Final Report

DEVELOPMENT OF AN ELECTROLYTIC SILVER-ION GENERATOR FOR WATER STERILIZATION IN APOLLO SPACECRAFT WATER SYSTEMS

Apollo Applications Program

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SUMMARY

An electrolytic water sterilizer has been developed for control of microbial contamination in the Apollo spacecraft. Individual units are self-contained and require no external power or control. The small size (2.5-in. diameter by 4 in. long), light weight (0.6 lb), and absence of interface requirements make it possible to incorporate such sterilizers at various desirable locations in the potable water system or the waste water system.

The sterilizer produces silver ions in concentration of 50 ppb to more than 200 ppb in the water flow system, the desired concentration being adjusted to the average water flow rate. After installation, no maintenance is required. The unit can be neglected with no damage to the cell or the system, since it becomes self-limiting if water flow is shut down. An external shunt is provided for on-off functions and monitoring of current flow. Probable life expectancy is 9000 hr without a change of batteries.

Laboratory tests under simulated conditions have demonstrated essentially complete kill of Staphylococcus aureus and Escherichia coli within 8 hr, using initial bacterial concentrations greater than 5×10^5 organisms per ml.

Methods for passivation of aluminum piping systems to minimize losses of silver ions by reduction have been developed. Elimination of system losses enhances bactericidal effectiveness, decreases the required current, and permits closer control over silver-ion concentrations in the water systems.

CONCLUSIONS

Adequate bacteriological control can be obtained within the water systems of the Apollo spacecraft by electrolytic generation of silver ions at concentrations of 50 to 100 ppb.


Spinoff
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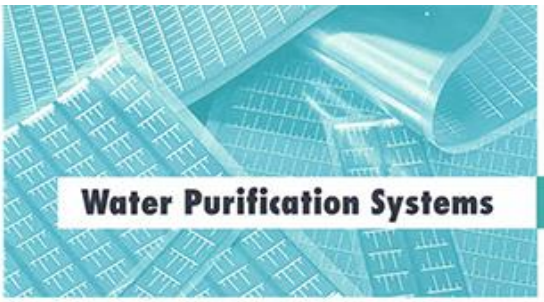
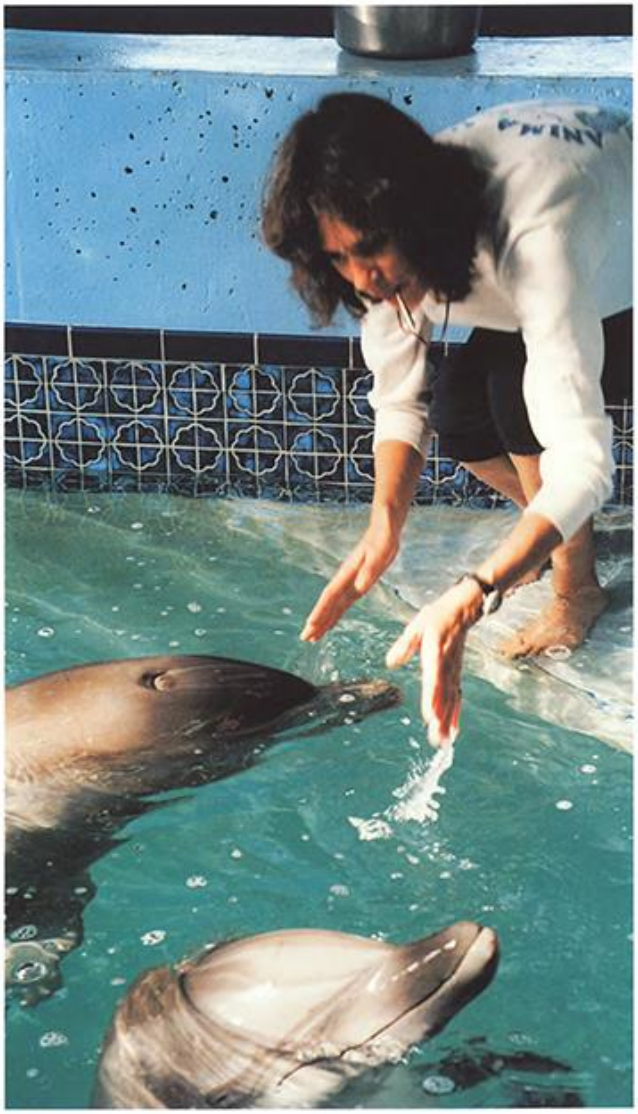


Water Purification Systems

Consumer/Home/Recreation



At left is a view of the dolphin pool at the Clearwater Marine Science Center, Clearwater Beach, Florida; **below** is the center's sea turtle tank. Because high levels of chlorine cause damage to the skins of dolphins and turtles, the Marine Science Center employs a chlorine-free system of water purification. The system, manufactured by Clearwater Pool Technologies, Inc., Largo, Florida, is based on technology developed by NASA during the Apollo Lunar Landing Program.

In the 1960s, Johnson Space Center conducted a research program aimed at development of a small, lightweight water purifier that would require minimal power and no astronaut monitoring; it was intended to supply pure drinking water for three-man Apollo crews on missions up to two weeks. From that research emerged an electrolytic silver ion generator only slightly larger than a cigarette pack and weighing only nine ounces. One or more units, mounted at various locations in the potable water supply on Apollo or later spacecraft, would disperse silver ion concentrations of 100 to 300 parts in a billion, sufficient to eliminate the bacteria in the water within hours.

This technology has found broad application because it offers an alternative to use of chemical disinfectants, long the standard method of controlling such water pollutants as bacteria, algae and viruses. In recent years, stricter government rules regarding discharge of chemicals into public water supplies, along with increasing costs of complying with environmental regulations, have expanded interest in non-chemical or minimally-chemical water treatment systems.

A number of companies have acquired NASA licenses to commercialize the NASA technology in water management systems. In many instances, they have used the NASA technology as the core of a system and incorporated advancements or refinements developed through their own research efforts.

Clearwater Pool Technologies employs silver/copper ionization to purify water bodies like the Marine Science Center dolphin/turtle pools. The ClearWater Pool Purifier **(above)** consists of a microcomputer that monitors water conditions; a pair of metallic electrodes; and a rheostat controller. Ions are generated by passing a low voltage current through the electrodes. Distributed throughout the pool, the silver ions kill the bacteria and the copper ions kill algae. The controller automatically introduces the correct amount of ions to the water.

Clearwater Pool Technologies employs variations of the basic technology in a number of other applications. For cooling towers, the ClearWater Purifier cleans tanks of bacteria and algae, while a ClearWater Magnetizer attacks the "scale" and corrosion that commonly build up in such towers. The company produces systems for cleansing spas, hot tubs, water recycling systems, systems for bacteria/algae control in ponds and marine saltwater habitats, systems for hospital water purification, and systems for purifying drinking water in Latin America and the Caribbean.

(Continued)

Foreword

In today's global economic environment, technology is one of the strongest currencies. Over the past three decades, more of the world's nations have recognized the link between technological prowess and economic advancement. They have invested large-scale resources in upgrading their technical capabilities, and in many cases, their efforts have been very fruitful. So today, international economic competition is intense; it is a global engagement whose rewards are greater market shares and improved economic status for the successful contestants.

The United States, long the world's leader in science and technology, must meet the challenges of increasingly competent competitors. The route is clear: We must advance our own capabilities to produce superior products for the global marketplace. It is vital to the nation's economic health and wealth that we do so.

The Clinton Administration is investing heavily in science and technology development, coupled with an effort to stimulate partnerships with industry that promote private sector investment in technological innovation. And NASA, as always, is leading the way.

Since its inception in 1958, NASA has been a prime source of much of the nation's new technology. The agency's accomplishments in technology development have been buttressed by an effective effort to promote re-use, or secondary application, of NASA-developed technologies by the private sector.

The results are impressive. Literally thousands of "spinoff" products and processes have emerged as secondary applications of the technological treasure chest NASA has built in meeting its challenging missions. Collectively, these technology transfers constitute an immense contribution to the U.S. economy.

It is a proud record, but we must do better. We have to stress revolution, not evolution, in creating new NASA technology. More and more, we are going to put out ambitious guidelines for our missions and let industry tell us what cutting-edge technology is needed to accomplish them. We will give our field centers and project managers greater flexibility in funding technology transfer opportunities, and will work to make sure promising technologies translate more quickly and effectively into marketable products and processes.

These new approaches forecast a new, broader role for NASA, a new technological direction and a new way of doing business. We will emphasize research and development partnerships with the private sector. We will consider the economic potential of each technology and aim for its commercialization from the time an R&D project is initiated.

We have already made a start toward that goal. We have developed and are implementing an agenda for change that embraces many new mechanisms to foster commercialization of NASA technology.

As a consequence of these changing times, NASA is committed to expanding its technology transfer efforts in addition to its traditional aeronautics and space missions. The remarkable successes NASA has achieved in those areas lend confidence that the new emphasis on technology commercialization will succeed as well, to the enormous benefit of the nation's economy.

Daniel S. Goldin
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