A Region IX
Historic Mechanical Engineering Landmark

The Archimedes/Oliver Wind-Powered Screw Pumps
San Francisco Bay

Leslie Salt Co., Newark, California
February 28, 1984
The American Society of Mechanical Engineers
The San Francisco Bay Region is one of the few areas in the world where salt is commercially recovered from brine by solar evaporation. The Bay itself provides the brine, and the mild climate provides favorable atmospheric conditions. A long season of mild temperatures, little rainfall, and almost constant northwest wind allow efficient solar evaporation. The steady wind also makes wind-powered pumps effective.

**Development of the San Francisco Bay Salt Industry**

In the mid 19th century the need for salt arose when salt was required for preserving meat and fish before development of refrigeration. In the 1860s, after discovery of the Mother Lode — a 120 mile long quartz vein in the Sierra Nevada containing rich deposits of gold and silver — the need for salt increased greatly because of its use in refining silver. At first the salt was brought from the East Coast as ballast in ships, but its excessive cost generated a need for locally produced product. The climate made possible the recovery of salt from bay water through solar evaporation, and before long many small salt companies were formed. The early companies built crude ponds with hand labor and dug out the crystallized salt with picks and shovels. The business attracted more adventurers and by 1868 there were some seventeen companies harvesting 17,000 tons of salt annually.

The wind played a part in producing the salt recovered by virtually all the companies, but different pump designs were used. Whatever type pump was used, the pumps transferred the brine from one evaporation pond to another. The Archimedes screw pumps originally designed and built by Andrew Oliver in the 1870s were the longest surviving wind-powered pumps and were used until electric pumps came into general use beginning early in the twentieth century.

Two of the earliest and longest surviving salt companies were the Oliver Salt Company, founded by Andrew Oliver in 1872, and what was then the Leslie Salt Refining Company, founded in 1901. The Leslie company absorbed some seven other companies to become the Leslie-California Salt Company in 1924. Meanwhile the Oliver Salt Company absorbed some four other companies by 1927, and then itself was absorbed by Leslie-California in 1931. The Arden Salt Company, which had its beginning as the Union Pacific Salt Company in 1872, was absorbed by Leslie along with the Alviso Salt Company in 1931. The Leslie Salt Co. as organized today was established in 1936, and in 1978 Leslie Salt Co. became a wholly owned subsidiary of Cargill, Inc. of Minneapolis.

The Oliver family did not stay out of the salt business for very long after their company was absorbed by Leslie. Andrew Oliver's grandsons, Alden and Adolph, bought the Johnson salt property in 1937, built a new plant near the east end of the San Mateo Bay bridge, and as the Oliver Brothers Salt Company, produced salt there until 1981.
Leslie Salt Co. owns 28,000 acres of salt producing property and maintains salt-making rights on an additional 12,000 acres which are owned and operated by the federal government as part of the San Francisco Bay National Wildlife Refuge. Leslie’s East Bay property, with a plant site at Newark, produces about 700,000 tons of salt annually. To that are added another 300,000 tons from their Redwood City operation and 200,000 tons from a site near Napa. It takes over 9 billion gallons of salt water to produce that tonnage. The same fundamental process of solar evaporation is used today as introduced over a century ago. During the early summer the brine from the bay is pumped into concentrating ponds that vary from 200 to 800 acres. As the brine becomes more saline through evaporation, it is moved from one pond to another of higher salinity. The brine goes through ten stages of concentration by the time it reaches the pickle ponds and finally the crystallizers at the plant site. During that time, about five years, the brine assumes a pink-red color because of the growth of a red bacterium. Brine shrimp thrive in this water, and are harvested for sale as fish food for aquariums. The pickle ponds contain saturated salt solution which in April or May is pumped into 20 to 90 acre crystallizers. There, the almost pure salt crystallizes out, leaving a solution of other elements such as magnesium, bromine and potassium. By late summer the crop of salt is ready to harvest. Crews work five days a week, twenty-four hours a day to complete as much as possible of the harvest before the winter rains begin. Heavy, slow-moving harvesting machines inch along the crystallizers, which at one time were farmed for other crops, scooping up and loading the crystals into miniature railroad cars pulled by small locomotives that transport the salt to the wash house. At the wash house, the salt is thoroughly washed with saturated brine, sea water, and fresh water to remove the last traces of impurities. The salt is then stored in the mountainous piles visible in Newark, Napa, and Redwood City. Much of the salt is sold directly from the stack. Thousands of tons are rewashed and dried in rotary gas fired kilns. The prime end-uses of this kiln dried salt include supplementary livestock feeding, water softening and many industrial applications. The small amount of salt for human consumption is further purified by means of vacuum crystallization to a purity of 99.99 percent.

Of all the solar salt produced from San Francisco Bay, 20 percent is used for food processing, meat and hide curing, table and home use, and for baking. Another 70 percent is used industrially as a building block for other chemicals, water softening, in the oil industry, road de-icing and other miscellaneous uses. The last 10 percent finds its way into agriculture, primarily for livestock.
From the beginning of the salt industry in the Bay Area until early in the twentieth century, all of the pumping of brine in the salt ponds was done by means of wind-powered pumps of various designs, with probably hundreds of them in operation. When electric pumps were developed, they gradually replaced the wind-powered pumps. Despite the efficiency of the wind-powered pumps, the wind is not available all of the time. Electric pumps can be turned on and off at will, and are capable of pumping against higher heads.

In 1978, Leslie's pond superintendent, Don Holmquist, decided to restore a wind-powered Archimedes screw pump to working order. Using O. E. Oliver's original drawing, Don and his colleagues painstakingly rebuilt this pump and placed it in a pond on Leslie property. This pump, with its 20-foot diameter fan blades turning a 22-foot long redwood shaft, is a faithful reproduction of the original pumps used a hundred years ago.

The Archimedes screw pump consists of a continuous spiral chamber formed around an inclined enclosed redwood shaft which raises the water as the shaft is rotated by the four-bladed wooden windmill. With full sail and a wind of 25 miles per hour, the pump, turning at 60 rpm, will raise 1,500 to 2,000 gallons of water per minute. Assuming a four-foot lift some 1.5 to 2 horsepower is represented.

The principle of the screw pump is traced to Archimedes, a Greek who lived in Sicily from 287 to 212 B.C. Pumps of this type were first used in Egypt, and then in the Roman world, even making their way to Japanese mines for drainage purposes. Originally muscle-powered, the windmill drive was added in seventeenth-century Holland when such pumps began the reclamation of land from the sea. Small hand-cranked pumps of this nature are used by today’s Egyptian peasants for irrigation of their fields.

The Archimedes screw pump has been restored as a reminder of the history of the salt industry adjacent to San Francisco Bay.
DEDICATION PROGRAM
WIND-POWERED ARCHIMEDES SCREW PUMP

Tuesday, February 28, 1984
Visitor Center Auditorium
San Francisco Bay National Wildlife Refuge
Fremont, California

Opening Remarks
Dr. Richard G. Folsom, P.E.
Past President, ASME

Welcome to the Dedication Ceremony
Robin M. Orans, P.E.
Chair, San Mateo County Section, ASME

Welcome to the Wildlife Refuge
Roger Johnson, Manager

Introduction of Honored Guests
James D. Woodburn, P.E.
Vice-President, Region IX, ASME

The ASME Historical Landmarks Program
Dr. R. Carson Dalzell, P.E., Chairman
National History & Heritage Committee

Recovery of Salt from San Francisco Bay
Jim Smith, Operations Manager
Leslie Salt Co.

Restoration of the Archimedes Screw Pump
Don Holmquist, Pond Superintendent
Leslie Salt Co.

Presentation of Commemorative Plaque
Frank M. Scott, President, ASME

Acceptance of Plaque
Don Holmquist, Pond Superintendent
Leslie Salt Co.

In Conclusion
Dr. Richard G. Folsom

Refreshments
Tour of Salt Recovery Ponds
Viewing of Restored Pump
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Founded in 1880 as a non-profit technical and educational organization, ASME now has over 107,000 members including about 20,000 student members. ASME serves the fields of education, industry and government, encouraging the development of new technologies and helping to solve the problems of our increasingly complex society.

An elected eight member Board of Governors and the President, immediate Past President and President-elect establish policy for the Society. Five Councils — Member Affairs, Engineering, Codes and Standards, Education and Public Affairs — along with their operating boards and committees, do the actual work of ASME.

ASME Headquarters is in the United Engineering Center in New York. Five field offices — in Chicago, Dallas, San Francisco, Burke (Virginia) and Danbury (Connecticut), along with a Government Relations office in Washington and the Gas Turbine Division office in Atlanta — represent ASME throughout the country.

THE HISTORY AND HERITAGE PROGRAM

Established under the Public Affairs Council in 1971, the History and Heritage Program serves to recognize and preserve historically important mechanical engineering works, provide a roster of landmarks, and invite attention to our engineering past not only by engineers but also by the public in general.

LANDMARK DESIGNATION

Upon nomination by local sections or technical divisions, the National History and Heritage Committee reviews proposed works, and if appropriate, designates them as Regional, National or International Historical Mechanical Engineering Landmarks. The 85 landmarks designated to date include engineering works in 28 states, the Commonwealth of Puerto Rico, and England and France. For this country the earliest is the Iron Works of 1647 in Saugus, Massachusetts. Included also are such nearby landmarks as the San Francisco Cable Railway Powerhouse of 1877 and the Joshua Hendy Iron Works in Sunnyvale, of 1906-1946.

ACKNOWLEDGEMENTS

The ASME San Mateo County Section gratefully acknowledges the efforts of all who cooperated on the landmark designation of the Archimedes Wind-Powered Screw Pumps as a Regional Historic Mechanical Engineering Landmark, particularly the staff at Leslie Salt Co. Special thanks are extended to Don Holmquist, who restored the only currently operable wind-powered pump. Without his study, patience and craftsmanship, this designation could not have taken place.

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Oliver Brothers Salt Company
Alden Oliver