that objects may be kept immune from the ice by a small application of heat.

Anchor Ice.—This ice grows in situ on objects immersed in water and subjected to cooling by radiation at night. It also grows by the sticking down of frazil crystals. Anchor ice grows in weed-like forms, and when sufficiently thick often rises up under its own buoyancy and brings up stones, weeds and mud. The sun has a wonderful influence on this ice. No sooner have the sun beams penetrated to the bottom of a river than up comes the anchor ice, melted off by a minute temperature elevation, too small to be recorded except on the most sensitive electrical thermometer. Anchor ice is known as "ground ice" in many countries, and is found in

Fig. 9.—C.G.S. "Lady Grey" backed down the channel ready to come forward full speed into the ice. The V groove of the ship's prow may be seen in the foreground. The smoke of the "Montcalm" may be seen on the horizon.

an open channel not protected by surface ice. It may form at various depths, depending on the clearness of the water and the temperature of the bottom.

Open rivers, as a rule, thirty feet deep, are free from anchor ice, but in the sea it has been known to form seventy feet down.

Experiments at Cap Rouge.

An inspection of the map of the River St. Lawrence will show at once how narrow the River becomes at Cap Rouge, above Quebec. Here the river narrows down to something less than a mile wide. The taking of the ice-bridge at this point occurs practically every winter, early in January. Owing to high tides, immense pieces of shore ice are loosened up stream and float down with the current. These fields of ice are the result of the packing and freezing of loose floating ice carried by the wind and currents into the bays and shallow places along the shore. The "battures" (as they are called) are made up of a conglomeration of mixed ice—frazil, anchor ice, and broken pieces of surface ice—all cemented together in irregular masses. When these battures are broken away by the high tides, they come down, often a mile or two long and many hundred feet wide. It is the sticking of a batture in the Cap Rouge gorge that causes the beginning of an ice-bridge. The bridge soon grows by the packing in of floating surface ice, frazil and detached lumps of anchor ice. The packing increases with great rapidity, until the River is frozen up to Lake St. Peter. The ice-bridge becomes continually thicker, until it may be as much as fifty feet deep and fifteen feet above the surface. During the winter of 1909, the "Montcalm" was detailed by the Government to break up an ice-bridge that took on January 5th. On the 15th of the same month the ice-breaker set to work, and commenced, unaided, to cut it out. So thick had it become, however, that the progress was slow and the packing of the ice grew faster above the bridge than it could be cut away below. Seven hours of ebb tide per day was the working time during which the currents could carry away the pieces broken off. Slow, steady progress was made through the bridge and up through the pack, until on April 4th they had broken a channel completely through the ice-bridge, and it commenced to come away. On the 5th they succeeded in going up to a point about four miles below Pointe aux Trembles. Thus, from January 15th to April 5th the ship had only been able to cut out the bridge. On April 8th she reached the Richelieu Rapids, and on April 16th Three Rivers.

This year (1910) the "Montcalm" and "Lady Grey" were stationed at Quebec, in order to prevent the bridge from forming. As usual, it took in January, but the two boats immediately cut it away and cleared the Channel. Twice during the remainder of the winter it took, but both boats working together cut it away in a few hours. The two boats assist each other very much, preventing any serious sticking after ramming into the ice. A cross cut by one boat at once sets the other ship free, and great progress is made. The ordinary method of ice-breaking cannot be practiced on the batture ice or the ice at Cap Rouge. The masses of ice are of irregular structure and do not split. They are very thick and cannot be crushed down by the weight of the ship. Only by ramming can a cut be made and the pieces dislodged. When working alone, the "Montcalm" was many times stuck for several hours with her nose in the ice. Especially did this impede the progress of the ship in breaking ice under which there was much frazil ice. Just below the Richelieu Rapids, the "Montcalm" was stopped for ten hours,

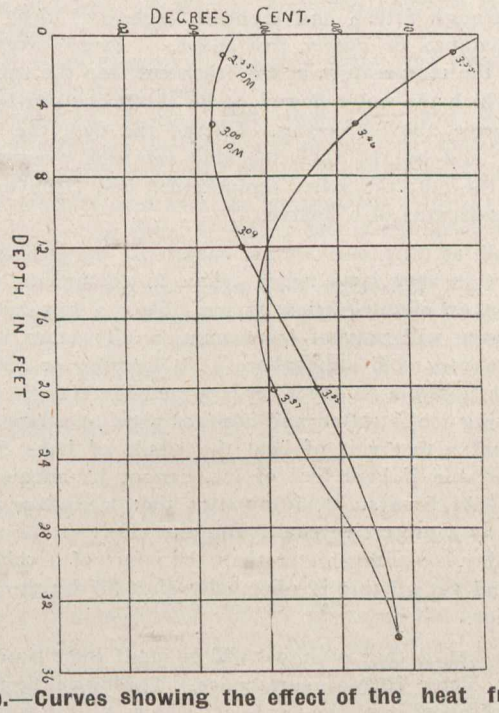

Fig. 10.—Curves showing the effect of the heat from the ship in warming the water.

by the frazil rising up under the ship, after cracking off the surface sheet. This ice squeezed out all the water and, in consequence, the ship was held firmly. Fig. 6 shows the side of the ship at that time, and illustrates, also, the remarkable effect of a very small amount of heat in disintegrating the frazil ice around the ship. Just where the circulating water from the pump comes out, all the frazil in a very short time was removed and carried away by the cur-