Experimental Evaluation of Russian Anode layer Thrusters

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1 Iall thrusters were successfully developed in the former Soviet Union during the 1960's and 1970's, Performance characteristics of the stationary plasma thruster with extended accelerat ion zone (SPT) have been studied both in the former Soviet Union and at U.S. facilities; in addition, it is reported that more than 50 SPT-70 thrusters have flown in space, starting with the Meteor I in 1969-1970.

SPT thrusters have demonstrated good performance in the range of specific impulses that arc optimal for north-south stationkeeping for communication satellites. Typical mission applications of interest require operating times of several thousand hours. Potent ial usc of the thruster for nor[h-south stat ionkeeping of commercial communication satellites will also require the capability for several thousand on/off cycles. A cyclic endurance test is being performed at JPL, and data from these and other tests indicate that S1"1' thruster operating life may bc limited to approximately 4500 hours.

A t ypc of Russian 1 Iall thruster known as the anode layer thruster purports to solve the insulator erosion problem characteristic of SPT thrusters. This thruster differs with respect to the SPT in that the acceleration zone of the anode layer thruster is much narrower, and the chamber walls arc made from electrically-conducting materials. However, minimal performance and life test data about anode layer thrusters have been reported.

This paper describes the results of a preliminary evaluation of a 1.35-kW anode layer thruster. Data cm performance and plume characteristics will bc presented, Data on thruster characteristics such as thrust, plume current densities, discharge voltage, discharge current, and mass flow rate along with the results of a 500-hr endurance test wear will bc presented. This evaluat ion is being performed with support form the Innovat ive Science and Technolog y (IST) office of the Ballistic Defense M issile Organization (BMDO).

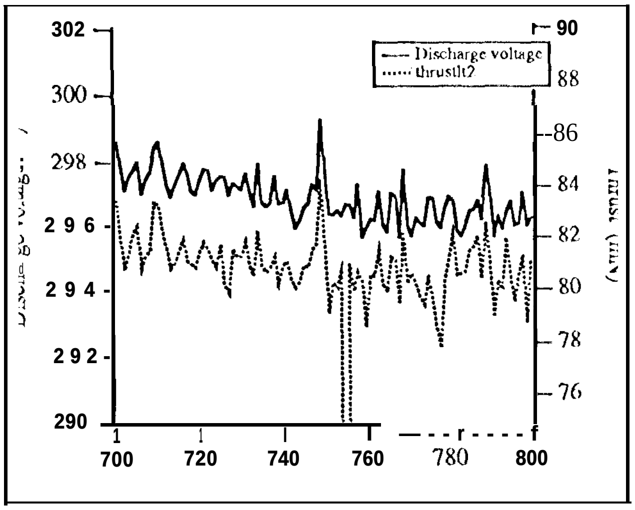

Fig. 5 (g). Discharge voltage and thrust vs cycle number.

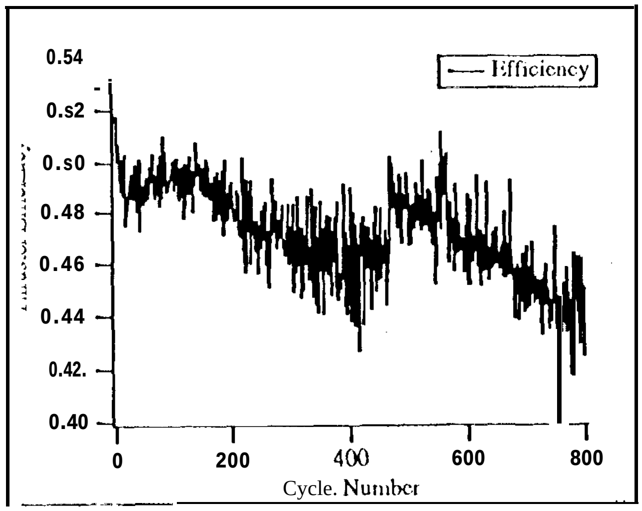

Fig. S (h). Thruster efficiency vs cycle number.

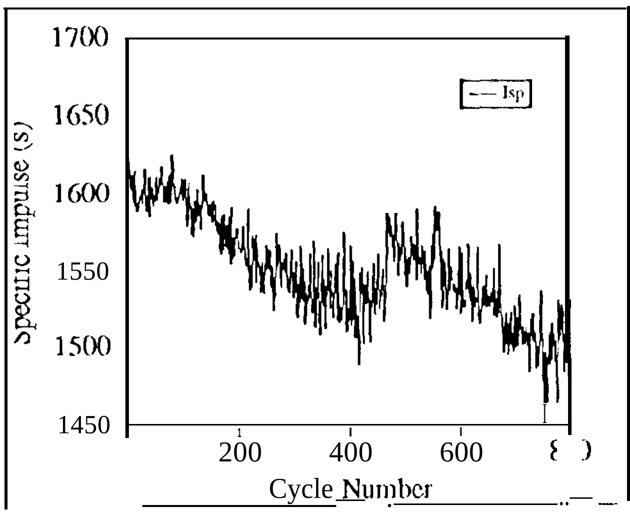

Fig. 5 (i). Specific impulse vs cycle number.

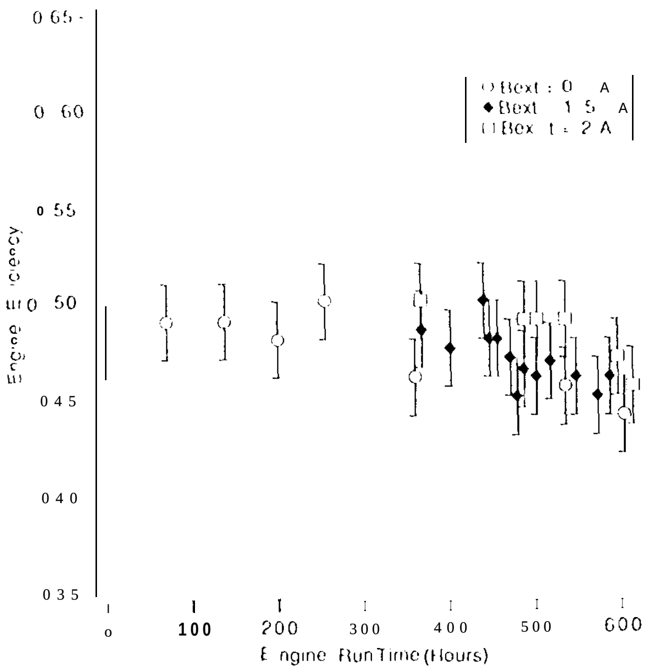

Fig. 5 (j). Selected thruster efficiencies vs cycle number,

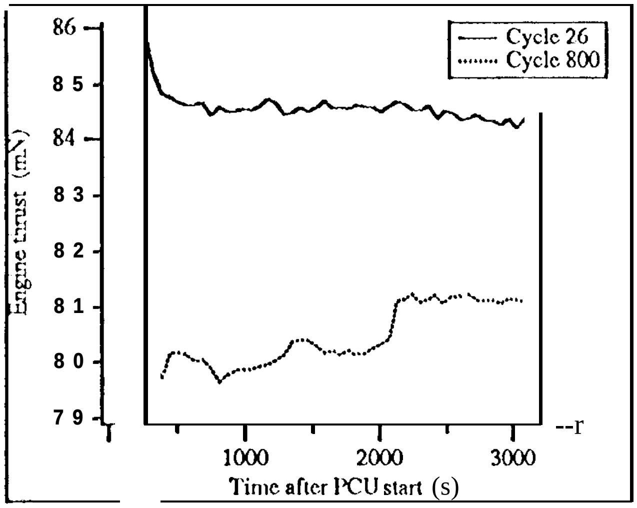

Fig. 7 (a). Engine thrust for cycle 26 and cycle 800.

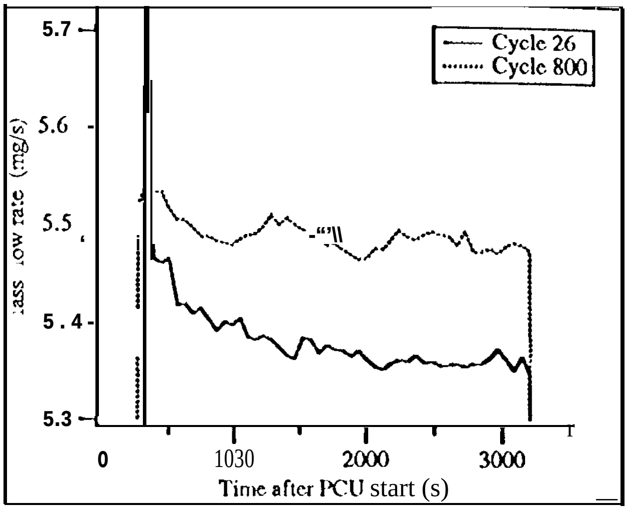

Fig. 7 (b). Mass flow rate for cycle 26 and cycle 800.

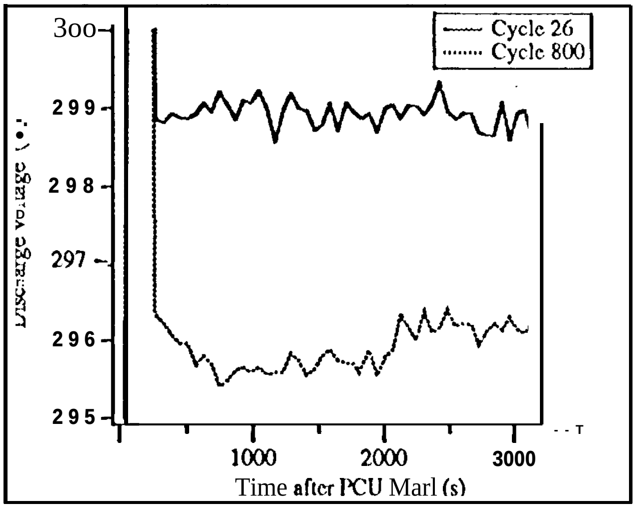

Fig. 7 (c). Discharge voltage for cycle 26 and cycle 800.

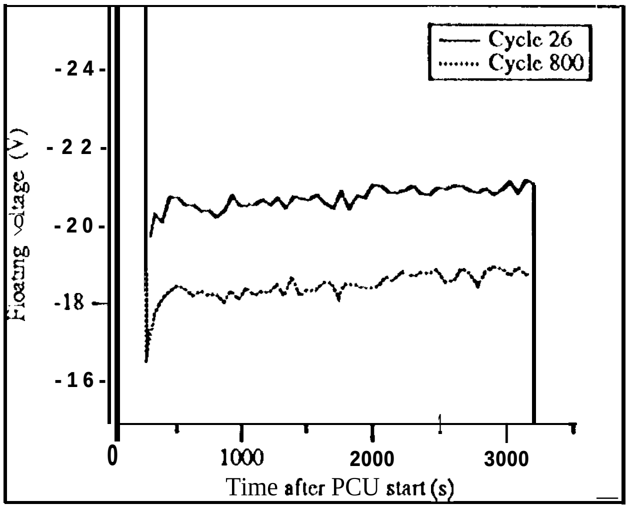

Fig. 7 (d). Floating voltage for cycle 26 and cycle 800

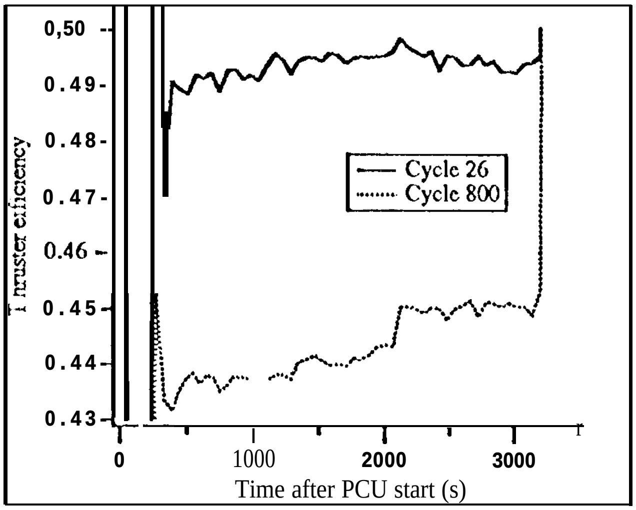

Fig. 7 (c). Thrust efficiency for cycle 26 and cycle 8(K).

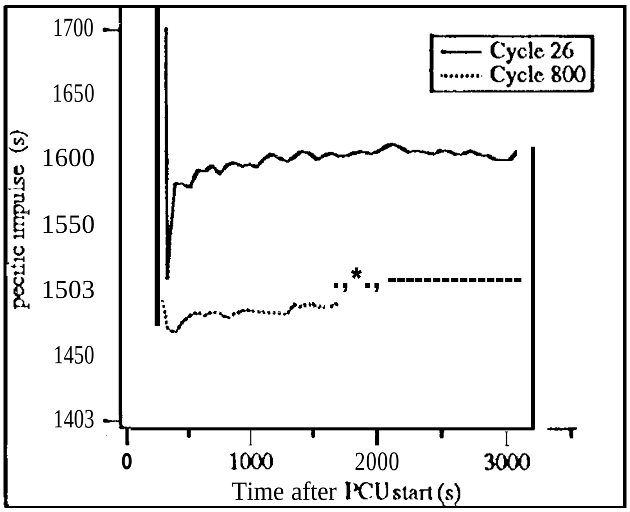

Fig. 7 (f). Specific impulse for cycle 26 and cycle 800.

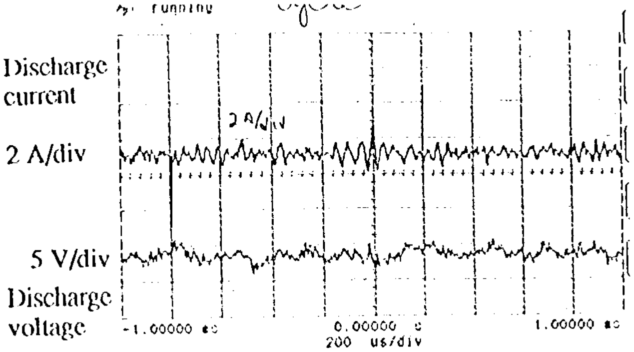

Fig. 6 (a). Cycle 11, engine run time = 5.1 hours.

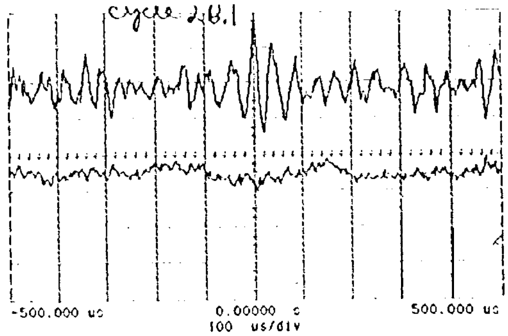

Fig. 6 (b). Cycle 28, engine run time = 9.7 hours.

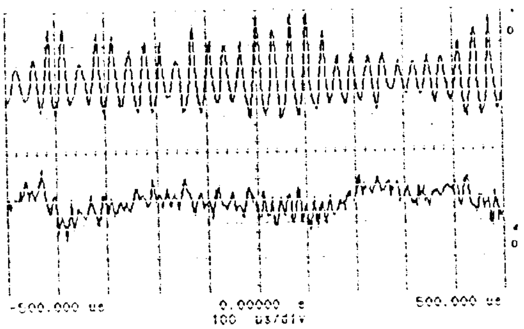

Fig. 6 (c). Cycle 206, engine run time = 154.3 hours.

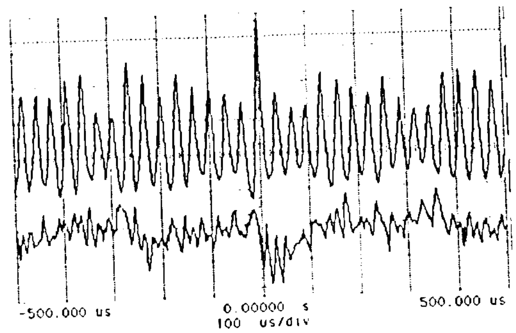

Fig. 6 (d). Cycle 466, engine run lime=: 370.4 hours.

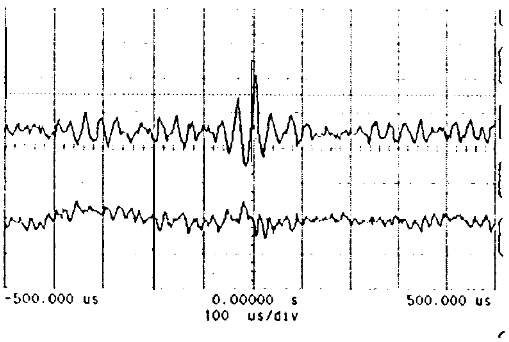

Fig. 6 (c). Cycle 470, engine run lime= 372.5 hours. The SM'-100 used 1.5 A of externally-applied magnetic field current.

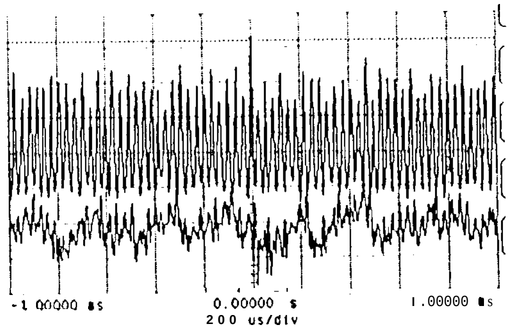

Fig. 6 (f). Cycle 800, engine run time = 647 hours.

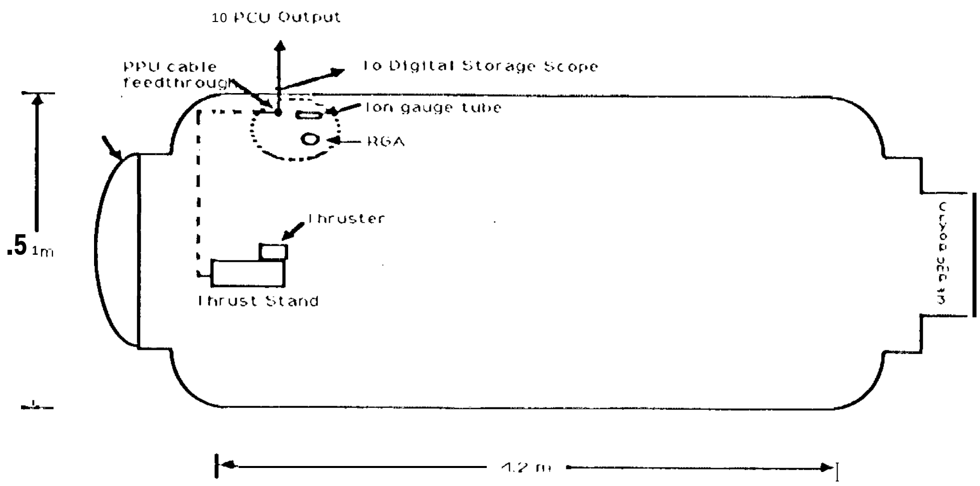

Fig. 6 (g). Location of inductive, and Hall probes for *measuring* discharge current and voltage oscillations.

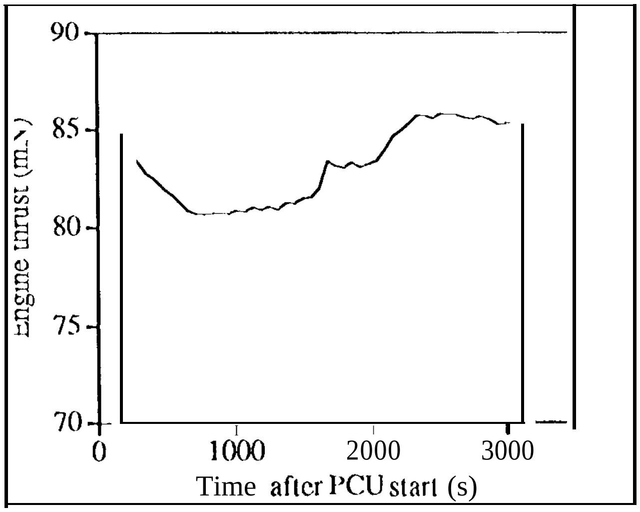

Fig. 7 (a). Engine thrust for cycle 330.

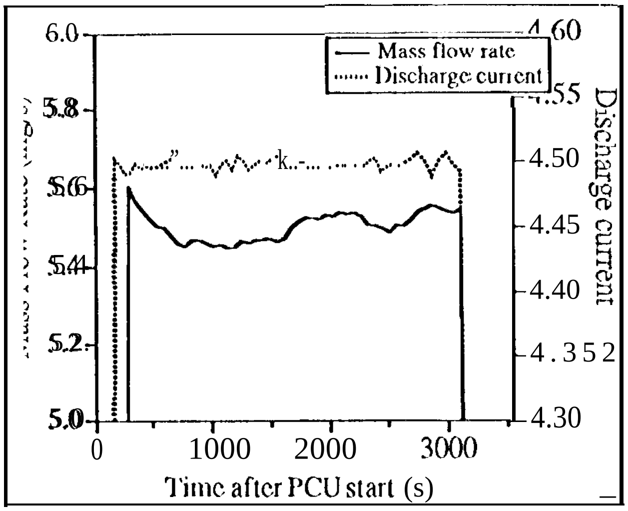

Fig. 7 (b). Mass flow rate for cycle 330.

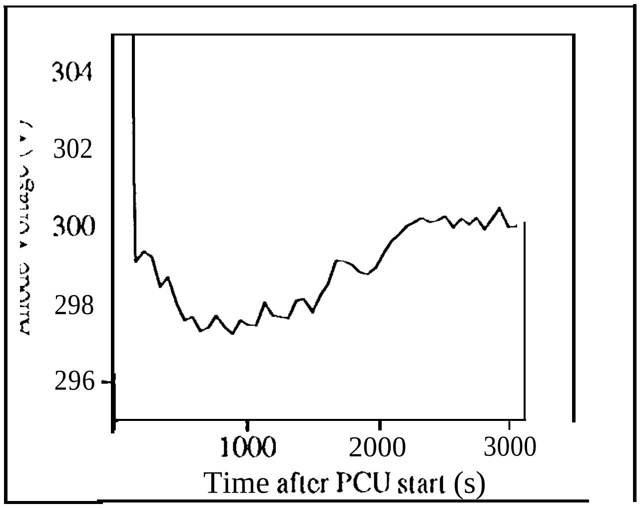

Fig. 7 (c). Discharge voltage for cycle 330.

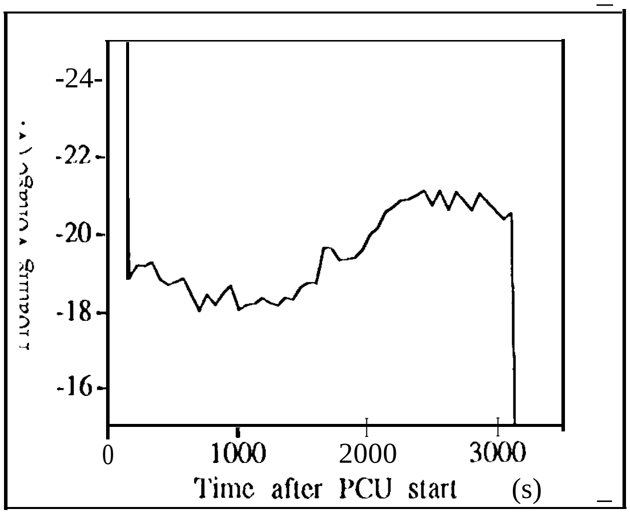

Fig. 7 (d). Floating voltage for cycle 330.

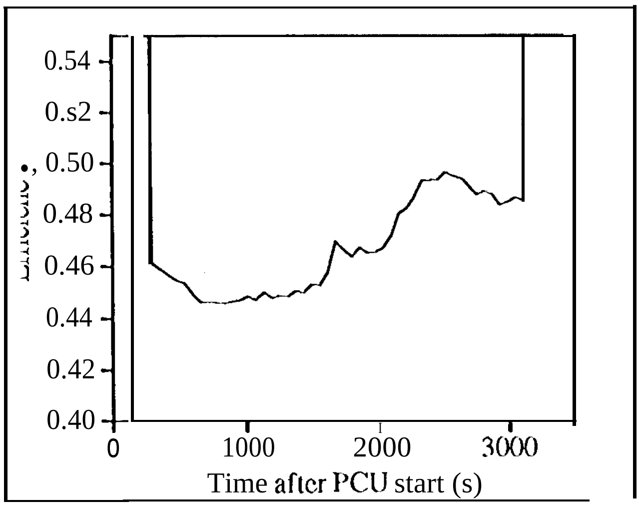

Fig. 7 (e). Thrust efficiency for cycle 330.

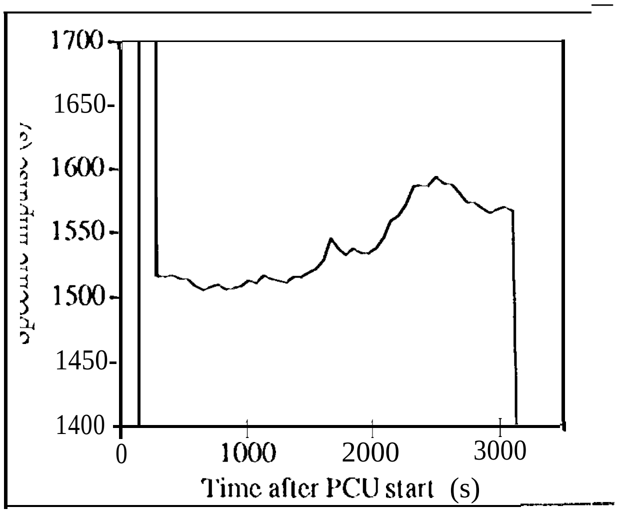

Fig. 7 (f). Specific impulse for cycle 330.

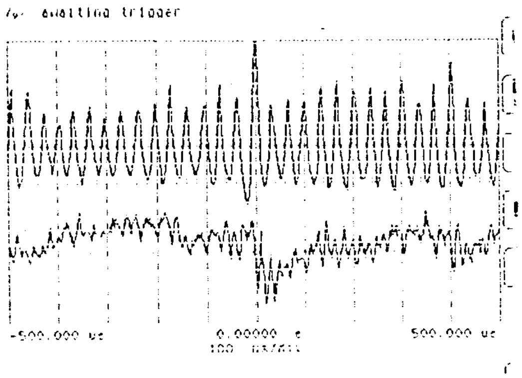

Fig. 8 (g). Oscilloscope trace from cycle 330 taken 24 min after engine start.

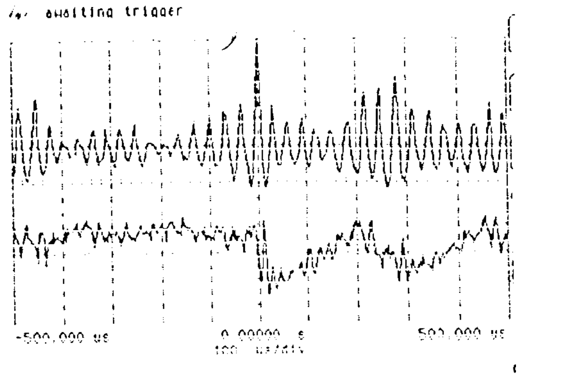

Fig. 8 (h). Oscilloscope trace from cycle 330 taken 30 min after engine start.

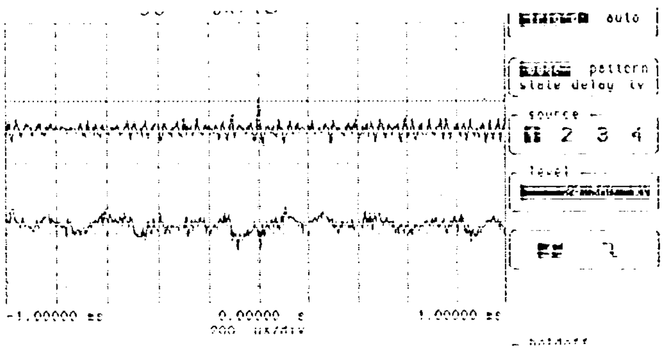

Fig. 8 (i). Oscilloscope trace from cycle 330 taken 40 min after engine start.

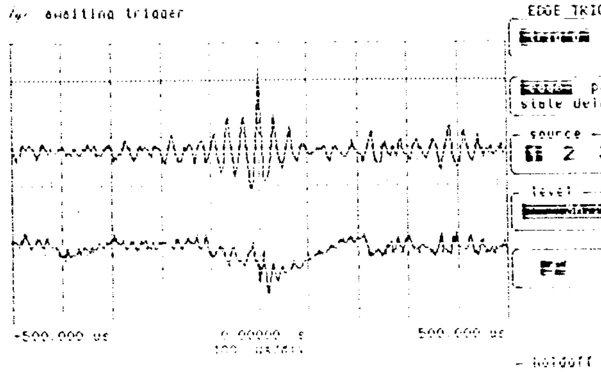

Fig. 8 (j). Oscilloscope trace from cycle 330 taken 3 min before engine shutdown.

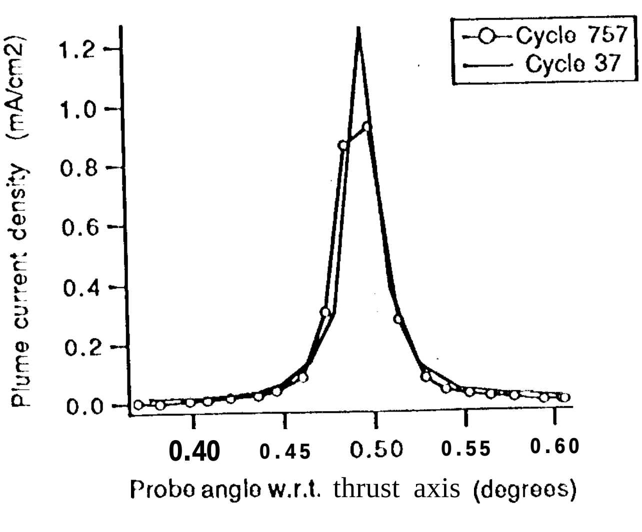

Fig. 9 (a). Plume current densities measured by the center probe (probe 13) for cycle 37 and cycle 757.

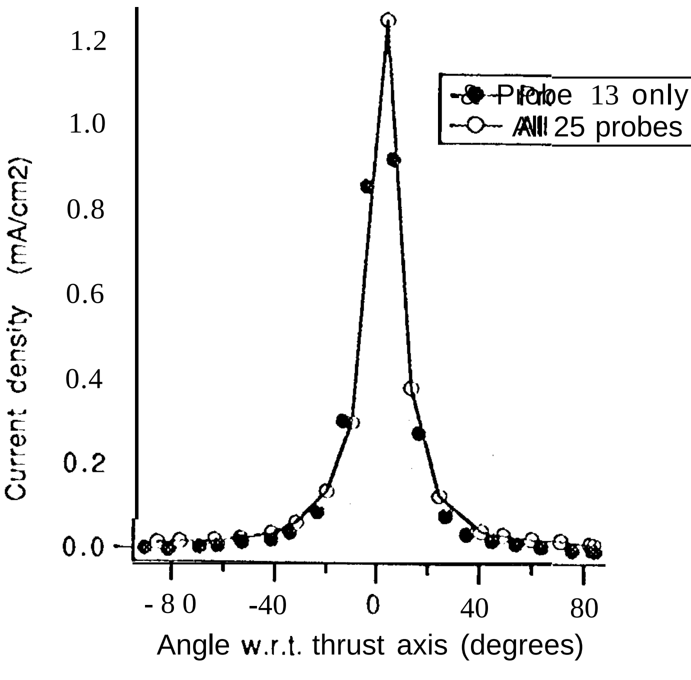

Fig. 9 (b). Horizontal and vertical slice of the SPT-100 exhaust plum.

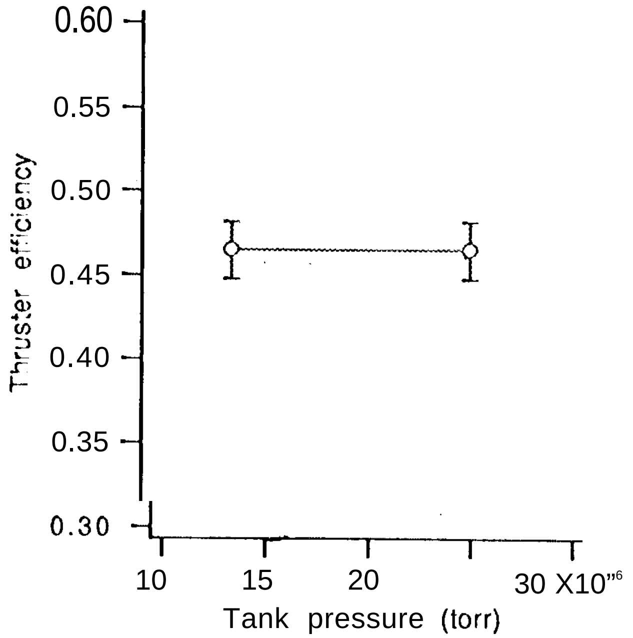

Fig. 10. Thruster performance as a function of tank pressure.

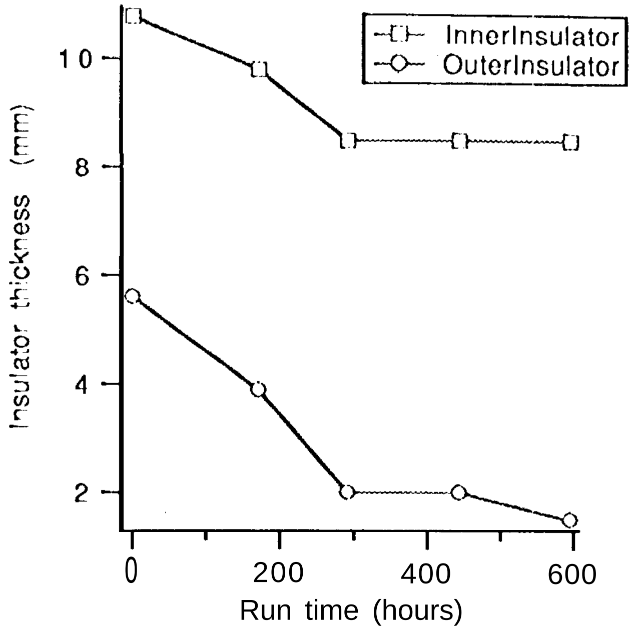

Fig. 11. Insulator thickness as a function of run time hours.

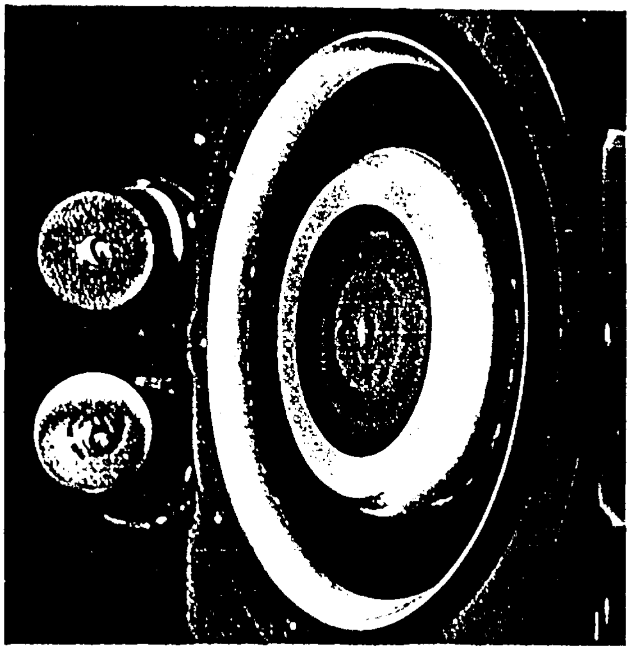

Fig. 12 (a). SIT-100 after approximate.1 y 600 hours of cyclic test ing.

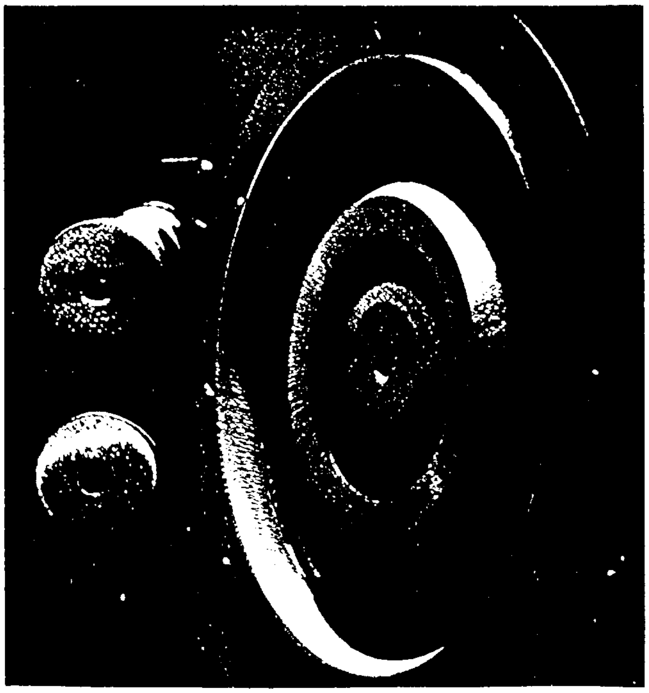

Fig. 12 (b). Grooves eroded into WI'- 100 insulators after 600 hours of cyclic testing.