"some men camped twenty miles west from here inquired if we had heard the rumble last night: it appears their Afghans jumped up and said 'buggy coming.' Whatever the sound was, it was not caused by cattle galloping."

The sound resembled a distant, prolonged peal of thunder or the discharge of a far-away piece of ordnance or mine explosion. The nearest working mines would be about sixty miles away, the sea about fifty miles, and it is needless to say there is no artillery within hundreds of miles. No noticeable meteor was seen by anyone, and had the noise been due to this, would it have been heard at places twenty miles apart? It might have been due to an earthquake, but no tremor was noticed.

I have heard from ear-witnesses of dull sounds resembling this being heard in the Kimberley district of this State. At the time, a black-fellow said, "Hill tumble down," and next day they found that great masses of rock had fallen. This might, perhaps, be accounted for in part by the unequal temperatures between day and night—the day very hot, the night very cool. Though the days in August were hot (about 90° F. in the shade) and the nights very cool (requiring several blankets in the early morning), the nearest hill to us was four miles at least away to the east.

Was this, then, an instance of the phenomenon known as "barisàl guns" on the Brahmaputra and "mist pouffers" off Belgium?

Mr. W. E. Cooke, the Government astronomer, to whom I forwarded an account of the phenomenon with the above inquiry, advised me to record it according to the wish of Sir George Darwin. J. BURTON CLELAND.

Department of Public Health, Perth,
W. Australia, April 16.

Welsh Saints and Astronomy.

THERE were in Anglesey two contemporary saints who were in the habit of meeting together at a spot mid-way between their respective abodes. One was called Seiriol Wyn, "Seiriol the White or Bright," the epithet signifying his coming from the east, the region of sunrise. He had his abode on Puffin Island, on the extreme east of Anglesey. The other saint was called Cybi, and because he travelled to meet his friend from the west he was called Cybi Velyn, "Cybi the Yellow." He lived on Holy Island, at Caer Gybi, "Cybi's Camp," the Welsh name of Holyhead. Their place of meeting was in the parish of Llandyvrydog, where there are two springs called Ffynnon Cybi and Ffynnon Seiriol, which are referred to by Matthew Arnold.

> "In the bare midst of Anglesey they show
> Two springs which close by one another play,
> And 'thirteen hundred years agone,' they say,
> 'Two saints met often where these waters flow.'"

Cybi, known in Cornish literature as Kebie, seems to have reached Wales from Cornwall. His wanderings and settlements are curiously coincident with the distribution of the cromlech areas in Wales. On further inquiry one finds that Cybi and Seiriol were regarded as astronomers, and that their places or settlements in Wales may be regarded as observatories.

In an ancient poem, to an extract from which I find the reference "Archaiol. vol. ii. p. 38," they are numbered among the "seven cousin saints," the others being Dewi, Beuno, Dingat, Cynvarch, and Deiniol. "Those are the seven . . . who have been in (or who entered) the Stone (of round form? 'graen grynder'), and the seven who numbered the stars." The expression "a fu'n y Maen," "who have been in the Stone," must be taken in the sense that they had entered a stone chamber or circle, and it is hard to find any meaning to the phrase unless a cromlech or stone circle is meant, especially when read in connection with numbering the stars. Thus it may fairly be taken that the leading saint-astronomers of Wales are spoken of as having made an astronomical use of stone monuments. This inference is confirmed by the fact that the Cybi churches in Wales, and most likely churches associated with the names of the other six saint-astronomers, preserve in their relation to adjoining churches the cromlech astronomy, especially the May-November year. JOHN GRIFFITH.

Meteors from κ Draconis in May.

ON May 31, 10h. 40m., I saw amid the gathering clouds nearly overhead a very short third-magnitude meteor close to its radiant at 193° + 74°. I had never previously remarked any indication of this shower at the end of May or in June, though it seems continued in an intermittent manner from July to December, and on January 19, 1887, I recorded four meteors from 191° + 72°. There is another winter shower near, viz., at 194° + 67°, from which I saw seventeen meteors on December 18–28, 1886.

A bright, doubly observed meteor seen in 1893 by Corder and myself had a radiant at 186° + 74°. This shower is one of the most interesting of those in the circumpolar region. It is, unfortunately, omitted in the diagram of Ursid radiants facing p. 292 in the Gen. Cat. Radiants, vol. liii. of the Memoirs.

The straggling constellation Draco contains many showers, and some of these are visible over long periods. Thus meteors continue to fall from a centre at about 261° + 63° during the whole year.

Bristol, June 1. W. F. DENNING.

FORMATION OF GROUND- OR ANCHOR-ICE, AND OTHER NATURAL ICE.

THE formation of ice on the bottom of a river or stream has occasioned much comment and often scepticism in the minds of scientific men. Instead of ice forming on the surface of the water and growing downwards, we find, in circumstances now well understood, ice forming on the bottom and growing upwards. The phenomenon has been observed in all countries where ice is formed, and has been given various names. In Europe it is called ground-ice or bottom-ice (glace-du-fond, grund-eis), but we often find local names, such as ground-gru and lappered-ice. The term anchor-ice evidently originated in America, for the first record of its use seems to be by a writer in the "Encyclopædia Americana," published in 1831. The term is universally used in the United States and in Canada.

There are many early records of the appearance of ground-ice. It was seen by Hales in 1730 in the Thames. Ireland, in his "Picturesque Views" of the Thames, published in 1792, speaks of ground-ice, remarking, "the watermen frequently meet the ice meers or cakes of ice in their rise, and sometimes in the underside enclosing stones and gravel brought up by them ad imo." It was observed in the Elbe as early as 1788, in the Rhine at Strassburg in 1829, and in the Seine, by Arago, in 1830. So much interested was Arago in the ice that, for the benefit of the doubting savants of his time, he published in France, and in the *Edinburgh New Philosophical Journal* for 1833, an account of his observations. Other interesting papers on the same topic were published about that time. In the same Edinburgh journal we find, in 1834, a paper by the Rev. Mr. Eisdale. Two very interesting and instructive papers were published in the Phil. Trans. for 1835 and 1841 by the Rev. James Farquharson, F.R.S., of Alford, of his observations on the Don and the Leochal.

In Canada the formation of anchor-ice has been given much study, largely owing to its great abundance and economic aspect. For the same reason, much attention has been devoted to it in Russia by prominent engineers, notably by M. Leon Wladimirof in his study of the ice conditions in the Neva.

Nowhere can be witnessed a more wonderful sight of the delicate poising of the forces of nature than in a river like the St. Lawrence, with the advent of the winter season. In November, when the temperature of the water arrives at or near the freezing point, the manufacture of ice begins, and for a period of nearly five months the temperature of the water remains almost stationary. During this time a tremendous struggle goes on between water and ice, growing more severe as the air temperature falls further from the freezing point. The outward calm of the ice-bound river gives no indication of the contest beneath, but it is only during the annual spring break-up that the volume of existing ice is realised. At that time the river frees itself from its icy burden in a few days by a mighty shove, which is viewed by thousands along the river shore at a safe distance from the relentless piling of great ice-blocks.

In all the quieter parts of the river, surface-ice forms into a sheet, and protects the water from excessive loss of heat. Wherever the water flows too swiftly for the surface sheet to form, the comparatively warm water is exposed to the winter weather with all its severity. Ice-crystals are produced all along its surface, and are carried under by the currents, to be whirled about for miles, until finally swept under the barrier-ice at the beginning of quiet water. There they rise and become attached to the under-side of the surface sheet, building downwards immense hanging dams, which form as effective a barrier to the flow of the river as so much rock. Winter floods and ice shoves are the result of this packing of the ice, and, in one part of the St. Lawrence, the damming is so complete as to change the course of the river every year. The natives call this fine ice "frazil," meaning cinder-ice, and this term has now come into general use in Canada.

During the ice survey of the river by the Montreal Flood Commission in 1886, it was revealed that the packing of the frazil extended to the bottom in many places, giving an unusual amount of solidity to the surface sheet. In one case, a depth of 80 feet of solidly packed frazil was measured. Hanging dams of the ice are observed to a greater or less extent for a distance of twelve miles below the barrier-ice at the foot of the Lachine Rapids, and the magnitude of the ice accumulation may be realised when it is stated that the winter level of so mighty a river as the St. Lawrence, which is two miles wide at Montreal, is twice as high as in summer.

A careful study of the winter river temperature by means of very delicate instruments has revealed the fact that the formation and growth of the ice is an accompaniment of a minute temperature depression in the water of the order of a few thousandths of a degree. When the temperature equilibrium of water and ice is upset by this minute amount, fresh ice-crystals are formed, and, being supercooled, adhere to anything in their path which is likewise supercooled. In this way large quantities of anchor-ice are formed on the stones and boulders over which the ice-laden water sweeps. The crystals themselves stick together and form frozen masses. When carried through the rack or screen at the intake of a power-house they freeze to it, and rapidly choke the free water-way. They stick to the turbines, and glue the wheels fast in a short time. When the temperature equilibrium of the river is restored, the ice no longer adheres, and a rise of a few thousandths of a degree above the freezing point changes the ice to a mass of a soft and spongy consistency, capable of passing easily through the most delicate machinery.

It may be said that the whole condition which determines the rapid formation of ice in its harmful adhesive condition hinges on this temperature balance in the water. Since this important fact has been recognised, effective means have been devised for the judicious application of heat about the vulnerable parts of a power-house during such time as supercooling exists. There is no need to melt the ice or to warm the total volume of water flowing, so long as the machinery itself is prevented from falling in temperature with the water. The ice is as effective as water in producing a head. What the engineer has to guard against is that the ice does not stick in its passage through the turbines.

Fig. 1 shows the interior of a penstock, or wheel-pit, after it has been completely blocked with frazil ice. At the time of this photograph the stop logs had been introduced at the rack, the water removed, and more than one-half the frazil-ice shovelled out. This condition is a result of the slight supercooling of the machinery by the water. Where artificial heat is used, conditions like this no longer occur.

The greatest factor for preventing this minute supercooling in the water is the absorption of the sun's radiant heat. During the sunny hours of the day no ice troubles are ever experienced, no matter how low the air temperature may be. Nocturnal radiation, on the other hand, is one of the most effective agencies in supercooling the water and objects immersed in it. Anchor-ice is formed by this means in large quantities, and it has been known to grow on the river bottom before the temperature of the water itself had reached the freezing point. During cold, clear nights anchor-ice forms in large quantities. When the air is cold enough to produce supercooling in the water, frazil crystals adhere readily to the anchor-ice and assist in building it up. On cloudy nights, anchor-ice does not usually form, unless the supercooling is great enough to bring the bottom of the river into a supercooled condition. A bridge is found to protect the river bottom from anchor-ice, and even in the severest weather the anchor-ice is always less thick under such a covering.

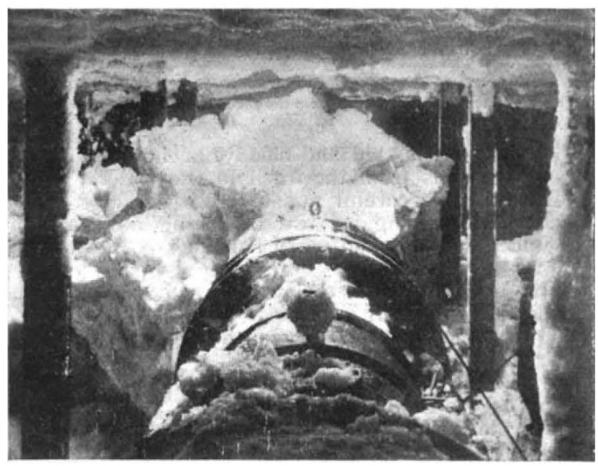

FIG. 1.—Interior of a penstock or wheel pit after the water has been removed, showing the accumulation of adhesive frazil ice.

Anchor-ice is never found to grow under surface-ice. When produced previous to a surface sheet, which in some places does not form until the severest weather, the masses are detached by the natural heat of the earth, and rise to the under-side of the sheet. This has been observed extensively by M. Wladimirof, who has found in such cases an exact correspondence between the line of attached masses under the surface-ice and the river bottom.

Farquharson observed, in the small Scotch streams, that overhanging weeds protect the bottom from the frost, just as a tree will protect the ground from the dew or hoar-frost deposited at night.

The sun's rays are effective in detaching the anchor-ice from the bottom. On a clear morning in winter, as soon as the sun rises, the open surfaces of the St. Lawrence become dotted over with large masses of anchor-ice, which rise high out of the water by the impetus they attain, and sink back with a characteristic noise. Large boulders frozen to the masses are frequently brought up and carried in the currents.

Fig. 2.—Anchor-ice grown up from the rocks and protruding above the surface of the Ottawa river.

When the day is cold and cloudy, anchor-ice does not rise, but builds from the frazil in the water.

Boatmen are careful not to cross the river when anchor-ice is rising for fear of having a mass come up under the boat and carry it helplessly into a rapid or over a waterfall.

The limit of depth below the water-level where anchor-ice will form appears to be roughly about 40 feet, but in the clear waters of the Gulf of St. Lawrence it has been observed as deep as 70 feet. Twenty feet below the surface, anchor-ice will often attain a thickness of 5 or 6 feet during prolonged cold weather. When seen through the water, the growth resembles nothing more closely than the weeds that are found in the shallower portions in summer. Anchor-ice grows in arborescent forms, and with more abundance on dark-coloured rocks, although when it becomes very thick the radiation takes place chiefly from the ice-surface itself. During mild weather, especially with rain, practically all the anchor-ice is detached from the bottom, and this has been shown to accompany a slight temperature elevation in the water above the freezing point.

Fig. 2 shows an ice bridge on the Ottawa River in the process of formation. The anchor-ice may be seen protruding above the water in the shallower parts, and frazil-ice may be seen floating in the current.

Fig. 3 shows the spillway and waste weir of a large power station. Anchor-ice to which frazil has adhered may be seen under the water surface and in places protruding above. The thickness of ice on the crest was from 18 to 22 inches at the time the photograph was taken. In the background men may be seen with long rakes scraping the frazil-ice off the rack-bars or screen through which the water passes to the turbines.

When turbines are operated under very high heads, the supercooling of the water is corrected by the heat generated during the fall and the lowering of the normal freezing point by pressure. Power-houses so situated are seldom troubled with adhesive ice. Many power-houses are fortunately situated so that water is drawn from deep ice-covered channels, where frazil or anchor-ice cannot form, but for nearly all there are times, at the outset of cold weather, before the surface-ice forms, when trouble is encountered. For these and for all water-works situated below permanently open water, steam or electric heating must be resorted to at times, if interruption to the operation is to be avoided.

Through the good work of Mr. John Murphy, M.A.I.E.E., of the Department of Railways and Canals, Ottawa, practical and effective devices are now available for overcoming ice troubles, and in place of expensive auxiliary steam plants for carrying the load during the frazil season, with their corresponding large consumption of coal, a modest steam boiler, or a small amount of electrical energy—usually available in excess—proves an effective means of keeping the plant running smoothly.

To the practical superintendent of a power-house the idea of a thousandth of a degree has little meaning, and yet there is no doubt that the ice problem, as it is presented in the development of "white coal" in northern countries, depends on just such minute changes of temperature.

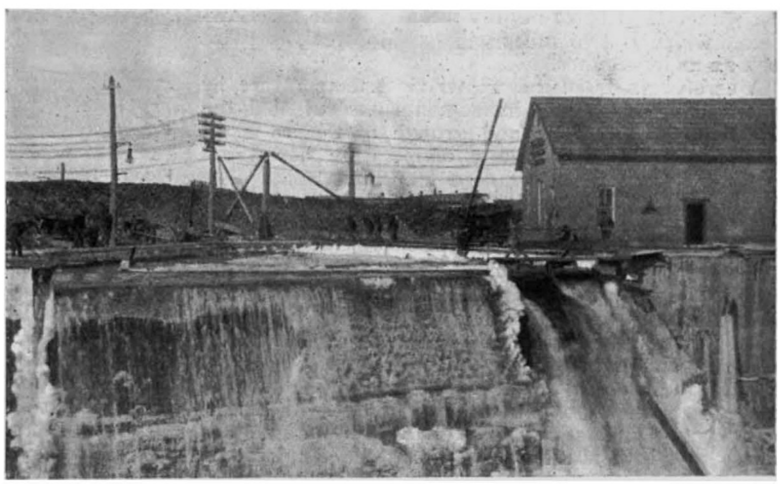

Fig. 3.—Spillway and waste weir of a power station showing anchor-ice. The thickness of ice on the crest of the spillway is from 18 to 22 inches.

It has been thought that the ice conditions in Canada might detract from the value of the vast water powers available for power purposes, but, from a scientific study of the conditions underlying the formation of ice, it is safe to say that no such bar exists.

H. T. Barnes.