PHYSICS- ENGINEERING

Ice Meets Its Match

A Canadian Physicist is Using His Knowledge of the Behavior of Ice to Combat Winter's Paralyzing Cold

MAN'S great enemy at this season of the year is ice. Ice has ended for several months commerce between some of the most progressive nations. Their rivers and harbors are closed to vessels.

Ice is piled high in jams in important rivers so that cities along their banks are flooded. Icebergs are being born that in the spring will threaten the commerce of the world's most used ocean traffic lane. Airplanes are covered with ice and forced to descend. Even sidewalks and highways are sleeted to bring danger to man as he moves about. His wires of communication are swept down by ice.

But now a real effort to combat these forces of nature, against which man has been practically helpless for all time past, is being organized. It depends upon a material which has been used in industry for more than a quarter of a century as a heating agent for welding metal, while its possibilities as a weapon against ice were unknown. It is thermit, a substance which will generate in the heart of an iceberg a temperature nearly as great as that of the sun itself. Its application to the struggle against ice has been discovered in recent years by Dr. Howard T. Barnes, of McGill University, Montreal, who is still experimenting to find ways of using it most effectively.

As reinforcements to powerful thermit, are substances familiar to us all but of little use in the fight against ice until Dr. Barnes tested them and learned how to apply them to get the best results. There is sodium chloride, better known as common salt; calcium chloride, its first cousin; calcium carbide, the chemical that generates acetylene in the farm gas plant; and sulphuric acid. Even gravel, ashes, cinders, carbon, lamp black, and corn syrup are finding a place on the firing line against ice.

The story of how Dr. Barnes found that thermit is so effective against ice carrys one back through a life-long study of this weapon of nature during which man learned some surprising facts about ice—facts that few of us know today.

For example, it has been shown that water is not the simple substance of two atoms of hydrogen and one of oxygen that the older chemistry books teach. Simple H_2O can exist only as dry steam, it has been found, while ice is a molecule made up of three groups of the two hydrogen and one oxygen atoms. Pure liquid water is the double molecule, H_2O, taken twice, but it can exist only just before water turns into dry steam at the critical temperature of about 695 degrees Fahrenheit.

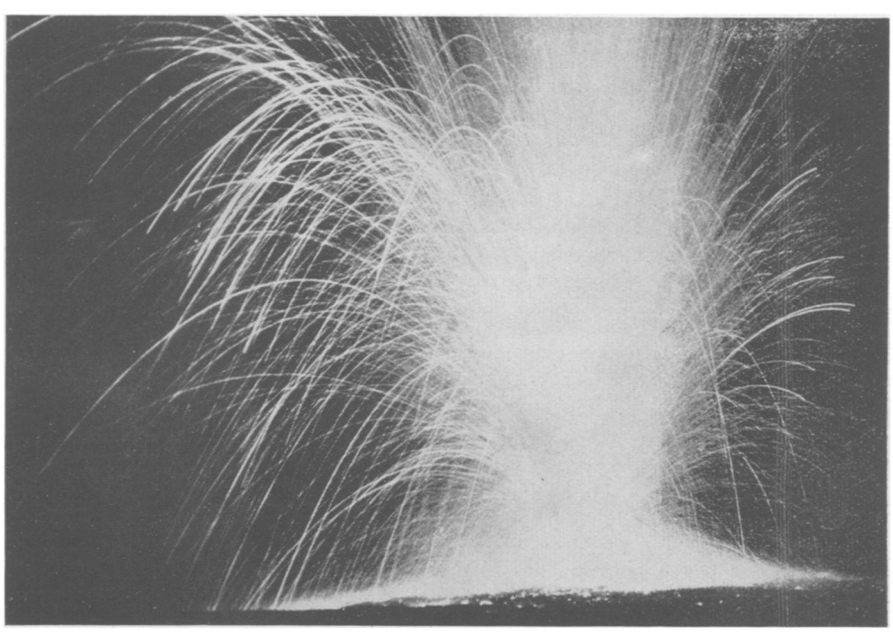
Water, as we know it, is really a mixture of the double molecule and triple molecule. At normal atmospheric temperatures it contains about 30 per cent. ice, the triple molecule, in solution, but these particles of ice are so fine that they cannot be seen through a microscope. At the freezing point, however, the percentage of triple molecules increases and they begin to collect into groups large enough to be seen under the microscope.

This explanation of ice and water has made understandable the readiness with which water supplying power houses in the north freezes and clogs the gates and water wheels. It is this frazil ice which causes trouble for the water power operator, and Dr. Barnes explains it thus:

"It only requires a few thousandths of a degree change in temperature in a stream to stop the operation of the largest water power development or to dam a mighty river and divert it from its course. Nowhere can one find a better example of the delicate poising of the forces of nature, since within the limits of so small a fluctuation such tremendous physical effects are produced.

"With the first cold weather in the autumn when the water comes to the freezing-point there is often a very large and sudden formation of frazil, the ice that accumulates from the minute particles. The explanation of this is exceedingly simple when we realize that the entire body of the stream is nearly 40 per cent. colloidal ice before freezing and coagulation takes place, when the temperature of the water has dropped a few thousandths of a degree.

"This mass of ice rapidly coagulates into streamers and subsequently into lumps and large clots which are carried in the current to great distances. So abundant is this formation that within a



THE SLOWEST EXPLOSION

With a wonderful pyrotechnic display thermit begins a disintegrating action that will be felt for days.

few minutes the whole stream may appear to be loaded with sand. During this time of supercooling these clotted masses of colloidal ice grow rapidly and freeze to any object with which they come in contact."

So slight is the temperature change required to melt frazil ice that energy enough to dispel it is contained in the light of the sun. Frazil forms over night, but in the early morning the radiant energy supplied by the sun loosens solidly frozen ice crystals and causes small ice particles to disappear.

Scientists have learned other strange things about ice and water. For instance, they have found that water will not always freeze even though its temperature is kept 10 or 15 degrees below the freezing point for hours. In experiments at the Ice Research Institute at Morrisburg, Ontario, water in a tank was cooled far below freezing and at the end of a half hour a pail of ice was taken out. But before another pail of ice was frozen a whole hour had passed, and two hours were required to freeze the third pail. Four hours later on ice had been produced.

"This extraordinary result," Dr. Barnes says, "can be explained on the colloidal theory. It is evident that a nucleus is required for the colloidal ice mass, and after exhausting these nuclei, the formation of further ice is rendered difficult."

Stranger yet, this same water could be made to freeze readily again by warming. After it had been raised to room temperature and then cooled it would form ice as easily as before. Apparently the first freezings used up all the triple molecules in solution and more were quickly formed when the water was brought back to room temperature.

THERMIT UNIT

Which will be sunk in the ice to tear away a jam.

Armed with such facts as these about ice, Dr. Barnes was prepared to pick the best weapons with which to fight it. For ice jams in rivers, ice blocking harbors and icebergs he chose thermit as his chief weapon.

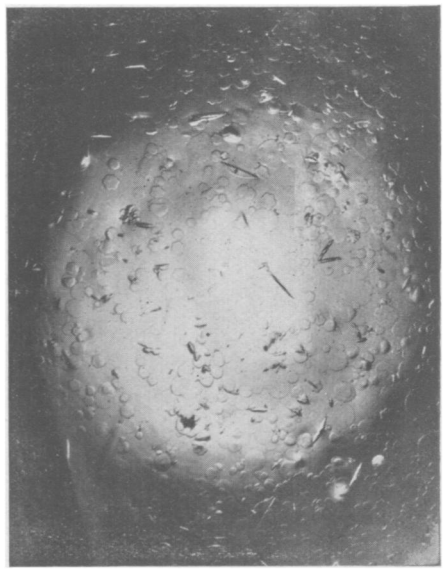
Thermit is a mixture of aluminum and iron oxide. It is cheap, easily obtained and easily handled. When ignited it explodes slowly and gives off an intense heat. A mass of molten iron is produced that is too bright to look at except with dark glasses. The temperature varies from 4,500 to 6,300 degrees Fahrenheit and is reached in a few seconds.

The aluminum reacts with the iron oxide and liberates molten iron. As soon as the white-hot flowing iron touches the ice or water a second chemical change takes place which breaks up the water into oxygen and hydrogen. The freed hydrogen burns in the air to produce a fantastic volcanic effect. Thus thermit gives two important essentials for ice fighting—heat and explosion. But the explosion makes little or no noise and is admitted by experts to be the slowest known. It will last for several seconds.

The reaction, then, is so intense that it affects ice the same way the sun does. Very little ice is actually melted. The important fact, as explained by Dr. Barnes, is that the energy pours out in a penetrating heat ray which overcomes the exceedingly small temperature effects responsible for the pranks and inconveniences caused by ice. It is possible to see thermit heat units glowing through several feet of water and ice masses, which proves the penetrating power of the radiation.

Thermit does not immediately tear away an iceberg or a river jam. It so cracks and weakens the ice that its effect is felt for several days after the actual explosion. When applied at the proper points as indicated by a thorough study of the problem, it is said to produce better and more economical results than any other form of explosive.

A big victory for thermit was the breaking up of a 25-mile ice jam in the Allegheny river which threatened to flood Franklin and Oil City, Pa. Five tons of thermit costing $6,000, reinforced with dynamite, calcium chloride, ashes, sand and gravel were used. A steel bridge which had been raised by the ice 18 inches above its masonry foundation was lowered back in place without being swept aside by the jam. The effect of thermit on icebergs has also been listed by Dr. Barnes.



PURE WATER

To the naked eye, but the microscope reveals thousands of tiny ice particles. Such knowledge of how ice forms is enabling engineers to fight it more successfully.

Other weapons in the warfare against ice do not have as immediate or as powerful an effect as thermit but when properly used they will more than repay their cost and the trouble of applying them. When the ice of a river is treated during winter months by these methods the spring break-up is hastened by at least two to three weeks. Certainly the opening of traffic to a large seaport half a month early is worth thousands of dollars.

Calcium carbide, calcium chloride, and sodium chloride have a powerful action in rotting and destroying surface ice in the coldest weather and they leave it so weakened that it offers no resistance to an ice shove. Young ice can be destroyed in a few minutes and channels for shipping opened in proportion to the economic desirability of such work.

Even gravel, ashes and cinders, which are often used to help clear the sidewalks, have a larger application. Together with charcoal and lampblack they are very useful scattered on surface ice where they draw the sun's heat and so hasten the destruction of ice jams.