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THE DRY ICE INDUSTRY IN THE PACIFIC NORTHWEST

by

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The production of solid carbon dioxide in the Pacific Northwest dates from the depression period of 1932. In those days it was very difficult to find a market for the dry ice that could be produced; today it is just as difficult to find enough dry ice to satisfy the market.

There are two plants in the Pacific Northwest producing dry ice. One is the Liquid Carbonic Pacific Corporation in Seattle and the other is the Gas-Ice Corporation also of Seattle with a plant at Klickitat, Washington. The former organization produces the carbon dioxide from which dry ice is made by the burning of petroleum fuels. The plant at Klickitat, Washington, utilizes natural carbon dioxide obtained from wells. The combined capacity of both plants is about 25 tons per day.

Carbon dioxide is a colorless non-inflammable gas at normal temperature. Twelve cubic feet at atmospheric pressure weighs about one pound. It exists as a liquid at -76° F and as a solid at -110° F at atmospheric pressure. A cubic foot of dry ice weighs between 90 and 100 pounds depending on the degree of compression. It sublimes directly to gas leaving no trace.

Sources:

Whenever fuel is burned large quantities of carbon dioxide are given off as a product of combustion. It is also given off in the processes of fermentation. Attempts have been made with some measure of success to utilize the smoke from steam generating plants. The difficulty has been the cost of separating the carbon dioxide from other gases with which it is mixed. Probably the greatest single producer of dry ice today is Michigan Alkali, a corporation closely held in the family of John B. Ford, Jr. (Fortune, July 1932). Carbon dioxide is a by-product of the chemical processes carried on by that company mostly by the burning of coke.

Natural carbon dioxide is given off from deep-seated volcanic magmas in their process of cooling. This carbon dioxide is mixed with a large number of other gases. These gaseous mixtures may remain confined under enormous pressures or they may gradually filter upward through the earth to the surface and be discharged to the atmosphere. As these gases rise through the earth's crust they encounter percolating surface waters moving downward, which become heated where percolation is deep. These waters aid the rocks of the earth's crust in absorbing the various gases. It may thus happen that carbon dioxide is the only gas left to reach the surface.

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In some instances these gases are encountered in wells drilled for oil or fuel gas. Not infrequently the carbon dioxide thus found is under enormous pressure and, as it reaches the surface, the adiabatic expansion cools it down so rapidly that it solidifies in the form of snow. Some such wells in the West give off such enormous quantities of gas at such high pressure that the derricks and surroundings become covered with carbon dioxide snow. A well near Price, Utah, produces carbon dioxide gas at a pressure of about 500 lb. per square inch. This is piped into the dry-ice plant and of course saves much of the mechanical compression that would otherwise be required. However the gas is impure and must be "scrubbed" to remove sulphurous and other gases.

History:

Some businesses get their start in odd ways; the dry-ice industry is an example.

Herbert Samuel Elworthy, a physician in the British army, liked his Scotch and soda. Soda was not always obtainable as it had to come from natural carbonated spring waters and for the most part from Vichy, France.

Sir Herbert decided he could carbonate tap water and thus find a fair substitute. He therefore proceeded to experiment with the idea and finally produced liquid carbon dioxide. The heavy iron containers required, however, were a serious handicap to the enjoyment of his favorite beverage so he continued his experiments and finally succeeded in solidifying the gas. Thus the bulk packaging was reduced to its lowest denominator and Sir Herbert was happy.

He took out a patent on his processes in 1897. However, 25 years elapsed before any further attempt was made to utilize this product, and of course the Elworthy patents had expired and anyone could use them.

In 1923 a company was formed in Long Island City, named Prest Air Devices Co. The company offered solid carbon dioxide for use in a goodly number of novelties. Among them may be mentioned the Prest Air Tire Pump - a device to fill automobile tires with CO_2 gas from a small liquid container carried in the car in the "get out and get under days." This device met defeat when it was discovered that, like Romeo's "stony limits can not hold love out," rubber could not hold carbon dioxide gas in - it filtered through the rubber.

The next was a Prest Air Home Siphon - just what Sir Herbert would have given his eyeteeth for. Another was a device that came to stay - the Prest Air Fire Extinguisher invented by Thomas Benton Slate, an officer in the company. Prest Air Devices Company was officered by a group of inventors who developed many gadgets but no customers and the company was wrecked on the financial rocks.

A successful successor was the Dry Ice Corporation of America who did develop customers. One of the first was Frank C. Shattuck, manager of the Schrifft store at 181 Broadway, New York City. The idea of holding ice cream between the moment of purchase and that of consumption appealed to him very much. Accordingly he made a small container for both ice cream and dry ice. One of his first sales however resulted disastrously. A customer's children ate the dry ice and went into convulsions. Whereupon the father filed suit against Schrifft's for damages. However he later withdrew it when Shattuck himself and the corporation's representative both ate dry ice in the father's presence to demonstrate its harmlessness.

By 1929 the Dry Ice Corporation of America had 17 plants from New York to Los Angeles. In that year it produced a total of 14,000 tons and the dry-ice industry outgrew its swaddling clothes.

The company has given to the world the name "Dry Ice" - a trade name for a specialized product but now the accepted generic term for solid carbon dioxide. An interesting article on this industry appeared in Fortune, July 1932.

The Klickitat field:

The carbon dioxide gas in the Klickitat field comes from a volcanic magma probably located 10 miles or so below the surface of the earth. As these gases rise through the earth's crust and the zone of permanent water saturation, all other gases are absorbed leaving only pure carbon dioxide to reach the surface. This process has been going on for millions of years and will continue for untold generations to come. Samples taken show a small amount of nitrogen and oxygen but the probabilities are that these are from air mixed with the sample. It is rather difficult to get a sample of the gas entirely devoid of air.

Upon reaching the surface this gas is dissipated over a large area in the vicinity of the town of Klickitat. Owing to certain peculiar characteristics of the earth's crust, the gases appear to have greater concentrations in certain areas, doubtless due to faults or non-conformities between successive lava flows which have been cut by the Klickitat River and its tributaries.

Carbon dioxide gas is a prominent constituent of the natural Klickitat mineral water. It bubbles up through the bed of the river and along the shores and springs and various other places in the area. These Klickitat springs were known to the Indians and used by them extensively as a health resort. The production has been increased by drilling wells, nearly all of which are artesian in nature.

In the beginning of the development, the gas was taken entirely from the mineral water, from which it was separated and then passed into the plant for manufacture into dry ice. Later however it was discovered that wells drilled along the benches of the river canyon would produce dry carbon dioxide free from mineral water. The reason is obvious. This gas is moving horizontally into the river canyon through the broken lavas and non-conformities between the successive lava flows. It is only necessary therefore to penetrate these non-conformities by wells to bring in a dry gas well.

The pressure of the gas is low - 2 to 3 pounds per square inch. The wells do not tap the magma of course; they merely form a less resistant path by which the gas may reach the surface rather than filter up through the ground. After rains the soil is less porous and the pressures in the wells increase.

One means of detecting the localities of gas concentration issuing from the ground is to observe where melting occurs immediately after a snowfall. This gas is at a temperature of about 62° F and as it reaches the surface it melts the snow. Along fault lines therefore and at the exposed non-conformities between lava flows the snow will be melted in large surface patterns that indicate concentrated escape routes for the gas.

Manufacturing process:

No matter what the origin of the carbon dioxide, the process of solidifying it is practically the same at all plants. The gas must be freed from all water vapor and other gases if present by passing it through drying and scrubbing devices. It is then compressed and at the same time is cooled by refrigeration until it forms liquid carbon dioxide at about 0° F under a pressure of 340 lb. per square inch. This liquid is then allowed to expand through a small orifice into a snow press, which is a chamber having pistons operated by a hydraulic press that can produce pressures up to 1200 lb. per square inch. Of the gas so expanded in this chamber about half is converted into a solid in the form of snow; the other half is returned for recirculation through the plant.

The snow is then compressed into cakes by this hydraulic press. When so compressed it weighs nearly 100 lb. per cubic foot and is at a temperature of about 110° below 0° F at atmospheric pressure. The cakes from the Klickitat plant are 10 x 10 x 15 inches and weigh between 80 and 90 pounds. Upon removal from the press they are wrapped in paper cartons and stored temporarily in a heavily insulated box to prevent loss of the gas. Dry ice is transported and sold in cartons. It may be reconverted later into liquid carbon dioxide to fill the containers used by soda fountains and bottling works.

A process has recently been developed whereby liquid carbon dioxide is delivered to customers somewhat along the same line as gasoline would be delivered from trucks. The trucks in this case however are refrigerated in order to keep the pressure down to between 300 and 400 pounds. This process avoids the freight charges on heavy steel containers that would otherwise have to be shipped by the consumer to the factory for refilling. When carbon dioxide is at 70° F it develops a gage pressure of 845 pounds per square inch and reaches a gage pressure of 1000 psi at 82° F. The cost of refrigeration therefore must be balanced against the cost of containers strong enough to withstand such high pressures.

Uses:

The uses of dry ice are manifold. It has not yet been developed as a practicable refrigerant for household use. It is used extensively in transcontinental shipments to prevent water ice from melting so rapidly. Another important use is its value in fruit shipment, not entirely as a refrigerant however but to envelop the fruit in a CO_2 atmosphere and thus prevent decay. For example, cherries shipped from the Pacific to the Atlantic coast will lose from 7 to 10 percent in a trancontinental trip if held with water ice alone. By putting cakes of dry ice in the car an atmosphere of carbon dioxide is created which reduces the loss to less than 1 percent of the shipment.

Dry ice is used also as a refrigerant to send fish, meat, fruits, and other perishable goods through the mails since there is no drip from the packages. It is used to produce rapid freezing of fruit. It seems that perishable foods if frozen very rapidly will hold their natural flavor much better than if they are frozen by the normal mechanical processes.

Another use for dry ice has been developed in the airplane industry. In order to get rivets tight they are first cooled with dry ice and then driven into the holes. The resulting expansion fills the holes solidly and prevents them from working loose.

Since carbon dioxide is non-inflammable it is used to a great extent in fire extinguishers where it is in the liquid form. Filling the heavy steel containers for power plants on land and in ships is frequently done by liquifying dry ice, thus saving shipment of empty containers.

The most general use of dry ice is in the ice cream and dairy industry. Enormous quantities are used in trucks that gather milk and cream. Ice cream is very often retailed with a few pieces of dry ice in the package to hold the ice cream frozen between sale and consumption. Long distance shipments of ice cream depend upon dry ice almost exclusively to keep it frozen during transit.

Production:

The accompanying table shows the production of dry ice in the Northwest and in the United States since 1929. From this tabulation it is apparent that the production in the Pacific Northwest for the 11 years - 1933 through 1943 - has increased 10 times.

Production of solid carbon dioxide (dry ice) in The United States and in the Pacific Northwest

Year	Pacific Northwest Tons	United States Tons	Authority
1929	----	14,000	Fortune, July 1932
1930	----	35,000	" " "
1931	----	45,000	" " "
1932	250	60,000	" " "
1933	356	----	
1934	546	----	
1935	810	----	
1936	936	----	
1937	1,050	156,600	1940 census
1938	1,130	----	
1939	1,490	178,400	" "
1940	1,730	----	
1941	2,560	214,700	War Prod. Board
1942	2,940	252,800	" " "
1943	3,550	270,000	" " "
1944 (partly estimated)	4,030	300,000	

Future demands:

It is of course impossible to predict the future of the dry-ice industry. New uses for it are being found every day. One thing appears certain. The industry is here to stay with an ever-widening field.

In the early days the Dry Ice Corporation of America, one of the earliest producing agencies, set up the following potentialities as an annual target:

Carbonated beverages	44,000 tons
Transportation of fruits and vegetables	37,500
Ice cream refrigeration	150,000
Frozen foods	1,500,000
Express and truck for unfrozen meats	90,000
Refrigeration of carload shipments of perishable food stuffs	1,800,000
Total annual demand	3,621,500 tons

This is only 12 times the 1944 production and is not at all impossible of realization.

Prices:

The sale price of dry ice has varied from 5 cents per pound in the early days of the industry to 1.5 cents or possibly even lower in the competitive market of Michigan Alkali.

Average prices are disclosed in the following tabulation:

Authority	Period	Production tons	Revenue	Average revenue per ton
Gas-Ice Corp.[1/]	1932-1944	14,650	$ 864,602	$ 59.20
U. S. Census[2/]	1937	156,600	4,618,937	29.50
" "	1939	178,400	5,532,315	30.90

1/ Based on actual sales and actual revenue.

2/ Production may substantially exceed actual sales and thus reduce average revenue. The revenues given are identified as "value" in the 1940 census report and may not represent actual sales.

Ashland, Oregon, plant:

The lithia water springs at Ashland are a source of natural carbon dioxide. The Gas-Ice Corporation of Seattle and Klickitat owns leases and land surrounding these springs and is now engaged in the construction of a second plant for the manufacture of dry ice. This plant will have an initial capacity of 5 tons per day, which will be increased to 10 tons per day as soon as the exigencies of the war will permit. It is also contemplated that both the Klickitat and the Ashland plants will in a few years be increased to 20 tons daily capacity each.

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MERCURY IN SEPTEMBER 1944

According to the U.S. Bureau of Mines monthly mercury report released November 3, 1944, production and consumption of mercury in September showed no change from the 2500 and 3900 flasks, respectively, reported for August and, as a consequence, stocks again decreased notably. The Abbott, New Idria, New Almaden, Mt. Jackson, and Reed mines in California, the Cordero in Nevada, and the Bonanza in Oregon produced 84 percent of the September total. Eleven other mines that produced more than 15 flasks each are as follows: Ord and Pine Mountain in Arizona; Helen, Mirabel, Knoxville, Guadalupe, Culver-Baer, and Altoona in California; Red Rock in Nevada; Horse Heaven in Oregon and Waldron in Texas.

Salient statistics on mercury in the United States in 1939-43 and in January-September 1944, in flasks of 76 pounds each

Period	Production	Consumption	Stocks at end of period: Consumers and dealers 1/	Stocks at end of period: Producers 2/	Price per flask at New York
	Average Monthly				
1939 . . .	1,553	3/ 1,742	12,600	376	$ 103.94
1940 . . .	3,148	2,233	14,100	607	176.87
1941 . . .	3,743	3,733	12,400	439	185.02
1942 . . .	4,237	4,142	10,700	1,377	196.35
1943 . . .	4/ 4,327	4,542	13,200	3,457	195.21
	Monthly				
1944:					
January	4,400	3,400	11,300	5,459	151.60
February	3,800	3,700	9,400	5,450	130.00
March	3,800	3,600	9,900	5,011	130.00
April	3,700	3,200	9,700	5,604	128.20
May	3,400	3,100	8,900	6,171	115.54
June	3,000	3,400	9,000	5,757	101.69
July	2,700	3,000	9,300	4,025	100.56
August	2,500	3,900	9,100	2,252	104.04
September	2,500	3,900	8,400	1,936	104.28

1/ Largely excludes redistilled metal. 2/ Held by reporting companies. 3/ Apparent consumption. 4/ Based on final figures.

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CH-82 -

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