(a) Loss of heat by contact with a cold air; (b) Loss of heat by radiation. The first cause is probably responsible for the greater amount of the fine floating ice seen in our rivers whenever the current is too rapid to permit of the formation of a surface sheet. The churning up of the water in shallow rapids is simply a special case of this, in that a greater area of surface is exposed to the influence of the colder air, causing a more rapid abstraction of heat. In quiet waters subjected to a cold atmosphere, every one has noticed how long needle crystals of ice shoot out horizontally in all directions over the surface. These crystals by increasing and compacting form the first layer of surface ice. In agitated water, time is not given for surface crystals to grow to any size. On the contrary, small needle crystals are formed, the degree of fineness depending on the rate of agitation.

An experiment was carried out at McGill University, by Prof. Nicolson, which will illustrate this point. A quantity of water in a tub was kept in rapid motion under the influence of a cold atmosphere in winter. The result was that fine needle crystals of ice, in every respect similar to frazil, were formed throughout its mass, until the whole became somewhat like a thin paste. During the progress of the experiment no deviation in the temperature of the water from freezing could be detected with a thermometer reading to hundredths of a degree. In smooth, gently flowing water it is possible to have thin, flat plates of ice formed which become mixed with the finer crystals. Previous observers have noticed these plates mixed up with frazil and have endeavored to draw a distinction between the two. It does not seem necessary to draw a distinction, as these will be formed in a river ice of every degree of fineness.

Loss of heat from the water under the surface ice will take place by slow conduction through the ice, the upper layers of which must be nearly at the temperature of the air. In the experiments conducted by the writer under the surface ice, it was noticed that when the air temperature was very cold, long needle crystals would grow out which could be seen through the hole cut for the thermometer. This fact has already been noted by previous observers, and shows the tendency for surface ice to grow on the underside. The writer has seen the opinion stated that surface ice never grows in thickness beneath, but always on top The explanation given for this is that ice is always somewhat porous and water is drawn up through pores and frozen on the surface. It is difficult to conceive how this could take place through two or three feet, how water could be drawn through a mass of ice cooled below freezing, as surface ice must be, without its becoming transformed into ice on the way. In this case the pores, if they ever existed, would soon become choked up. It has been urged as a further proof that the surface level of ice formed on a river rises, even though the water does not. This would naturally occur as the ice would be continually buoyed up as it grew deeper into the water. This force would of course act so slowly that the surface ice would move without cracking, continually adjusting itself in response to the pressure underneath.

In regard to the second cause of the loss of heat in a river, there has been a good deal of dispute. Some claim that as all the phenomena of ice formation in a river may be satisfactorily explained without the aid of radiation, it is unnecessary to introduce it at all. But as radiation exists, as is shown by Dr. Wells' beautiful experiments on the formation of dew, described by Prof. Tyndall, it becomes important to see how far it influences the formation of ice in a river. On clear days, irrespective of the temperature of the atmosphere, immense quantities of heat are radiated from the earth off through the atmosphere into space. This has the effect, as is well known, of cooling the surface of the earth, which in its turn cools the atmosphere. During cloudy weather the heat radiated from the earth is reflected back again by the clouds, so that under these conditions the earth does not become cooled. From Tyndall's experiments on radiant heat, it is seen that heat rays may be passed to a certain extent through clear water or clear ice. He beautifully illustrates this by heating platinum red hot in the sun's rays, concentrated by a lens of ice. There is no reason then why the bottom of a river should not radiate heat straight through the water and atmosphere into space. Then the bottom will become cooled below the temperature of the water, which in winter is at the freezing point, and ice will be formed *in situ* by the abstraction of the latent heat of the water in immediate contact. The process of thickening will take place by radiation from the surface of the ice itself. Radiation from the bottom will be, of course, greatly hindered by the granular texture of the ground ice, and when it becomes so thick as to prevent any further radiation, or on a cloudy day, not sufficiently cold to produce undercooling in the water, heat slowly conducted through from beneath will melt off the hold which the anchor ice has on the stones and rocks.

Engineers have held that heat conducted through from beneath must help to keep up the temperature of the river, and that stones could not become cooled below the freezing point on account of this. One observer says: "How then could a stone, whose upper surface is at, or almost at, 32° F., and whose lower surface is at a somewhat higher temperature, radiate cold into a body of water from which it is itself receiving cold?" From the results of the observations on soil temperatures which have been carried on now for several seasons at the McDonald Physics Building by Prof. Callendar, in conjunction with Prof. McLeod, with delicate electrical thermometers placed at different depths in the ground, it has been shown that the conduction of heat through the earth from beneath is exceedingly slow. It may be easily calculated from the results of their work that the amount of heat which would be conducted through the earth to the bottom of a river in one hour, would not be sufficient to melt a layer of ice more than 1-500 of an inch in thickness.

It is very improbable that ground ice could be denser than normal, and therefore prevented from rising, as some observers have thought. There are certainly no experimental data to support such a supposition. On the contrary, the growth of the crystals in a mass of anchor ice is as far as possible in a vertical direction, showing that the ice must possess buoyancy even as it forms. This no doubt gives rise to the beautiful tree-like forms of masses of ice on the bottom, resembling the weeds in summer. Where a river is flowing very gently and smoothly a surface layer of ice forms, which becomes covered very soon with a layer of snow. This layer of snow will act as a check to radiation, hence the well-known fact that anchor ice does not form under a layer of surface ice. There is another possible reason why in deep, gently flowing rivers, ground ice is not readily formed. Below 39° F. it is well known that warmer layers of water sink to the