prototypes free. Hall, still worried about reliability, because the RTGs would be the sole power source, decided to put four RTGs on the spacecraft when the Jupiter mission needed the power of only three.[21]

A letter of agreement signed with the AEC, although difficult to put together, later avoided problems and contributed to good working relationships. TRW continued as the spacecraft contractor. In December 1970 prototype generators were delivered. It soon became apparent that good working relationships were vital. One of the generators, in testing, began to degrade rapidly in power and Hall insisted on a comprehensive assessment of what he feared was an inherent problem. He described the work that followed as a "tremendous engineering job" involving Teledyne personnel, and Bernard Rock and Harold Jaffe of the RTG program. This team identified the problem within a month."[22]

The defective device was examined at Teledyne facilities near Baltimore. A sample of the gas inside, supposed to be a mixture of argon and helium, revealed traces of hydrogen and water vapor. Moreover, the metal of the RTG had been weakened by water which had saturated the device. Hall attributed the flaws to a failure to maintain a low humidity atmosphere in loading; Teledyne attributed the basic problem to outgassing from the heat source.[23]

Several actions were taken to correct the problem. The ratio of gas fill in the generator was altered. A redesign eliminated the many seals in the Nimbus SNAP-19 to the point that the device carried on Pioneer had only one seal. The assembly procedure changed to a glove box process whereby all the assembly steps, including welding, were carried out in a sealed box into which the worker inserts his hands by means of gloves mounted on the side of the chamber. The assembly was conducted in a submarine-like, controlled atmosphere chamber. A new and more efficient thermoelectric material called "TAGS"* was introduced. These actions persuaded NASA and Hall to proceed with RTGs.[25]

The launches of Pioneer 10 on 2 March1972, and of Pioneer 11 on 5 April 1973, received less publicity than the manned missions to the Moon. The purpose of the two spacecraft was to "extend the studies of interplanetary phenomena beyond the asteroid belt, fly-by Jupiter...and transmit data several years after [a] Jupiter encounter before...departure from the solar system."

*The term TAGS is derived from the names of the major constituents: tellurium, antimony, germanium and silver. TAGS is a solid solution of silver antimony teluride in germanium telluride.[24]