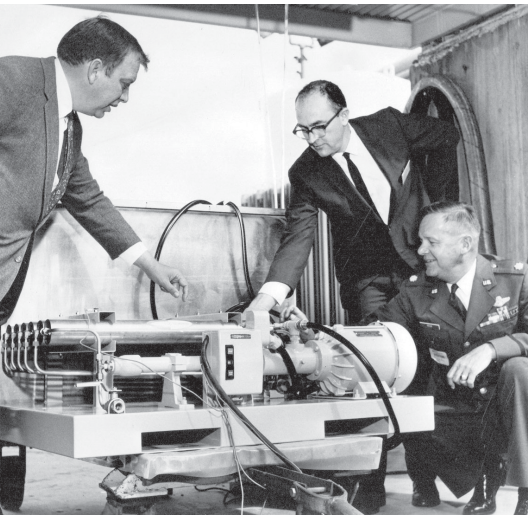
Living in Interesting Times:

Donald T. Bray



Donald Bray (center) and US Airforce Colonel Peck review prototype RO system in the late 1960s

Julianne Bray in a Nimbus ad

The Nimbus van at a trade show in Escondido, California, 1970

Donald T. Bray and Julianne Bray, 1996

By Patricia Capone

Donald T. Bray's contributions to the water treatment business are legendary. One of the pioneers in the field, he patented the first commercial spiral wound configuration. But his accomplishments extend far beyond that ingenious bit of engineering. He and his partners and colleagues are responsible for a long list of patents and innovations, including the first commercial residential RO system, the first multi-layer RO membrane, the air/water storage tank, the faucet air-gap, the first faucet-mounted RO system, new membrane casting techniques and multi-cartridge rolling systems and machinery. Amazingly, this modest man is also responsible for several successful companies and has employed hundreds of people over the years.

"Well, I didn't set out to do those things at all," Bray recalls. "After the war, I was going to be a nuclear engineer…but I was fortunate enough to be sidetracked by so very many interesting problems."

The early years

Bray's grandfather and family had come to Idaho in a covered wagon in the late 1870s. The family went through some tough years, typical of those hardy pioneers. At one point they over-wintered in a cave dug out of the side of the Malad River; Bray's father was born in that dugout. In 1881, the family moved to the Clover Creek area and homesteaded 640 acres in a valley between volcanic rock-rimmed canyons. After roughing it in another dugout on the property, they built a log cabin, still standing as part of the current 'Old Home'. In those days, there were Indians living in teepees camped near the property's natural hot springs. Located on the original route between the Camus prairie and the town of Hagerman, this family home served as the US Post Office for Blanche, Idaho for about 30 years.

Bray's father left the ranch in the 20s to try to earn a living in Oregon and Donald T. Bray was born March 9, 1922 near Oregon City. When he was 10, his family moved back to the dry sagebrush country of south central Idaho, about two hours east of Boise.

It is a wide-open land with grand views of canyons, cliffs, volcanic outcroppings and a meandering creek. It's also harsh, dry, alkaline and difficult to work. Bray feels his lifelong awareness of water issues stems from his youth there.

Over the years, the original homestead was broken up and sold until just a portion remained in the family. The loss of this land and his family's legacy always bothered Bray. One of the first things he did after his companies started to make a little money in the 1980s was to buy back all of the original homestead.

College and beyond

Bray attended the University of Idaho until he joined the ROTC in 1942. He married Fran Widener in 1943 and was sent to Fort Benning, Georgia for Officers Training. He was among a group of 20 young men from Idaho being trained as second lieutenants to help augment the US forces in Europe. During the last week of training, Bray broke his arm trying to set another record on the obstacle course; this delayed his training by several weeks. The Idaho contingent set off for the D-Day invasion without him and many of his friends were killed. A deeply patriotic man, Bray has always regretted that he was not with his friends during the invasion of Europe. When peace finally came, he ended up in Berlin as part of the occupation army.

With the war over, Bray resumed his studies at the University of Idaho, graduating with a Masters in Chemical Engineering in 1950. He was selected from a pool of about 500 applicants to attend the prestigious Oak Ridge School of Reactor Technology, where he received the equivalent of a doctorate in nuclear technology. Oak Ridge was an integral part of the Manhattan Project and was the source for much of the technology and nuclear material used in the nuclear bombs dropped on Japan. After the war,

Oak Ridge researched peaceful uses for nuclear power.

In 1954, Bray and 10 other graduates from Oak Ridge started a consulting company called Internuclear and won a contract from the Italian government to design the first civilian nuclear power plant in Italy. Bray, his wife and three children moved to Italy for several years. After the tragic death of his oldest daughter, Bray began to look for a job back in the US. He met with Fred de Hoffman, President of the newly formed General Atomics Company (GA) and moved to La Jolla, California to begin work in 1958 as a Senior Staff Engineer.[1]

From nuclear engineer to RO engineer

Many of the early nuclear scientists who had been involved with the development of nuclear weapons were determined to find civilian uses for their life's work. Some were convinced that nuclear power plants would provide cheap energy for all kinds of energy-intensive projects including seawater desalination plants to make the deserts bloom. One idea combined a sea-based, nuclear power plant to produce cheap electricity and fresh water.[2] The Office of Saline Water was established in 1955[3] by the federal government in order to study seawater desalination, but funding and interest was low.

By the early 60s, as part of the overhaul of the National Laboratory program, Congress began to push for a more balanced funding of basic scientific research (less focused on nuclear technology). One beneficiary of this change in policy was the Office of Saline Water. The Kennedy and Johnson administrations (respectively) continued to fund seawater desalination research through universities and defense contractors (including companies who were closely linked with nuclear technology). A minor race ensued to see which company and what scientist would come up with the best RO apparatus using the newly developed cellulose acetate (CA) membrane. One of these contracts came to General Atomics. Although Bray had joined the company to work on small nuclear reactors for military use, he was also somewhat familiar with RO theory and thought it had real potential.

Bray was interested in the idea of purifying brackish water and desalting seawater for several reasons. First, his childhood years on a drought-prone ranch had made him keenly aware of the importance of good water for stock and crops. Water on the ranch was not only scarce; it was often brackish. Second, since settling in California, he had been spending a lot of time camping in the arid Baja peninsula and felt the area would greatly benefit from a cheap, reliable source of fresh drinking or irrigation water. Third, he was beginning to get bored with his job at GA. Designing nuclear reactors for commercial use was slow and tedious.[4] A design would be worked on and then frozen for the construction and testing phase. This could take four to five years. Bray wanted to tinker with new designs and this new contract was just the thing he had been looking for.

One of the first spiral wound RO membrane prototypes created at General Atomics in 1965

Membrane innovations

While the bulk of GA's resources were devoted to the various nuclear projects, a small development group was formed to work on the desalination project. They used the cellulose acetate membrane pioneered by Loeb and Sourirajan in 1962[5] and tried to come up with an efficient configuration that would maximize membrane surface area. Like most at the time, Bray and his colleagues were convinced that some type of spiral wound configuration would provide the basic template, but the actual design proved elusive. There were so many variables. What type of pressure container should be used? What materials should be used to support the membrane? How would the product water be removed from the apparatus after it had passed through the membrane? What about leaks? Boundary layers? Pressure drop? It was an engineering conundrum more than anything else. Bray and his colleagues were watching everyone else, brainstorming together and constructing scale models. Like many scientific achievements made under competitive pressure, the exact details of the breakthroughs are indelibly marked on the memories of the participants.

"Some of us remember him rolling the first single leafer, unrolling it the next day and observing that the resultant fold could be made in *advance* of rolling. This technique became the principle of the multi-leaf element,"[6] noted Ron Fox, a former colleague at GA and later VP of Research and Development at DSI.

Amicon and Alan Michaels had filed a patent in 1962[7] that used a true spiral wound configuration with a single leaf, but the design was flawed. Julius Westmoreland, a GA colleague, filed for a patent in December 1964[8] with another single-leaf version of a spirally wound RO cartridge but it also suffered from several design limitations. Bray's patent for a multi-leaf spiral wound element was filed in March 1965.[9] He says the design came to him while on a camping trip in Baja. The new design truly worked and it was repeatable and commercially viable. This patent for a multi-leaf spiral wound RO element was improved over the years, sometimes with additional patents filed by Bray, but the basic design remains the same and is the pattern for the membrane separation industry today.[10]

After almost eight years with GA (and three years after his patent for a spiral wound RO element had been tested and proven), the Office of Saline Water offered Bray a job as director. He accepted and quit his job at GA. But the job offer from the Office of Saline Water was withdrawn. Bray attributed this to objections from other contractors especially, Aerojet General, who believed Bray would unduly favor GA in future contract awards.[11] While the Office of Saline Water would go on to find another director, Bray was without a job.

From engineer to entrepreneur

It was not easy being 45, broke, divorced and unemployed but Bray is nothing if not tenacious. He spent the next two years living on his dwindling savings trying to figure out how to manufacture a commercially viable spiral wound RO cartridge. There were two obvious paths: use the technology for large desalination projects or make smaller systems for residential use. Since both looked equally fascinating from a development standpoint, he decided to do both. He eventually created two separate companies. For commercial and industrial membrane work, he started Desalination Systems, Inc. (aka Desal or DSI) with Stanley Hancock in 1967. Hancock and Bray had worked together at GA and Hancock had a small but well-equipped machine shop in Escondido, Calif. Together they built a commercial-size cellulose acetate casting machine. About a year later, Hancock sold his portion of the company to Jim Bartlett.

Nimbus Water Systems was incorpo-

rated in 1968 and jointly owned by DSI and Clem Macewicz. It was set up to design and build small home-based systems. From that point on, Bray essentially managed two completely different development departments, in two very different companies, at the same time. Needless to say, he worked constantly.

Ideas and inventions

At DSI, he began an ambitious program to invent, develop and construct better membrane casting equipment and cartridge rolling equipment. He also began to invest in basic research attempting to create a better RO membrane. His R&D achievements are documented in the many patents filed over the years. That record, however, misses the thousands of incremental improvements Bray and his development group made behind the scenes. Small things like better membrane inspection equipment and new glues and large breakthroughs, like multi-stage casting for layered RO membrane and the ability to store and ship dry CA membrane cartridges. During the 70s and 80s, DSI also developed many new membranes, including the rugged Desal-3 RO membrane and the first, true multi-layered nanofiltration membrane, Desal-5.

It is easy to forget that new ideas and new techniques come as often from mistakes as from plans. For example, Bray's company was the first to figure out how to manufacture dry CA membrane cartridges. This was a considerable advance, since dry membrane is not subject to bacterial degradation and has a longer shelf life. The breakthrough came while learning to run his new CA casting machine in the basement of the makeshift production area. During this learning process, Bray would often throw the waste membrane on the floor for later disposal. One day, he noticed that several areas of this dried-out membrane looked pretty smooth, so he carefully cut out a few samples and put them on the test cells. Much to his surprise, the membrane was good. Bray's group spent the next few weeks trying to create a production procedure by recreating those basement floor conditions.

Another breakthrough in CA membrane production came from a dropped beaker. Bray had just finished a lengthy mixing process for a new CA membrane. While carrying the glass container to the casting machine, he dropped it. Bray couldn't afford to waste either resources or time; rather than start all over, he simply scooped up the solution off the floor and sieved out the broken glass. The resulting test membrane was the best ever and Bray credits the mishap with starting him down a new development path. He went on to commercialize that membrane for use in the Yuma Desalting Plant in Arizona[12].

As DSI became known for innovative membranes and construction techniques, Bray, sometimes inadvertently, became the mentor to a large group of young RO engineers and scientists. Many of these people came to DSI at the start of their careers, learned the business under Bray's direction and went on to make breakthroughs of their own. As is usual in the business world, many of the improvements and processes Bray pioneered became disseminated through the industry and are now part of the general pool of RO technology.

Both DSI and Nimbus were run very frugally. Visitors to DSI were often surprised to see that his membrane development machinery was built on-site from plywood. For many years Nimbus was run out of an old orange packing plant and visitors had to watch their step when going down to the basement level production floor. Part of that frugality came from necessity. Both companies had to watch their pennies, especially in the early years, but mostly the frugality was Bray's personal philosophy. He was a child of the Depression who believed you worked with what was available, without waste and without unnecessary expense.

"Our first thin film coating machine was built of plywood and was given the pet name Betsy. There was a big sign on the front of her that read, "If it works, don't fix it". We pioneered much of the unique polymer and coatings technology at DSI on handmade machines like Betsy," remembers Deborah de la Cruz, a longtime DSI employee in R&D.

Residential RO

If DSI was the place where Bray made his contributions to large-scale RO technology, Nimbus was the small stage where he created the first RO system for home use. At the same time as he was working on high output RO membranes, he was deep in a development project on a small water storage tank that would fit under a kitchen sink. He and Ross Brown, a young engineer who worked for Bartlett, developed the first air/water storage tank in 1968[13]. Somehow, he also made time to work with Brown to develop the first air-gap for the sink faucet. By 1969, Bray and Brown figured out a way to package all the necessary RO steps—pretreatment, RO membrane, postreatment and storage—into a system small enough for residential use. As is typical of many commercial products created by scientists and engineers, they gave it a less-than-catchy name—the N-3A.

The N-3A, patented by Bray and Brown in 1970, was remarkable for its small footprint and number of innovations; in fact, it was considerably ahead of its time. Bray vividly remembers proudly presenting the small system to Arrowhead Water in 1970 and being politely told the company was not interested. Surprised, he asked the marketing director for the reason why. Bray was told that Arrowhead would enter this market as soon as this new product could take 20 percent of Arrowhead's customers. In essence, they felt home RO had limited appeal and was not a threat to their market share at that time.

Macewicz began to install the first few hundred N-3A units through Macewicz's company, Cal Soft Water in San Diego. This type of partnership between water softening and home RO soon became an industry standard. It would be years before the corporate world took the home RO market seriously.

Career components

"I met Don Bray in the fall of 1983 and worked for him at DSI and later at Nimbus. I vividly remember his sincerity, humility and hard work during those tough early years. Don was most comfortable in front of a blackboard with chalk in his hand. His R&D lab seemed more a collection of old peanut butter, pickle and juice jars than a modern research lab," remarks Charlie Price, DSI and Nimbus Water Systems employee.

When asked recently to sum up his professional life, Bray had several thoughts. First, and most importantly, wealth was never the goal—Bray was always fascinated by 'interesting problems'. Second, he is happiest when surrounded by people who have a passion for what they are doing. Every one of Bray's inventions, designs and breakthroughs was made with others. No one creates in a vacuum and Bray feels extremely fortunate to have worked with so many brilliant and forward thinking people. Finally, he is very proud of the fact that he provided so many jobs for so many people in such a worthwhile field.

"It was always apparent Don took his responsibilities seriously both as President of the company he had founded and to the folks he employed. He always met payroll. His lifestyle was never extravagant—no fancy cars, homes

or airplanes. All the money he earned went back into building the business," notes Larry Lien, longtime DSI employee and later General Manager of MDS.

Keeping busy

In 1996, Bray sold DSI to Osmonics (later incorporated into GE) and he began a quasi-retirement. At 86, he still owns Nimbus Water Systems and a cattle operation in Idaho, so his retirement is a little busier than most. At least he has stopped working on weekends and holidays and spends a more time traveling and gardening. He and his wife, Julianne, divide their time between their home in Carson City, Nev. and the 'Old Home' ranch in Idaho.

Recently, he decided his Idaho ranch needed a fruit orchard. Like most of his projects, this was quite ambitious and included a few challenges. He eventually planted over 100 trees. This wasn't as successful as he had hoped; most of the trees didn't make it. Some were killed by drought, voles ate the roots of some, and others were chewed down by deer. Undaunted, he had a deer fence built, baited the voles, completely redesigned the watering system and started all over with 125 more trees. Apparently, he hasn't lost his tenacity—or his fondness for interesting problems.

References

1. General Atomics (GA) was established as a division of General Dynamics Corporation in mid-1955. It was the creation of General Dynamics Chairman John Jay Hopkins and Frederic de Hoffmann, GA's first General Manager and President. De Hoffmann was a veteran of the Manhattan Project at Los Alamos. GA's very first offices were in the General Dynamics facility on Hancock Street in San Diego, Calif.

2. These were called 'nuplexes'. Oak Ridge has detailed plans, with illustrations, for these power-water plants. Information on this idea may be found at *http://www.ornl.gov/info/swords/swords.shtml*

3. The Office of Saline Water was established under the Department of the Interior, September 21, 1955.

4. The construction of research reactors had quickly reached market saturation; the small nuclear reactor work was taken over by Admiral Rickover and the US Navy.

5. Loeb S. and Sourirajan S., *Sea Water Demineralization by Means of an Osmotic Membrane, in Saline Water Conversion*, Advances in Chemistry Series Number 28, American Chemical Society, Washington, DC, pp.117-132 (1963)

6. *Solutions*, DSI newsletter, Volume 2 Number 6, Summer 1992.

7. Michaels, Alan S., March 16, 1965. *Membrane Separation Device*, US Patent #3173867.

8. Westmoreland, Julius C., February 6, 1968. *Spirally Wrapped Reverse Osmosis Membrane Cell*, US Patent #3,367,504.

9. Bray, Donald T. December 24, 1968. *Reverse Osmosis Purification Apparatus*. US Patent #3,417,870.

10. Several years later, Desalination Systems, Inc., received a letter from GA noting possible patent violations for the multi-leaf spiral wound concept. Bray notified the Office of Saline Water that GA was attempting to retain patent rights for work done under contract to the Federal government. Eventually, GA was convinced that the patent rights belonged in the public domain. Ironically, it would be many years before another patent, for the very successful FT-30 membrane, would receive the same consideration.

11. The Yuma Desalting Plant was constructed to maintain salinity levels at Morelos Dam as specified by Minute 242 of the International Boundary and Water Commission. Construction began in 1975 and was completed in 1992 under the direction of the Bureau of Reclamation, US Department of the Interior. Information on this facility may be found at http://www.usbr.gov/lc/yuma/facilities/yao_facilities.html

12. Bray, Donald T., Brown, Ross M., February 3, 1970. *Purified Water Supply Apparatus and Method*. US Patent #3,493,496.

13. Bray, Donald T. and Brown, Ross M., November 24, 1970. Reverse *Osmosis Water Purification Unit*. US Patent #3,542,199

About the author

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