109 Degrees Below Zero

A scientific gift horse and what happened when industry looked it in the mouth. Dry ice: its pioneering past, its warring present, its brilliant (but unproved) future.

DRY ICE is, among other things, a Case History. A Case History which shows, vividly and in small compass, what characteristically happens when Science hands over to Commerce a phenomenon. It illustrates one of Science's gifts to Industry—and some of the troubles resulting from looking the gift horse in the mouth.

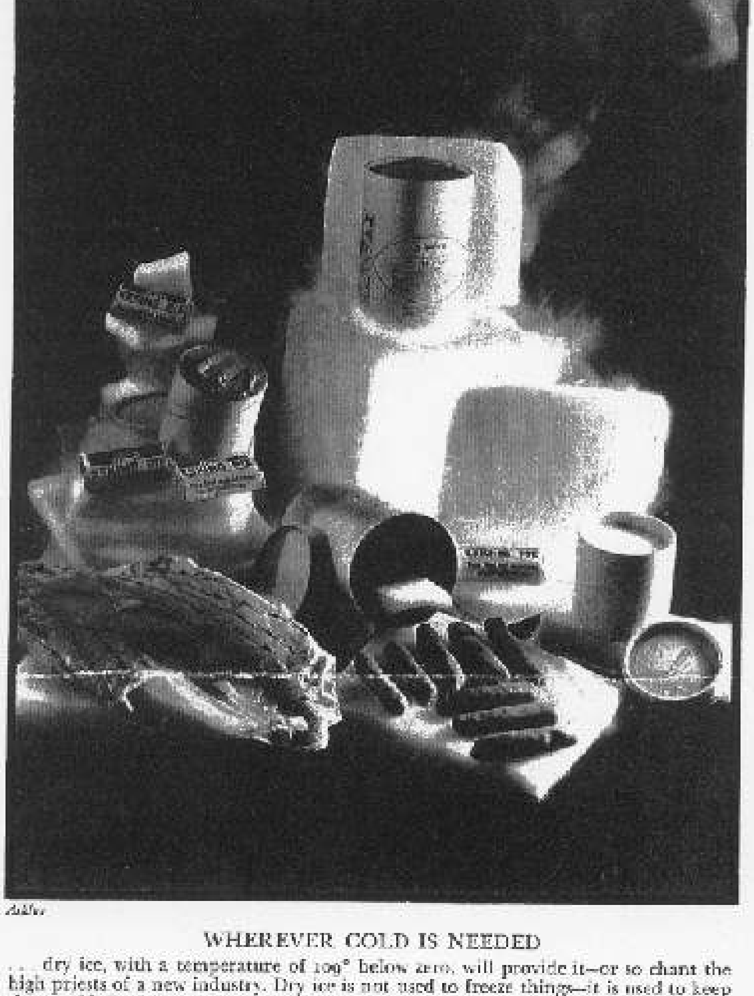
Dry ice is, among other things, a Boom.

It began in the middle '20's. It took the crash in its stride; there is no downward hook to the soaring curve of its consumption—1930: 70,000,000 pounds; 1931: 90,000,000 pounds; 1932 estimated: 120,000,000 pounds. Those are not large figures. But they're exciting.

There is something refreshing about talking to a dry-ice man. He will grumble to you about price cuts and overproduction (in an industry that didn't exist eight years ago!). But he hasn't lost his taste for dreams. He speaks as men spoke when the world was young and Steel sold for $45.

Rightly speaking "Dry-Ice," the name, is the property of a company called the DryIce Corp. of America. But it's such a good name, so right and proper, that already common usage has made it generic. Dry ice is today's name for solid carbon dioxide. At ordinary pressure and temperature carbon dioxide is, of course, a gas. But, sufficiently compressed and cooled, it changes first to a liquid and then to a solid. A piece of solid carbon dioxide looks almost exactly like a smooth-cut and tightly-packed cake of snow. But it has two important differences. It is very much colder, for solid carbon dioxide has a temperature of 109° below zero. Also it does not melt. It sublimes—that is, it passes directly from the solid to the gaseous state. Thus one cubic foot of dry ice turns into 450 cubic feet of carbon dioxide, leaves behind it no pool, no puddle. These characteristics of carbon dioxide were familiar physical facts in the middle 19th century and constituted nothing more exciting than a dull laboratory experiment.

Furthermore a cubic foot of dry ice changing from solid to gas, absorbs twice as much heat as is absorbed by a cubic foot of water ice changing from ice to water. And the large volume of gas formed in this process is cold, inert, heavier than air, and heat-resisting. The blanketing effect of the cold gas is itself such a potent cooling agent that dry ice may be not twice but ten times as efficient as water ice. And, finally, with its small bulk and light weight, dry ice is particularly suited to any kind of refrigerated transport. So there were many good reasons for the general application of dry ice.



Adler

WHEREVER COLD IS NEEDED

. . . dry ice, with a temperature of 109° below zero, will provide it—or so chant the high priests of a new industry. Dry ice is not used to freeze things—it is used to keep them cold. Its biggest customer is the ice-cream industry, especially the ice-cream manufacturer who makes large shipments by truck. But fish and meat, frozen and unfrozen, may also travel under dry-ice chaperonage. And the dry-ice man, optimistic, foresees the day when railroad refrigerator cars will substitute CO_2 for H_2O.

BUT the ointment had two flies. One was cost. The other was inertia. In its early days, dry ice sold at a little better than five cents a pound. This is $100 a ton. Water ice sells at around $4 a ton. Nearly all innovations cost more than what they replace, but not by a 25-to-1 (or a 12½-to-1 B. T. U. basis) ratio. Then the price of dry ice came down. It dropped to three cents a pound, which still left the dry-ice maker a good profit and gave the dry-ice business one enthusiastic customer—the ice-cream industry. But transporters of other perishable commodities remained largely committed to water ice. The railroads—greatest transportation agents—had (and have) a large investment in refrigerator cars designed for water ice only; also in water-ice plants along their right of way. The new thing always conflicts with the habit of doing things the old way. With dry ice the conflict is particularly sharp, since dry ice is a direct substitute for water ice, and the water-ice industry is an old and well-established industry which has already felt the impact of one scientific invasion and emerged bloody but unbowed. In the transportation field its railroad affiliation gave it a particularly intrenched position. So the new industry had plenty of trouble. Which it complicated by its own too rapid expansion, internal competition, litigation.

Yet dry ice still has both its prospects and its prospectus. Its accomplishments to date have indeed encouraged the most sweeping predictions regarding its future. It is not the 50,000 tons of the present but the 3,500,000 tons of the future that the dry-ice maker visualizes in his prophetic moments—not an industry with sales of $4,000,000 per annum, but with sales of $200,000,000. This tonnage, in his expansive moments, he estimates as follows:

Use	*Annual consumption, tons*
Carbonating beverages	44,000
Transport of fresh fruits and vegetables	37,500
Refrigeration of ice cream	150,000
Refrigeration of frozen foods	1,500,000
Express and truck shipments of unfrozen meat	90,000
Refrigeration carload shipments of perishable foodstuffs	1,800,000

Remember that these are optimistic estimates based on a very long pull and that the DryIce Corp. itself, largest unit in the industry, characterizes them as a most generous forecast of a most distant future. Present refrigerator cars, even if all dry iced, would not carry the estimated tonnage (1,800,000 tons) and there seems to be considerable duplication in the frozen-food and carload shipment items. But do not forget that in less than seven years dry ice has replaced something in the neighborhood of 500,000 tons of water ice and that its constantly (not to say violently) lowered costs are opening to it constantly widening markets.

ALTHOUGH dry ice today is used almost exclusively as a refrigerant, the earliest patents for the solidification of carbon dioxide were granted for a very different application. They were taken out in 1897 by one Herbert Samuel Elworthy, a doctor in the British Army Medical Corps. Dr. Elworthy, like many another Britisher, doctor, and army man, was fond of whisky and soda. But when he was stationed in Bandra, India, he found it almost impossible to maintain a supply of Vichy, and therefore made use of liquid carbon dioxide in cylinders. The liquid carbon dioxide was altogether satisfactory from the standpoint of manufacturing soda water, but Dr. Elworthy did not like to haul around 100-pound liquid carbon-dioxide cylinders, especially since they contained only fifty pounds of carbon dioxide. He therefore decided to solidify the liquid, thus getting his carbon dioxide in lighter, more compact, and more portable form. The Elworthy patents have long since expired, and solid carbon dioxide is not primarily destined for the use to which the doctor put it, although in the spring of the present year the DryIce Corp. has revived the Elworthy idea and arranged to supply Coca-Cola bottlers with solid carbon dioxide. But Dr. Elworthy was not thinking of dry ice as a cooling agent, and the first U. S. sponsor of commercial carbon dioxide was also interested in the liquid and gaseous as much as in the solid form.

Acme—P. & A.

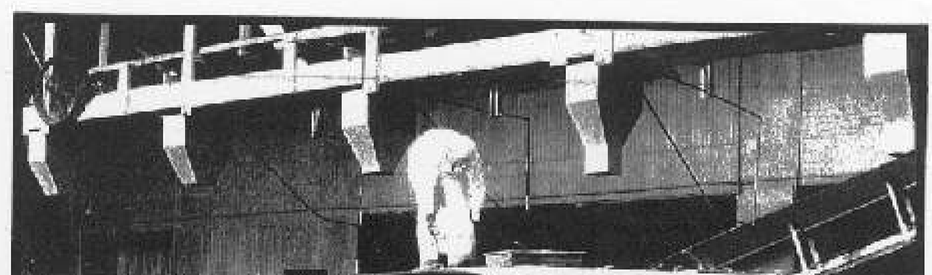
BUT FOR AUGUST HECKSCHER

. . . there would probably be no dry-ice industry today. For young industries, like young artists, need powerful patrons.

THIS sponsor was the Prest Air Devices Co., a company formed in Long Island City in 1923.

This company may best be described as being in the device business, as it was managed by an inventor who invented the devices and a promoter who promoted them. The inventor was Thomas Benton Slate, who had spent many years in the oil and natural-gas districts of the Southwest and had emerged with large ideas concerning the widespread utility of carbon dioxide in the home. He invented a fire extinguisher which was to put out fires by squirting compressed carbon dioxide on them; a siphon that was to be used in carbonating home-drunk beverages, a pump to inflate auto tires, and a grease gun. The promoter was Walter L. Josephson, who christened carbon dioxide "prest air," and took a double page in the *Saturday Evening Post* to advertise the merits of the Prest Air Fire Extinguisher, the Prest Air Home Siphon, the Prest Air Auto Tire Pumps, and other members of the Prest Air family.

But Prest Air Devices Co. did not much prosper. It was essentially a novelty business with its sponsors creators rather than constructors. The tire pump was subject to the handicap that carbon dioxide is one of the few gases that will leak through rubber, so "prest air" was not well calculated for inflating tires. The grease gun also had a bad habit of carbonating the grease. And there did not seem to be any lively domestic demand for squirting carbon dioxide into either tires or soda. Besides, the business suffered badly from lack of integration. Messrs. Slate and Josephson bought their carbon dioxide, already compressed, from General Carbonic Corp. It came in cylinders containing fifty pounds of carbon dioxide, the Prest Air company then transferring it into Prest Air containers which held fourteen ounces. Unfortunately, their methods of extraction were so crude that



CAUGHT IN CHARACTER

Seeing that trucked ice cream does not melt in transit is the most valuable function that dry ice has thus far performed. The ice-cream maker uses more than 75 per cent of all the dry ice consumed.

they were returning the fifty-pound cylinders still containing about ten pounds of carbon dioxide, for which they wanted a credit from General Carbonic. So General Carbonic sent them a Mr. George C. Cusack, who showed a more efficient method of emptying the cylinders and was invited to join the company on the strength of this demonstration.

Mr. Cusack did not think very much of the several Prest Air gadgets, so Mr. Slate exhibited to him another possibility in the Prest Air future. This was a cake of carbon dioxide in solid form. At first the solid carbon dioxide did not impress Mr. Cusack either. He had seen carbon dioxide solidified in college chemistry classes, and although he may have known that epidermis specialists were using solid carbon dioxide in the treatment of warts, this function probably would not have appealed to him as a major industrial use. But ah, said Mr. Slate, solid carbon dioxide is also a great refrigerant. The Prest Air company had added to its staff a Mr. A. R. Whaley, who had been a vice president of the New Haven Railroad and an honorary vice president of the New York Central. Mr. Whaley had interested one J. W. Norcross of the Canadian Steamship Lines, and Mr. Whaley and Mr. Norcross were going to get the railroads to try out solid carbon dioxide in their refrigerator cars. So on the strength of the potential railroad business (still a great dry-ice talking point, but still potential) Mr. Cusack joined the Prest Air company. He arrived in January, 1924, just prior to the first big railroad experiment.

Fish from Halifax

If Mr. Whaley had located somebody in the Southern Pacific Railroad or the Santa Fe the railroad tryout might have been a conclusive demonstration. But Mr. Norcross, with his Canadian affiliations, wanted the experiment to be conducted on Canadian soil. So in the dead of winter Prest Air borrowed two refrigerator cars from Merchants Despatch (the New York Central refrigerator-car subsidiary), loaded them with dry ice instead of water ice, and made four shipments of fish from Halifax to Montreal. The fish arrived in perfect condition, but the weather was so cold that Mr. Slate might almost have produced the same result if he had loaded the car with the tire pumps instead of the dry ice. Thus the demonstration might not have convinced a skeptic. But the Prest Air people were not skeptical and, greatly encouraged, went back to Long Island City brimming with plans for the large-scale production of solid carbon dioxide. These plans Mr. Slate soon got into tangible form, and the Prest Air company was ready to go into solid carbon dioxide as its major product. But the Long Island City plant was not big enough for this purpose, so Prest Air blossomed out with a fine new factory in (again because of the Canadian influence) Montreal.

Since this new plant cost money and since not a dollar's worth of dry ice had yet been merchandised, the advent of the new plant signalized the fact that Capital must have made its appearance in the carbon-dioxide enterprise. And Capital—persuaded by Messrs. Whaley and Norcross—had indeed appeared, personified in no less a capitalist than August Heckscher. So the dry-ice business, like so many young businesses, had risen to what might be called the Backer Era.

Acme—P. & A.

Keystone

Keystone

PILGRIMS OF DRY ICE

Thomas Benton Slate (above), who visioned carbon dioxide in every home and solid carbon dioxide in every refrigerator car. But who left dry ice and turned to dirigibles before the dry-ice dream came true.

Walter L. Josephson (left), who promoted Mr. Slate's visions, and told the U. S. public about carbon dioxide with full-page magazine advertisements, but whom the dry-ice business also left behind.

And Mr. Frank G. Shattuck (right), of the Schrafft's Stores (restaurant and confectionary chain), who gave the young dry-ice industry its first customer. And Mr. Shattuck still uses dry ice.

Backer Heckscher

At eighty-three, big-hearted, shrewd-brained Mr. Heckscher, bearded, spectacled, and Teutonic, is a great deal better known than either Prest Air or dry ice, and the solid carbon-dioxide venture is only one of the many corporate bodies into which Mr. Heckscher has breathed a financial being. Having made a fortune in the New Jersey Zinc Co. and accumulated much larger wealth in Manhattan real estate, particularly in the Murray Hill and Fifty-seventh Street districts, Mr. Heckscher in his later years has been most widely thought of as a philanthropist, with child welfare and slum abolition his major interests. But he has by no means ceased to be a capitalist, and furthermore a creative capitalist whose mind is still responsive to new enterprises. Whether solid carbon dioxide will eventually result in a net addition to or a net subtraction from the Heckscher wealth is still undecided. The management of the company has been subject to sudden and sweeping changes (the last one of which brought Mr. Heckscher's personal attorney to its presidency) which is some indication that solid carbon-dioxide progress has not been altogether satisfactory. But in 1924, dry ice was still in its dawn, and all dawns are proverbially rosy.

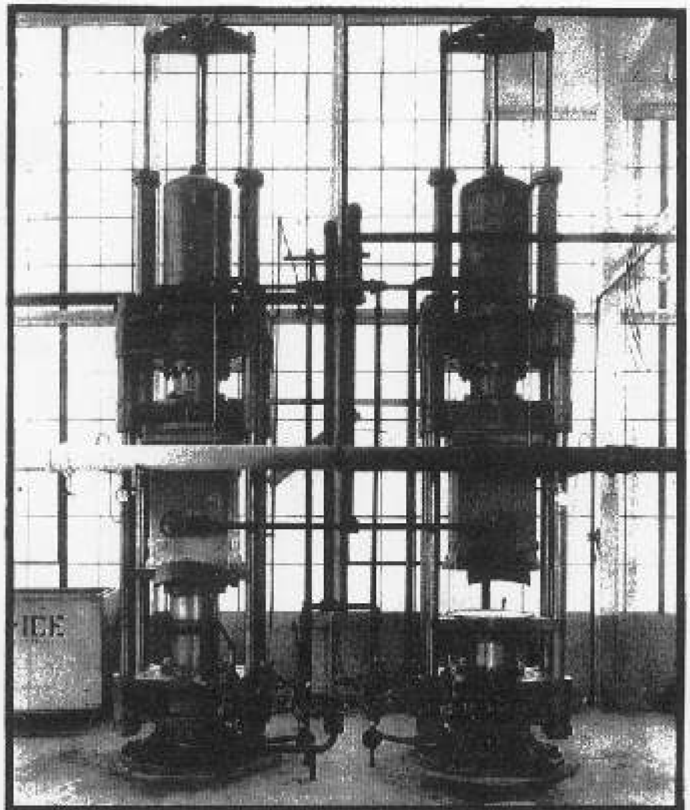
Departure of pioneers

Solid carbon dioxide, however, throughout 1924 and during the first half of 1925, showed no evidence of attaining any financial self-support. Mr. Heckscher satisfied the need for financial resources, but the management factor was still erratic. Although a considerable quantity of dry ice was being manufactured, not a single pound was being sold, and in October, 1925, Mr. Slate, who apparently had lost some of his enthusiasm for dry ice, just as dry ice had also lost some of its enthusiasm for him, left the company and went out to California. Later Mr. Slate, still inventive, turned up with a new and improved type of dirigible. In the spring of 1925 Mr. Heckscher eliminated the other original dry icer, Mr. Josephson along with a sales manager who was making no sales at $600 a week and an assistant sales manager who was making no sales at $200 a week. Mr. Whaley, of the original Prest Air company, became president. Mr. Heckscher also decided to leave the Prest Air family to its own devices, so he sold its gadgets to a Buffalo company. Thus ended the Prest Air period and thus began the more strictly dry-ice era under the sponsorship of DryIce Corp.

A customer

One of the first accomplishments of the DryIce Corp. was a feat never performed by Prest Air—namely, the landing of a customer. It was Mr. Cusack who did the landing, with Mr. Frank G. Shattuck of Schrafft's Stores in the customer's rôle. At this time (July, 1925) Schrafft's was experimenting with a package designed to keep ice cream hard between the moment of purchase and the moment of consumption. The package was a simple corrugated paper box, which was no great shakes as an insulating agent. Mr. Cusack, who had been doing some work on the problem of designing a container for Eskimo Pie, heard of Schrafft's difficulty and suggested that the ice cream container should also contain a little dry ice. Inasmuch as dry ice is unquestionably a potent refrigerant, the dry-ice Schrafft's package gave excellent experimental results and had a successful tryout at the 181 Broadway Schrafft's. But just before dry ice was to become a regular Schrafft's feature, an irate customer telephoned Mr. Shattuck. The customer, it appeared, had bought some carbon-dioxide-packed ice cream at 181 Broadway. His children had seized the package. They had eaten the dry ice. They had become deathly sick. But—and here the complaint took a new and unexpected tack—the gentleman who was doing the calling was an engineer who felt certain that he could provide Mr. Shattuck with a container which would be both efficient and innocuous. And he would be glad to call on Mr. Shattuck and show him how the trick could be turned. So Mr. Shattuck asked him to call, which he did. Who should he be but Mr. Josephson, late of the DryIce Corp.? Whereupon Mr. Shattuck decided that he would have no further commerce with dry icers, past or present, and called the whole deal off.

At this President Whaley became irked. He told Mr. Cusack that unless Schrafft's order were reinstated he, Mr. Whaley, would go to Mr. Heckscher with the advice that solid carbon dioxide was a snare and a delusion and the whole business had better be closed up right away. So Mr. Cusack tried designing a package from which it was difficult to extract the dry ice, and went down to Schrafft's with it. While he was demonstrating to John Shattuck (son of Frank G.), the father himself entered and announced that he would take no chances with carbon dioxide in any form and however packed. Desperate, Mr. Cusack snatched up a small fragment of solid carbon dioxide and began to chew it. Courageous, John Shattuck followed his example. The elder Shattuck, horrified, looked on with widening eyes. "Is there a trick to it?" he exclaimed as neither Mr. Cusack nor John Shattuck collapsed before him. And when Mr. Cusack, vigorously shifting his carbon-dioxide quid from one side of his mouth to the other (lest gum or denture be frozen) assured him that it was the veritable—but harmless—dry ice that was being masticated, Mr. Shattuck Sr. withdrew his objection. Whereupon Mr. Cusack and Mr. Shattuck Jr. thankfully expectorated the unevaporated portion of their refrigerating morsels—and dry ice went marching on.



Keystone, Los Angeles

SQUEEZING MOLECULES TOGETHER

. . . is an essential item in turning a gas into liquid or solid. Carbon dioxide liquefies at 0 degrees centigrade under pressure of thirty-five atmospheres. Above, a dry-ice compressor.

Dry ice cream

The DryIce Corp. later quarreled with Mr. Shattuck and lost his business, but Mr. Cusack had not chewed in vain. For the ice-cream manufacturer, awakened by Schrafft's experiment, realized that for him dry ice was indeed the ideal refrigerant.

Dry ice and ice cream are natural affinities, especially as traveling companions. Even when dry ice was selling at $100 a ton (five cents a pound), many ice-cream manufacturers preferred it to water ice at $4 a ton. Brine—a combination of water ice and salt, with the salt acting as anti-freeze agent—gives temperatures suitable for ice-cream refrigeration. But so much more brine than solid carbon dioxide is required for the same refrigerating purpose that cheapness is canceled by quantity, and the unwieldiness of the water ice remains as an added handicap to its employment.

Suppose you are shipping ice cream between New York and Philadelphia, and are sending it in five-gallon wooden tubs individually packed in ice. You will need about 100 pounds of ice and salt for each tub, and the total weight of tub, brine, and contents will be nearly 150 pounds, of which only about thirty pounds will be ice cream. But if you are refrigerating with dry ice, you can ship in five-gallon paper cartons, packing each with six to eight pounds of dry ice. Even when dry ice cost five cents a pound, you were using less than forty cents' worth of dry ice compared with about twenty-five cents' worth of brine. And you had a throw-away container with no empties to haul back.

On truck shipments, dry ice is even more advantageous. You can ship a 500-gallon truckload of ice cream about 60 miles a day with 1,200 pounds of salt and ice. The same trip, in a properly insulated dry-ice truck, needs only ninety pounds of dry ice. Here the difference between hauling the waste load of brine refrigeration and the pay load of dry-ice refrigeration is so great that you can use a two and one-half ton truck with dry ice in place of a three and one-half ton truck with water ice. So even at its pioneer prices, dry ice found a ready welcome from the ice-cream shipper and the DryIce Corp. had no longer a product without a market. First large manufacturing customer was the Breyer Ice Cream Co. of New York. Then came Abbott's Dairies, Inc., in Philadelphia, a group of Pittsburgh dairies, and a Boston confectionary chain. In 1925 the DryIce Corp. sold 269,000 pounds of solid carbon dioxide. It began to look as though Mr. Heckscher had picked another winner.

Troubles of expansion

But milking the dry-ice cow proved almost as hectic a process as giving it birth. In 1927, DryIce decided to stop purchasing carbon dioxide and to manufacture its own gas. So it built a $500,000 coke-reduction plant in Elizabeth, New Jersey, the carbon dioxide of course being given off by the burning coke. The plant was one of the largest coke carbon-dioxide producing centers in the world, and there was nothing at all the matter with it except that the carbon dioxide it produced cost more than the carbon dioxide which DryIce could buy from any one of a number of by-product carbon-dioxide producers. So DryIce eventually shut it down and charged the venture to profit and loss.

Centralized production thus having turned out badly, DryIce went in for decentralization with equal enthusiasm. It decided to put up solid carbon-dioxide plants at various points throughout the country adjacent to carbon-dioxide producers. As one large carbon-dioxide producer was Liquid Carbonic Corp. (which supplies carbon dioxide to soda fountains and is also a leading manufacturer of the soda fountain itself) DryIce and Liquid soon concluded a working agreement. The gist of the deal was that DryIce would build units next door to Liquid's many existing factories and would purchase Liquid's carbon dioxide for solid carbon-dioxide manufacture. Liquid paid $650,000 for 20,000 shares of DryIce stock on the understanding that the money was to be used in putting up DryIce production units. In the fall of 1929 DryIce started a plant in Los Angeles, thus completing a coast-to-coast set-up with seventeen plants and a (1929) production of 14,000 tons.

But before the Los Angeles plant was in operation, DryIce engineers changed their minds again. They decided that manufacturing in one or two centers was better after all, and recommended the abandonment of many units in the far-flung structure. This procedure naturally irked Liquid Carbonic. So, after much conference and controversy, Mr. Heckscher took back his 20,000 shares. In exchange for these shares, Liquid took over not only the Los Angeles plant but also the DryIce units in Liquid's factories. Thus all ties between the two companies were broken. Liquid decided to solidify its own carbon dioxide and entered the solid carbon-dioxide field as an immediate and potent competitor.

Disappearance of monopoly

Distribution deals that fell through and production facilities that did not produce might have been dismissed as merely the unavoidable growing pains of a new and uncharted enterprise. But from the very nature of the dry-ice business, large-scale competition was almost certain to appear. Both fermentation and combustion yield by-product carbon dioxide, and many are the manufacturers with a plentiful carbon-dioxide supply to tempt them into the solid carbon-dioxide business. And by 1929, with the ice-cream market well developed and with dry ice selling at five cents a pound, there was a distinct profit incentive for getting into the field. In 1930 the Publicker Alcohol Co., well supplied with fermentation carbon dioxide, organized the Delancey Chemical Corp. as solid carbon-dioxide subsidiary, sold its product under the name of "Thermice." An even earlier competitor was the Solid Carbonic Co., which got its carbon dioxide supply from Eastern Alcohol Corp. (du Pont subsidiary). And some ten to fifteen smaller competitors were invading, or about to invade, the dry-ice pasture.

Failure of patents

Alarmed, the DryIce Corp. sued Solid Carbonic, alleging patent infringement. DryIce Corp. never had succeeded in getting a patent on the manufacture of solid carbon dioxide, which was an old story long before even Prest Air Devices had been thought of. It had therefore based its monopolistic position on a patent covering what the patent application called "a manufacture." This "manufacture" was described as "a transportation package consisting of a protective casing of insulating material having packed therein a quantity of frozen carbon dioxide . . . and a quantity of freezable product in freezing proximity to said frozen carbon dioxide . . ." This complicated description covered an equally complicated maneuver—an attempt to remedy the lack of a patent on solid carbon dioxide by considering the carbon dioxide as a part of its package and thus patenting the two together. Since anybody attempting to sell solid carbon dioxide would be bound to sell it in a "transportation package consisting of a protective casing," etc., the DryIce claim was undoubtedly sweeping.

But the transportation argument did not stand the scrutiny of the U. S. Supreme Court. In the spring of 1931, the Court ruled that even if the DryIce package were patentable, there was nothing to prevent any other solid carbon-dioxide manufacturer from selling his product for use in it. This decision was followed by a further ruling that the package itself lacked "invention and novelty." Thus the DryIce Corp. lost all pretensions toward being a monopoly. And hardly had the Supreme Court's decision been announced when the DryIce Corp. was confronted with a new and powerful competitor—a competitor with a price policy which has thrown the entire industry into a confused and turbulent state. This competitor was the Michigan Alkali Co. of Wyandotte, Michigan (suburb of Detroit), and with the arrival of Michigan the dry-ice industry definitely graduated from DryIce Corp.'s control.

Michigan Alkali

It is a sure thing that John B. Ford Jr. never had to eat even his bicarbonate of soda in order to make a sale. For his father, grandfather, and great-grandfather were in Michigan Alkali before him, and Mr. Ford is now the fourth generation manager of a large, long-established, and closely-held family company. Michigan Alkali tells nothing about its business; since no public holdings exist, neither is there any necessity for reports of income, sales, or profits. But Michigan Alkali is second only to Orlando F. Weber's Allied Chemical & Dye in the production of soda ash and caustic soda (the leading members of the alkali family). And since, to put a complicated matter in oversimplified terms, soda ash plus silica equals glass and caustic soda plus fat equals soap, it will be seen that both the glass and the soap industries are Mr. Ford's large and excellent customers. With the glass industry his relations are particularly close, since Great-Grandfather Ford was first U.S. plate-glass maker and Grandfather Ford was the Ford of Libby-Owens-Ford, window-glass makers. In Libby-Owens-Ford the Ford interest remains large. In addition to supplying Libby-Owens-Ford with soda ash for windows, Mr. Ford also sells soda ash to Owens-Illinois for bottles, and Owens-Illinois manufactures 41 per cent of all U. S. glass containers (FORTUNE, April, 1932). As one of the foremost suppliers to two of our most basic industries, and with a business which in forty years of steady expansion now occupies 1,145 acres along the Detroit River, the Ford Family was a Detroit institution long before the automotive industry camped alongside it. And from the standpoint of a stabilized income subject to hardly more than a strictly family division, Michigan Alkali must be a much more profitable enterprise than many a company in which public ownership has aroused more public interest.

It was therefore a large industrial unit that Mr. Ford was bringing into the dry ice field, and it was also a very large carbon-dioxide producer. For perhaps the most basic operation in Mr. Ford's many operations is the combustion of limestone in which carbon dioxide is given off in very large quantities. Thus the problem which had so much perplexed the DryIce Corp.—the question of purchasing carbon dioxide versus rolling its own—never was a problem to Mr. Ford. It is, of course, inaccurate to say that Mr. Ford's carbon dioxide costs him nothing, particularly since he has gone to the expense of constructing, in one corner of his spacious domain, a fine new solid carbon-dioxide plant. And obviously it is not waste product or even by-product carbon dioxide that this plant is utilizing. But it is extremely low-cost carbon dioxide, since it is Mr. Ford's own limestone and his own

[*Continued on page 80*]

coke, gathered together by his own assembling facilities and manufactured on his own premises. Superlatives are always subject to question, but it would seem altogether reasonable that Mr. Ford can make his carbon dioxide more cheaply than any one can buy it and that in Michigan Alkali the dry-ice industry has discovered its lowest-cost producer.

Furthermore, Mr. Ford habitually thinks in large units. Dry-ice people usually discuss their product in terms of pounds. But you do not sell caustic soda or soda ash by the pound: you sell it by the ton. And Mr. Ford's carbon-dioxide plant (completed in April of the present year) will have a capacity of 150 tons a day, which is some 50,000 tons per annum, or more than the entire carbon-dioxide sales for 1931. Along with his ideas about large volume, Mr. Ford also has ideas about prices. When he entered the dry-ice business (May, 1931), the price, to the large user, had stabilized around three cents a pound. In the summer of 1931 (the summer months are of course the big selling season) the price dropped as low as 1.9 cents a pound, largely through Michigan Alkali's disruptive influence. The price went back to three cents again in the fall of 1931, but in the spring of 1932 the price war reopened. The largest users (such as Borden and National Dairy) can now buy dry ice for as little as one and a half cents a pound, and in the present season it is likely that most of the solid carbon dioxide sold will be disposed of at below the two-cent level. Many of Mr. Ford's competitors maintain that neither Michigan nor any other dry-ice producer can make money on one-and-a-half-cent dry ice, and it may well be that the two-cent figure represents a more logical point of ultimate stabilization. On the other hand, with the disappearance of old prices there has come a newly revived interest in new markets.

Possibilities of dry ice

All of which brings us back to the matter of ultimate dry-ice consumption—a topic best introduced by the repetition of the potential table already set

109 Degrees Below Zero

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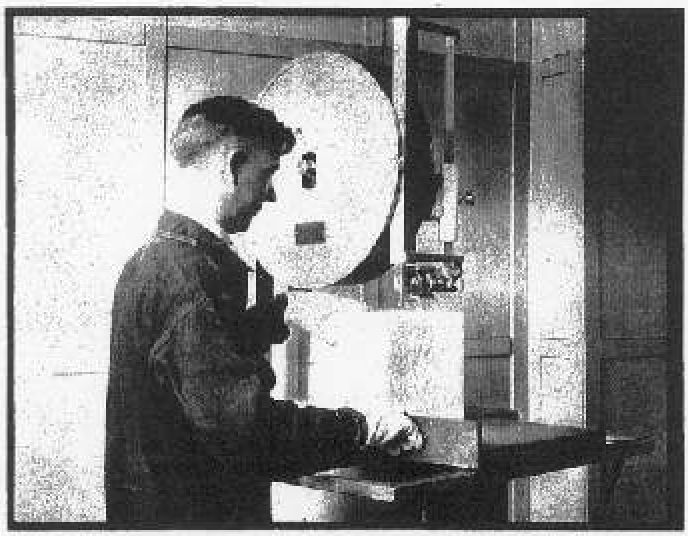

HANDLING WITH CARE

. . . . is doubly important when dry ice is the material handled. Not only is it so cold that it burns, but it evaporates so rapidly that nearly 25 per cent of total production is prematurely lost.

up as representing dry-ice's self-prophecy:

Use	*Annual consumption, tons*
Carbonating beverages	44,000
Transport of fresh fruits and vegetables	37,500
Refrigeration of ice cream	150,000
Refrigeration of frozen foods	1,500,000
Express and truck shipments of unfrozen meat	90,000
Refrigeration carload shipments of perishable foodstuffs	1,800,000

This estimate evidently depends largely upon the use of dry ice in connection with frozen foods and carload lot shipments, as these two items make up 3,300,000 tons in an estimated 3,621,500 ton total. Suppose, then, we examine the two uses by which dry ice hopes chiefly to develop.

Frozen foods

The frozen-food use of dry ice depends upon the development of the frozen-food business itself, which is an example of one infant industry looking optimistically toward another. Present dry-ice consumption is almost negligible. Mr. Clarence Birdseye of Frosted Foods, Inc. (General Foods subsidiary and owner of Birdseye Quick-Freezing Process) is the great exponent of frozen foods other than fish; Mr. Harden Taylor of Atlantic Coast Fisheries is chief freezer of fish. Mr. Birdseye uses possibly 400 tons of solid carbon dioxide per annum. Frozen foods are not frozen with dry ice, since ammonia freezing is just as satisfactory and much cheaper. And carload shipments of frozen foods are preserved not with dry ice but with brine ice or with mechanical refrigeration. Dry ice is used in frozen-food "holding rooms"—small and portable containers which the quick freezer takes with him on his food-freezing excursions, and in which he keeps his frozen foods provided no large and mechanically refrigerated storage plant is available. And dry ice is also used in the trucking of frozen foods. So Mr. Birdseye is undoubtedly a dry-ice consumer and both applications of dry ice to the frozen-food business will show large increases as soon as Mr. Birdseye's rapidly growing business supplies a sufficient volume of perishable cargo. In 1931 the Birdseye company froze 10,000,000 pounds of food. This is an infinitesimal portion of U. S. food consumption, and the frozen-food industry has theoretically an almost limitless expansion. But it will have to sell many billions of pounds of frozen food before using as much solid carbon dioxide as the dry-ice prophet estimates.

Silica gel

As for Mr. Taylor of Atlantic Coast Fisheries, here again dry ice may be used in trucking and display, but currently has small prospects in railroad shipments. For although Mr. Taylor is experimenting with a more modern refrigerant than brine, dry ice is not the only refrigerating novelty. Mr. Taylor's frozen fish travel in special refrigerator cars built for the use of what is called the "silica gel" refrigerating system. Silica gel is not itself a refrigerant; it is a very porous sand-like substance whose chief property is a great capacity for soaking things up. It is used in combination with any liquid refrigerant (ammonia, sulphur dioxide, methyl chloride, or even liquid carbon dioxide) and absorbs the vapors given off by the evaporating liquid. This absorption permits further evaporation and therefore further refrigeration. When the silica gel has absorbed as much vapor as it can carry, it is heated; the heat drives out the vapor and the silica gel is again dry and ready to resume its sponge-like function.

The progress of silica gel is obviously a direct menace to dry ice. For here is Mr. Taylor, otherwise an ideal dry-ice customer—for his frozen fish are particularly perishable—preferring silica gel, largely because the evaporation of the refrigerant is more readily controlled and a uniform temperature more easily established. Also, the silica gel sponsors have gone into the manufacture of silica gel trucks; thus compete with dry ice in the latter's most profitable application. Here, incidentally, is another characteristic hazard of the new-way producer—some still newer novelty may at any time arrive to split the market.

Unfrozen carloads

As for carload shipments of unfrozen foods (particularly meats, with Swift, Armour, Cudahy, and Wilson as largest ship-

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pers), here dry ice collides with an ultimately economic but immediately immovable obstacle. There are in this country about 180,092 refrigerator cars. Of these, 180,000 are built for water ice only, eighty comprise the silica gel fleet, and only twelve (built by the American Car & Foundry Co.) are designed for solid carbon dioxide. It is possible to work out an excellent theoretical case for the dry-ice cooling of refrigerator cars, particularly with dry ice at two cents a pound or less. For, assuming proper insulation, the dry ice may well be ten times as efficient as brine; and at two cents a pound it costs only ten times as much—and saves the expense of hauling so much weight. For the time being, however, the argument is entirely theoretical. Dry ice is not efficient in the *ordinary* refrigerator car, for such a car is not well enough insulated to preserve its cooling gas blanket. So evidently there will be no general use of dry ice in carload refrigeration until a sufficient number of dry-ice cars are built.

Furthermore, there is no good reason why the railroads should immediately go in for the large-scale construction of dry ice cars. They not only control many of the companies which build and operate refrigerator cars of the usual type, but they also have investments in most of the ice companies which supply ice for carload shipments. In the last five years the Pennsylvania Railroad alone has spent $22,000,000 on its refrigerator-car and icing facilities. The railroads have therefore a very large investment in the existing order and every motive for opposing its change. There is also the possibility that if a change does come it will be not along the line of dry ice but along the line of the mechanically refrigerated car, such as the silica gel cars already used by Atlantic Coast Fisheries. Conversion of refrigerator car shipments from brine to dry ice will therefore be at best a slow and a long process, and although it is the largest it is also the most remote of the dry-ice prospects.

Yet it should also be noticed that dry ice may well have the right on its side, from the standpoint of possessing an inherent economic advantage which will ultimately force itself even upon railroad conservatism. The use of water ice does involve a large waste load and does take up with the refrigerant space which might better be occupied by the commodity refrigerated. It may be that this inefficiency does not appear on the surface of present freight-rates, but nevertheless the shipper ultimately does pay for them. And the inertia of existing conditions is never sufficiently powerful to be also perpetual.

EVEN aside from its railroad potentialities, dry ice has ample room for expansion along lines in which its future should be more easily realized. Whatever the railroad may think of dry ice, there is no question but that the truck has taken to it very kindly indeed, and the marked increase of truck-hauled merchandise has been the most significant development in recent transportation trends. In the summertime trucking of perishable foodstuffs, particularly meats, dry ice has one of its most rapidly growing applications. Nor has dry ice by any means exhausted its ice-cream possibilities. For the ice-cream industry now uses not more than 30,000 tons of dry ice per annum and there would seem to be little reason why dry ice should not rapidly realize its 150,000-ton per annum goal. Meanwhile the DryIce Corp. has just brought out an apparatus whereby carbonated beverages may be charged with carbon dioxide directly from the solid. And the Atlantic & Pacific stores have agreed to dispense dry-iced ice cream kept in special dry-iced cabinets. It is pretty difficult to visualize any 3,000,000-ton dry-ice year for a good many years to come. But it is equally difficult to regard the present 60,000 ton consumption as anything more than the current milestone on a road of which the greater part has yet to be covered.

DRY ICE IN COCA-COLAS

Coca-Cola bottlers and the DryIce Corp. have just concluded an agreement whereby solid carbon dioxide is used to carbonate the pause that refreshes.

Stabilization of dry ice

Meanwhile the dry ice industry itself has entered upon a comparatively stabilized period. In April, 1932, the DryIce Corp. took over two competitors (Solid Carbonic and Cold Carbonic) and was said to be dickering with the Delancey Chemical Corp., the dry-ice subsidiary of Publicker Alcohol. Should the Delancey deal go through, the major eastern dry-ice companies will present a united front against their mid-western rivals, and the industry will be very largely in the hands of Michigan Alkali, Liquid Carbonic, and DryIce Corp., although Mathieson Alkali, a company very similar to Michigan, has also gone into solid carbon dioxide and has a large distribution in the Southeast. The DryIce Corp. now feels that its days of trial and error are ended, and that its experience, however costly, now gives it a considerable advantage over its newer rivals. In 1931 it sold more than twice as much dry ice as all its competitors combined, and with its recent mergers it has strengthened its position as chief dispenser of solid carbon dioxide.

Even if Mr. Ford has a lower cost carbon-dioxide *gas*, DryIce does not admit that he has a lower-cost *solid* carbon dioxide. Moreover the DryIce Corp. thinks that the raw material and the manufacturing end of the business is no longer its vital spot but that the problem of distribution has become the major factor. Mr. William Miller Laughton, DryIce's production head, estimates that in 1931 one pound of every four pounds of carbon dioxide manufactured was lost through evaporation—vanished into thin air and refrigerated nothing more than the U. S. atmosphere. And it is his belief that DryIce Corp. is superior to its competitors in the handling and merchandising of its elusive product. On the other hand, however, Mr. Ford of Michigan is always to be reckoned with. Where other manufacturers shake their heads over two cent dry ice, think that $45 a ton (two and a quarter cents a pound) is the lowest price consistent with a profit, Mr. Ford is selling dry ice as low as one and a half cents, although at what profit or for how long are questions difficult to answer. His competitors say that even a two-cent price is an uneconomic figure. Mr. Ford says nothing; sells dry ice at one and a half cents.