bottom and colder layers rise, so that the bottom of a deep river may be above 32° F. As a matter of fact the writer found the water under the surface ice slightly warmer at a depth; otherwise there seems to be very little reason why ground ice should not be formed under a layer of clear surface ice.

There is very little doubt that the immense thickness of several feet which anchor ice attains must be due, partly, to the sticking of surface formed ice carried down by currents which are continually shifting in a rapidly flowing river. The branching form, in which anchor ice grows, would tend to entangle and collect the floating ice. This sticking together of the ice was only noticed by the writer when the water was in a very slight undercooled state, caused by excessive abstraction of heat. The two principal atmospheric conditions for producing this effect the writer considers to be a dull, cold stormy day with wind, or a clear cold night. When measurements were being made of the temperature of the water in this state, in a shallow part of the rapids near the shanty, the stem of the thermometer was placed on the surface of some ground ice, which could be distinctly seen through the water. In a very short time the stem was frozen down. and could only be removed with great difficulty without injuring it. It is interesting to state that the writer was actually observing a small difference below freezing during the time the lower portion of the stem was becoming attached to the bottom. During this time immense islands of ice appeared in the shallower parts of the rapids, apparently growing by the attachment of frazil carried down by the currents. The river was of a dull, sandy color, as though full of ice. The whole tone of the river seemed different to that on a similar dull mild day.

Mr. Keefer, former president of the Canadian Society of Civil Engineers, in the discussion following G. H. Henshaw's paper on "Frazil," published in the transactions of that society, for March, 1887, gives an observation made by himself, which accords well with the one made by the writer. He has noticed that while crossing the St. Lawrence, opposite Montreal, in a canoe, when the thermometer was below zero, and when there was no floating ice, the water, instead of being clear as usual, was lead-colored, thick and "sandy" with ice. He further goes on to say that "spicules of ice, about the size of darning needles, attached themselves to the paddle by their points, and when it was withdrawn from the water stood out at right angles to the wood." He goes on to express the opinion that in this condition the river was loaded with ice spicules to the bottom, densely and uniformly distributed throughout the whole mass, and would supply the raw material for the formation of anchor ice at the bottom, when the latter was prepared to receive it. In this condition the writer thinks that had any ice been already formed on the bottom by radiation, then the lower layers of these ice spicules would have become entangled and subsequently attached.

Regelation has been proposed as an explanation of the way in which ice sticks to the bottom. This is very improbable, for there is quite a difference between the coalescence of ice particles by continued pressure, which cannot take place between ice and any other body, and the freezing together of ice crystals due to a natural growth on their surface. Even during very cold weather the sun has an enormous influence in determining the temperature of the river water. Its rays undoubtedly penetrate to the bottom and melt off the anchor ice. The writer has frequently noticed in the morning that, after a cold, clear night, beyond the amount of frazil floating down in the currents, there was no other ice visible, while as soon as the sun became brighter and more powerful, large masses of anchor ice were brought up from the bottom and floated down. Mr. Keefer states that mill-owners never find any trouble from the formation of anchor ice, no matter how cold the air is, if the sun is shining, and also if there is a cloudy sky at night. This again points to the formation of anchor ice by radiation.

In order to test the effect of radiation in the water, the writer arranged some experiments by which it was made apparent on the stem of the thermometer. During the day, when the sun was shining, it had always been noticed that the water was a little warmer than freezing, even though the air temperature was considerably below freezing. The writer found that by placing the thermometer at different depths in some comparatively quiet back water near the shanty, the upper layers of the water were always warmer than lower layers, and if the thermometer stem were sheltered from the direct rays of the sun, it showed a still lower temperature. The water within eight inches of the surface was apparently considerably warmer than freezing, although the air was very cold. No other explanation of this could be given, except that the sun's rays were radiated through the water and were warming up the stem of the thermometer itself.

Experiments were also tried to test the effect of having the thermometer actually cooled by radiation. These observations had to be taken during a very cold clear night. The result accorded closely with the expectation. The details of these observations would perhaps be somewhat beyond the scope of the present paper, but the writer hopes elsewhere to be able to give the actually observed differences of temperature in support of these assertions.

It will be of interest here to give two examples which have come under the writer's notice, the first one by direct observation and the second one through Mr. Kennedy, which will serve to illustrate the tremendous power exhibited by frazil during the time when it is agglomerating. Engineers have found this to be the most destructive state for the frazil to be in. It has been already shown that this is probably due to the temperature of the river being very slightly below freezing. During the course of the winter quantities of frazil are being manufactured in the Lachine Rapids and swept under the barrier ice by the swift currents. This frazil on reaching quieter waters soon rises and becomes attached to the underside of the surface ice. If reference is made to the report of the Montreal Flood Commission, it will be seen on the charts made of the cross sections of the river at different distances below the rapids how, the nearer the section is to the rapids, the greater the area of ice and the less the free waterways, while the further away, the less the total area of ice and the greater the channels. During a severe cold spell it would not be difficult to imagine the free waterways becoming completely choked up. This apparently occurred during the past winter, for during a severe storm about the end of January, the level of the water rose, and by increasing the head produced a shove.

It is well known how the Ottawa and St. Lawrence Rivers meet at the head of Ile Perrot and flow around the island into Lake St. Louis, the Ottawa on the north side and the St. Lawrence on the south side.