

# IS THERE AN ICEBERG IN YOUR FUTURE?

The idea of towing Antarctic icebergs to coastal deserts for water is undergoing a strong revival. The engineering problems are, to say the least, challenging.

BY KENDRICK FRAZIER

Eight days before sailing for the first time into waters south of the Antarctic Circle, Captain James Cook found his ship the *Resolution* among loose pieces of ice. Cook had his crew hoist out three boats, and the sailors broke the ice with axes into pieces small enough to be loaded onto the boats and brought aboard ship. They "took up as much as yielded about 15 tons of fresh water," Cook wrote in his journal. "The melting of the ice is a little tedious, otherwise this is the most expeditious way of watering I ever met with." That was in 1773.

Now, more than two centuries since this first documented use of Antarctic icebergs for fresh water, the concept of iceberg utilization has reached a stage so bold and imaginative as to challenge the skills and knowledge of the most innovative engineers, scientists and seamen. As the recent First International Conference on Iceberg Utilization at Iowa State University showed (SN: 10/15/77, p. 244), the idea of towing large tabular icebergs from Antarctic waters to the coasts of arid lands in both the Southern and Northern Hemispheres is alive and very well, despite enormous scientific and technological obstacles to be overcome.

The little-appreciated fact is that on a planet with widespread arid lands and steadily increasing population, the need for additional fresh water in many regions is acute. But the majority of all the world's fresh water (77.1 percent) is locked up in ice caps and glaciers. Nearly all the remaining water (22.3 percent) is underground and not always easily accessible. (Only a tiny 0.5 percent is in the lakes and rivers of the world, and the remaining traces are in the atmosphere and biosphere.) And of the three-quarters of the world's fresh water locked up in ice, 90 percent is in the Antarctic ice cap.

Icebergs, unlike sea ice, are composed of fresh water, not sea water. The ice in the Antarctic bergs was created by the buildup of snow and its compression into ice during millions of years over the Antarctic continent. The ice flows toward



U.S. Navy ship in Weddell Sea passes a tabular iceberg, the type best suited for towing.

the continent's edge. At the coast it forms floating ice shelves about 240 meters thick that are continually breaking off and forming icebergs.

The quantities are almost unimaginable. It has been estimated that the Antarctic ice shelves produce a trillion cubic meters (1,000 cubic kilometers) of icebergs a year. One 90 by 35 km iceberg currently stuck off the end of the Antarctic peninsula contains enough water to serve a city the size of Washington, D.C., for thousands of years. The water in this ice is extremely pure, having the purity of distilled water. This frozen fresh water merely drifts northward and eventually melts uselessly into the sea. It is no wonder that visionaries in the water-poor areas of the world are eyeing icebergs as a future fresh-water resource.

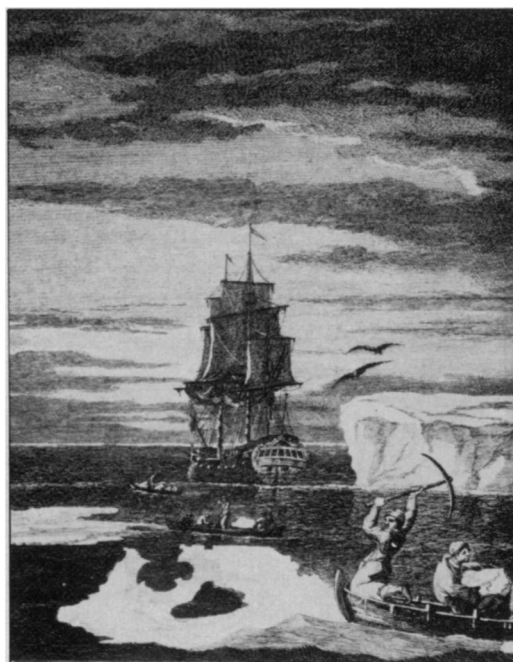
Small icebergs have been towed before. From 1890 to 1900, small bergs were towed from Laguna San Rafael, Chile (45°S), to Valpariso and even to Callao, Peru (12°S), a distance of 3,900 km. But the scale of effort envisioned in

the new proposals dwarfs that minor activity.

The first scientific paper analyzing the concept of towing large Antarctic icebergs to other continents for fresh water was published in the *JOURNAL OF GLACIOLOGY* in 1973 (and in later publications) by Wilford F. Weeks of the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) and W. J. Campbell of the U.S. Geological Survey's Ice Dynamic Project (SN: 5/26/73, p. 338). When they first heard the idea, they considered it something of a joke, but after studying the situation,



Faisal and Victor hope to make use of Antarctic icebergs as Captain Cook and crew of the *Resolution* did in 1773.



changed their minds. "Unless our analysis is grossly in error, the results . . . are very exciting." They found the possibility of delivering ice to coastal sites in Australia and South America economically attractive and said the number of major engineering problems that must be overcome "are within the reach of existing technology."

Later that year, John L. Hult and N. C. Ostrander, then of the Rand Corp., developed the concept of wrapping the iceberg to help protect it from melting and ablation. These became the two classic papers about iceberg utilization. No governments seemed interested, however, and as glaciologist Henri Bader says, "The idea seemed destined for early filing in the archives."

But now the iceberg idea has had a revival. The real excitement began about two years ago, says Paul-Emile Victor, veteran polar explorer and long-time head of the French Polar Expedition. That is when he received a call from Prince Mohammed Al Faisal of Saudi Arabia asking what Victor thought of the idea of towing an Antarctic iceberg to Saudi Arabia. Victor says he told the prince he had thought about the idea and would not say it was possible, but also would not say it was impossible. It might work, he told him, but it would cost a lot of money. Victor says Faisal thought for a moment and then said, "We can afford it." (Faisal says he himself first got the idea from a technical paper that had a footnote about the 19th century Chilean iceberg towing.)

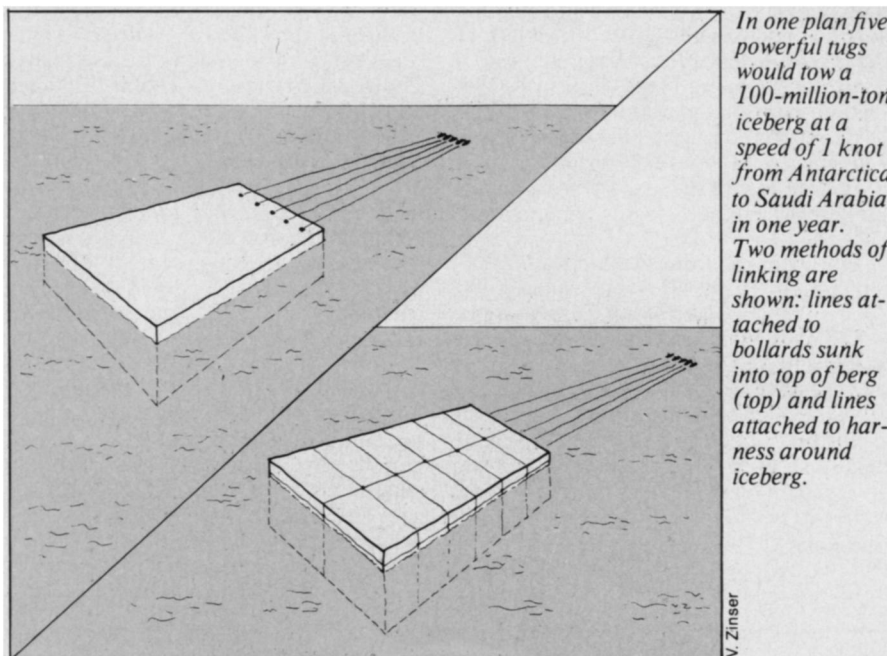
Since then Victor, ruddy cheeked, vigorous and charismatic at age 70 ("he's a man of action and a poet," says a fellow Frenchman), and Prince Faisal, a pragmatic, progressive, American-educated businessman (with, says a former schoolmate, "a mind like an engineer's"), have devoted considerable independent effort to studying, planning and

promoting the concept.

"Anybody who today says this idea is stupid and impossible does not have a scientific mind," was Victor's resounding challenge at the start of the Iowa iceberg conference. "I am convinced that it will be done."

A technical study prepared for Faisal and presented at a conference sponsored by him in Paris this summer contended that even under the worst conditions an

All sorts of exotic propulsion methods have been proposed for far-future towing programs. These include conventional but enormously powerful supertugs; nuclear-powered tugs; remote propulsion units attached to the iceberg's bottom; submarine towing tugs (a "Submatug"); specially designed nuclear submarines that would carry the iceberg on their backs; propulsion units built inside the iceberg; even paddle wheels attached to



iceberg utilization project could deliver iceberg water "at the faucet" in Saudi Arabia at a cost of 50 cents per cubic meter. This compares with the present desalinated water cost of 80 cents. Under favorable conditions, the cost of iceberg water in this analysis could go down to 25 cents per cubic meter.

The idea of towing an Antarctic iceberg to a distant arid coast is simple in concept, horrendous in execution. The basic idea goes something like this: Satellite and aircraft imagery would be used to locate a suitable iceberg. It would have to be flat and rectangular (unlike the irregular shaped Arctic icebergs) to minimize chances of rollover. It would have to be wider than it is thick for the same reason, and the best length-to-width ratio would be somewhere between 1.5 and 4. Shorter ones might not be economical; more extended ones might break apart with wave action. Studies indicate that the most economical solution would be to select the largest iceberg that could be towed at the agreed speed of 1 knot. A berg less than 1 km in length is considered not worth the effort.

Most studies assume an initial effort with a "small" experimental iceberg perhaps 1 km long, 400 m wide and 250 m thick. Such an iceberg would contain 100 million cubic meters of ice (about 22 gallons of water) and weigh about 100 million tons.

the iceberg's sides (this latter idea was proposed in a paper co-authored by Faisal). But at the Iowa conference the workshop on transport cautioned against diverting too much attention to "novel and exotic schemes" at the expense of "more mundane and conventional engineering considerations."

The first experiment would undoubtedly be done with existing means, and there are already 20 ocean-going tugs in the world, each capable of supplying a towing force of 125 to 150 tons. Five to eight such tugs spaced evenly across the front of the iceberg could deliver the necessary towing force. Their towlines would be 800 m long to avoid the influence of propeller wash against the iceberg.

The lines might be attached to bollards sunk into the top surface of the iceberg, or they might be fastened to a harness that extends entirely around the berg. In either case, obtaining an even pull on all lines would be a tricky task.

With linking achieved, the tow would begin. There is almost universal agreement that since the resistance of a towed object is proportional to the square of its velocity, the slowest possible speed able to overcome wave action and currents is the most economical. Most studies are thus based on a speed of 1 knot.

Once full towing force was exerted, the iceberg would reach the speed of 1 knot after about 5 hours. It would be the

largest object ever towed in the history of seafaring, five-sixths of it invisible beneath the surface. Its total volume could easily enclose 40 buildings the size of the Pentagon.

Before the iceberg got far toward warmer waters, it would have to be protected against melting, particularly on the sides and especially at the water line. Thick insulated blankets, plastic sheets and plastic foam have all been proposed. The mechanics of attaching and holding in place such materials on an object of such size in hazardous Antarctic waters are mind-boggling. Two workshops discussed the problem at the Iowa meeting, and neither thought that any of the schemes so far described for underwrapping or encasing the iceberg are acceptable. It is an enormous engineering challenge.

The distance from Antarctica's Weddell Sea to the Gulf of Aden is 9,000 nautical miles. At 1 knot, the journey would require 12 months. Once-a-month at-sea refueling by a tanker/tender would be necessary, and crews would have to be relieved three or four times.

Ideally the route would be chosen to make use of favorable currents, and for an Arabian destination accurate timing would be required to take advantage of the seasonal monsoons in the Indian Ocean.

At the destination, the iceberg would

be moored at a specially constructed terminal. If the water was too shallow, as it is in the Red Sea, the iceberg might have to be sliced (at an enormous energy cost) and melted in the sea, the water carried by aqueduct. For deep harbors, breaking up of the iceberg by cutting, drilling, blasting or crushing might all be possible. Meltwater from the sides could be trapped by a floating fence-like baffle. Melting could be enhanced by a spray of water on top that carried atmospheric heat back down to its surface. There wasn't much discussion of these matters at the Ames conference. But, as Weeks and Campbell said in their original paper, "We would guess that it would be a rare engineer who would not consider the design of an iceberg processing facility . . . to be an interesting problem indeed."

All of the foregoing simplifies to an almost embarrassing degree the enormous technical difficulties and challenges that exist nearly every step along the way. The Southern Ocean has some of the most adverse weather on earth. Old Antarctic hands familiar with the hazards and logistics problems of operating in and around that continent periodically sputtered in bemused frustration at the naivete of some suggestions that seemed to assume idyllic working conditions. Consider that problem of protecting or incasing the iceberg. Even the "small" experimental icebergs

under discussion are 15 to 20 times the volume of the largest buildings on earth, and they extend downward 200 m beneath the water. As Weeks says, the problem is formidable.

Glaciologist Weeks and CRREL engineering colleague Malcolm Mellor were at the Ames conference. "The enthusiasm that sparked this meeting is very commendable," they told the conferees, but it should be tempered by the fact that "most of the technical studies recommended in the 1973 papers have not yet been undertaken and some technical problems that may well be critical have been almost completely ignored." After considering some aspects of the problem in more detail, they said, "We have had to shrink the scale of the geophysically possible to where it may nearly coincide with what is practically feasible. . . . If the idea is feasible, it would appear to be most feasible for southern Australia."

They suggest such a short-distance operation would provide the experience necessary to assess realistically the chances of successful delivery to more distant sites. It would especially give time to find ways of solving the problem of decreasing the melt loss during transit.

The problem is, nobody in particular seems to be clamoring for iceberg water for Australia, the way Prince Faisal is for Saudi Arabia. Most of the interest is for the Northern Hemisphere, not surprisingly, since that's where the bulk of the planet's population is. John Hult, now head of an iceberg-technology-development company called Application Concepts and Technology Association, Inc. (ACTA) of Santa Monica, Calif., is proposing a pilot program of Antarctic icebergs for California. A resolution recommending that federal agencies support the concept is before the California legislature for action in January.

ACTA proposes a pilot program of towing two small instrumented Antarctic icebergs in tandem the 8,000 miles to southern California. The goal would be to test alternative theories of insulation, harnessing and transport as applied to larger icebergs for future use. One insulation technique would be to wrap the iceberg with overlapping bands of tough plastic fabric. Another would be to maintain a few centimeters of barricaded separation between the ice and the outside seawater as insulation. Hult even has an idea for how to recover much of the cost: Sell "souvenir products of [this] extraordinary venture that will capture the imagination of the American public."

The subject of iceberg utilization has its dreamers and skeptics, pragmatists and idealists, concepts people and operations-oriented people. Depending on who you talk to, it is an interesting idea with a lot of problems that may or may not be economically and technically solvable, or it is a challenging but certain answer to many of the world's water shortage problems. Time, especially the next 5 or 10 years, will tell. □



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