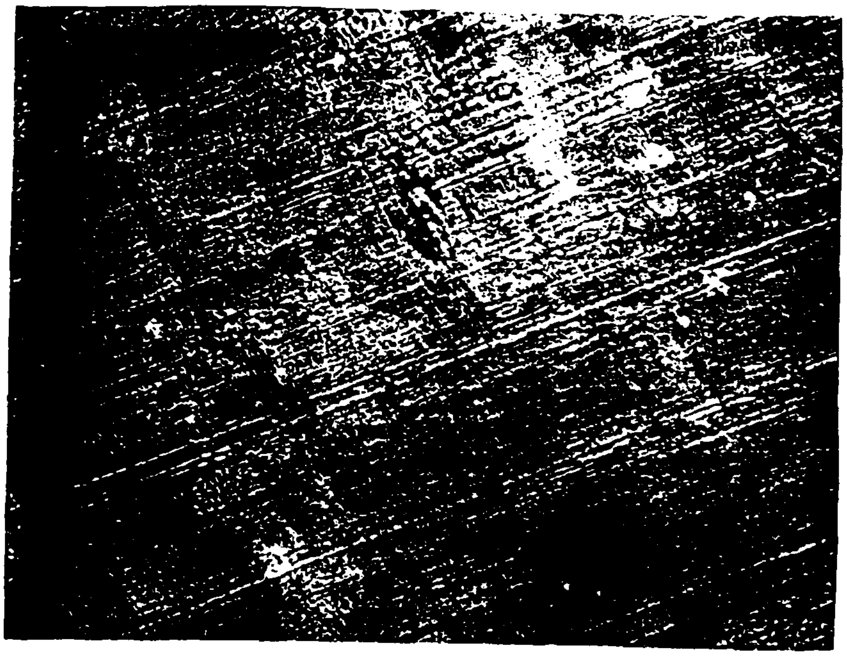

FIGURE 9: VIRGIN SUPERFERRIT ~600X

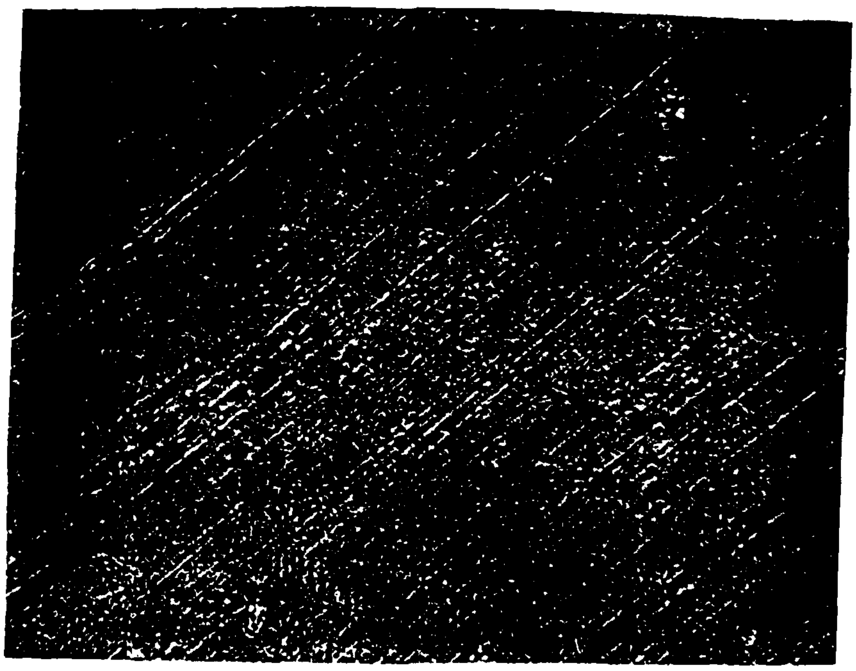

FIGURE 10: SUPERFERRIT - 2 DAY EXPOSURE TO BrF_3 ~600X

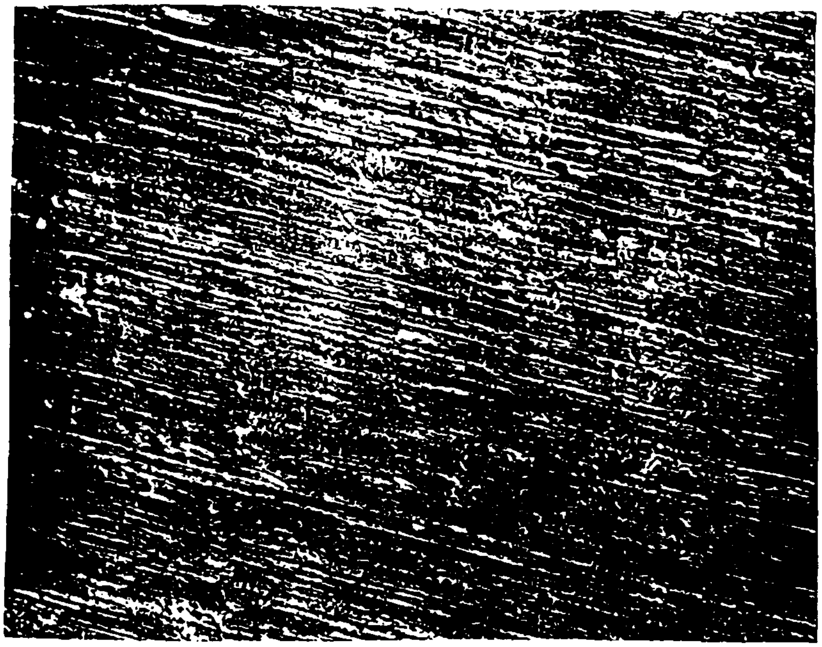

FIGURE 11: VIRGIN SHOMAC ~600X

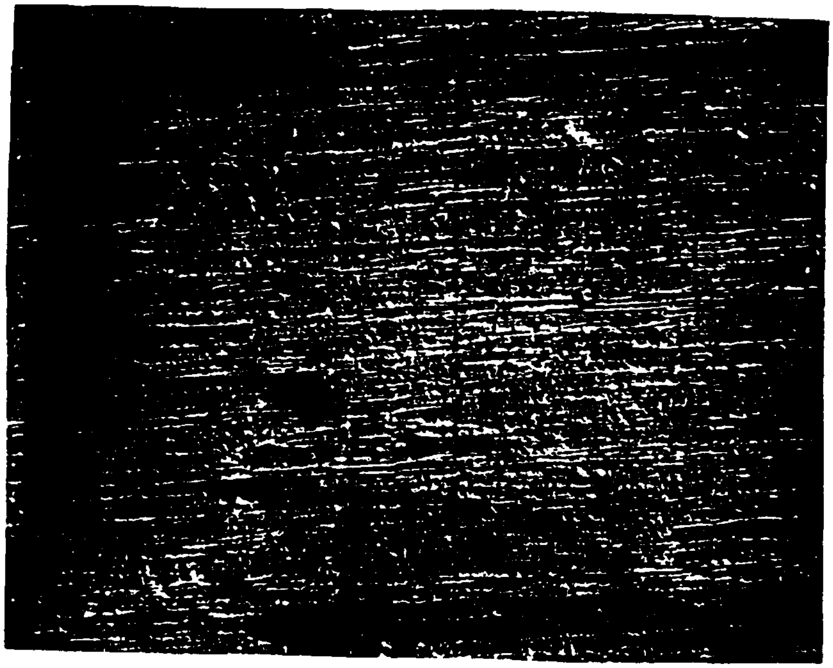

FIGURE 12: SHOMAC - 2 DAY EXPOSURE TO BrF_3 ~600X

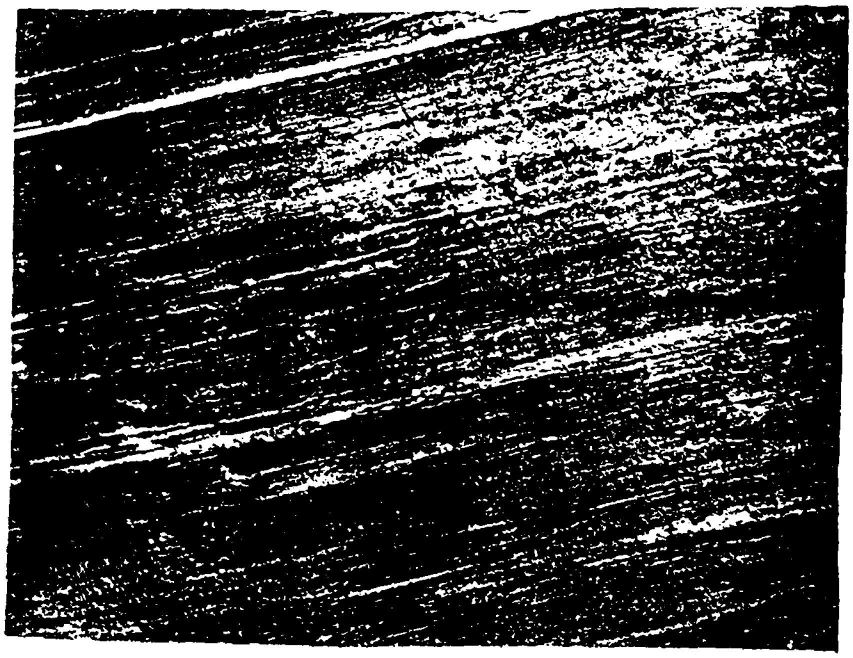

FIGURE 13: VIRGIN ALUMINUM ALLOY 1145-0 ~600X

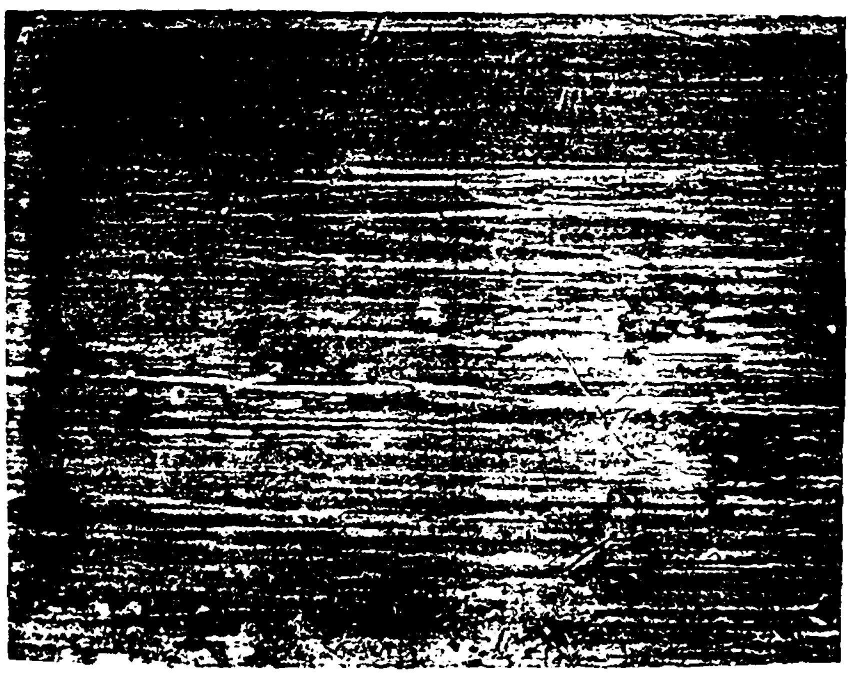

FIGURE 14: ALUMINUM ALLOY 1145-0 - 2 DAY EXPOSURE TO BrF_3 ~600X

FIGURE 15: VIRGIN HASTELLOY G30 ~600X

FIGURE 16: HASTELLOY G30 - 2 DAY EXPOSURE TO BrF_3 ~600X

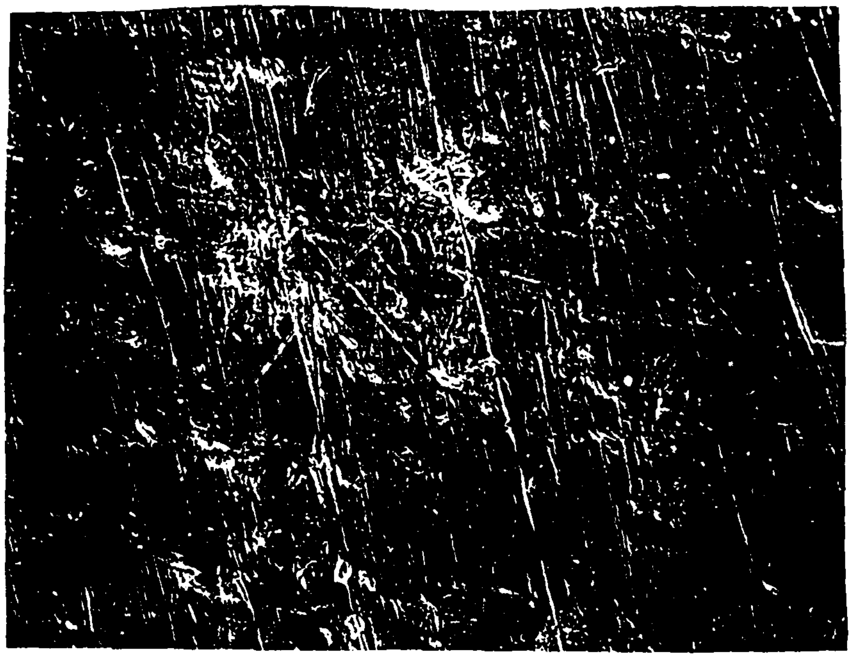

FIGURE 17: VIRGIN 29-4-2 ~600X

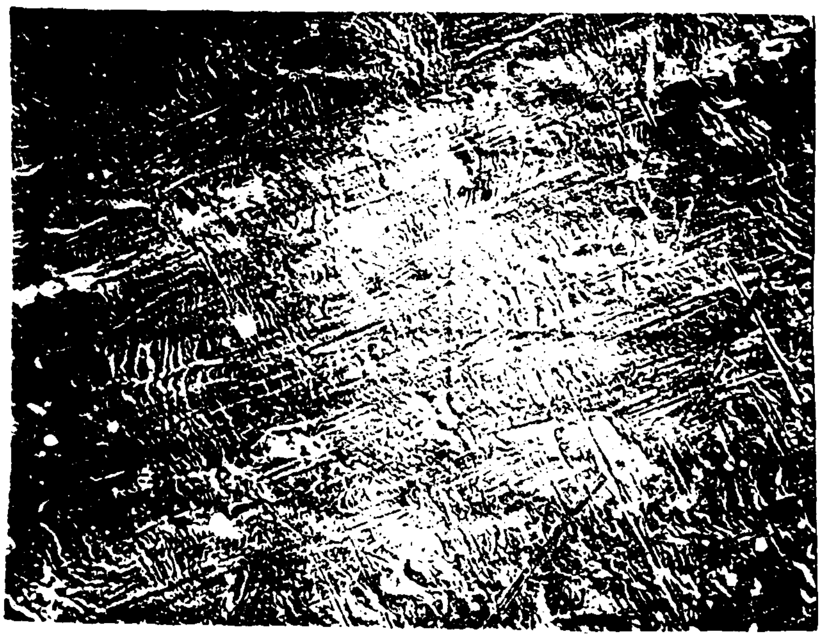

FIGURE 18: 29-4-2 TWO DAY EXPOSURE TO BrF_3 ~600X

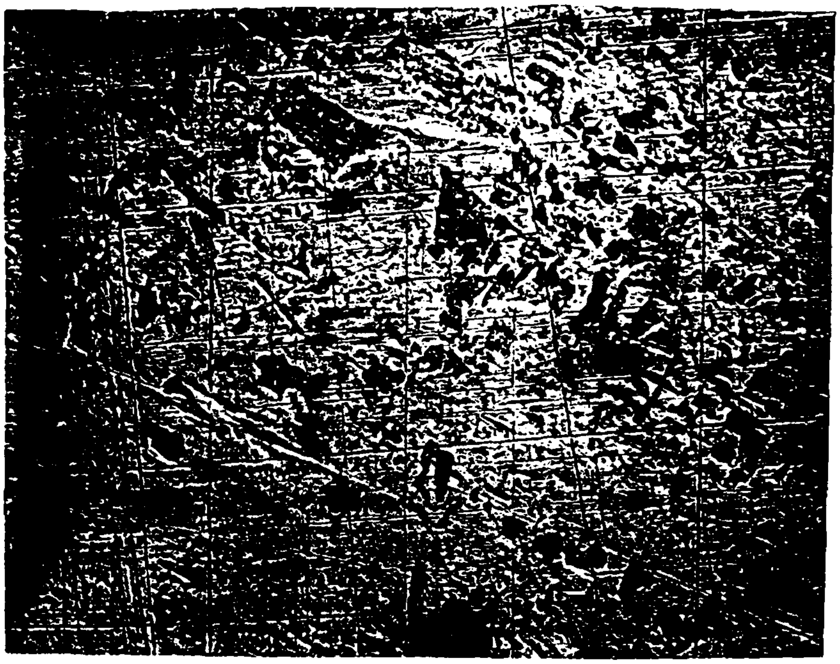

FIGURE 19: VIRGIN MONEL ~600X

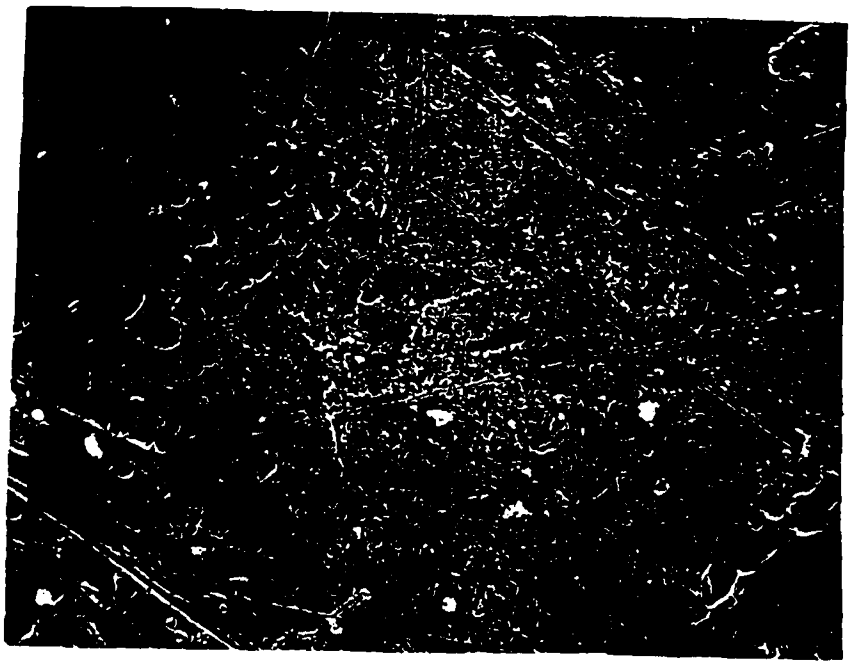

FIGURE 20: MONEL - 2 DAY EXPOSURE TO BrF_3 ~600X