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Some notes on the Baltic and Arctic Voyages of the "Ermack" in 1899

Arthur Gulston [a]

[a] Superintendent Engineer :. Sir W. G. Armstrong, Whitworth, and Co. ,

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the summer. The surface temperatures taken in Loch Ericht during the visit from 15th to 20th June show a range of 10·4°, viz., from 46·6° to 57°; the higher temperatures were obtained towards the northern end of the loch, and the lower temperatures towards the southern end of the loch. A glance at the temperature section (Plate III.) based upon the observations given in the table shows that the warmer water was all collected towards the upper end of the loch, as the result of a south-easterly wind which blew at times during the six days that were devoted to the survey of the loch, colder water having been drawn up at the opposite end of the loch to supply the place of the warmer surface water driven before the wind.

Loch Garry.—Loch Garry was visited on the 21st June 1900, when the surface temperature was found to vary from 57° at the south-west end to 59·4° at the north-east end, and this would seem to indicate a distribution of temperature similar to that observed in Loch Ericht, but since only one temperature series was taken, it is impossible to form an idea of the distribution of temperature throughout the whole body of water.

SOME NOTES ON THE BALTIC AND ARCTIC VOYAGES OF THE "ERMACK" IN 1899.

By ARTHUR GULSTON, Superintendent Engineer: Sir W. G. Armstrong, Whitworth, and Co.

ICE-BREAKERS were in existence as far back as the year 1870, the first being a converted tug at Cronstadt; but only in the last decade have they reached large dimensions: such as the railway ferry ice-breaking steamers on the great lakes of America and at the straits of Mackinaw; some built on the Tyne, one of them for Helsingfors in Finland, another for Odessa; ice-breakers at Reval, Riga, Copenhagen, Hamburg, and Vladivostock; and railway ferry ice-breaking steamers for Saratov, and for carrying the trains of the Siberian railroad across Lake Baikal, a distance of 52 miles, where the ice varies from 2 to 3 feet in thickness, and being fresh-water ice, is very tough and hard.

The step from these vessels to the *Ermack* is a big one. She is the outcome of the fertile brain of Admiral Makaroff, of the Imperial Russian Navy. He had advocated for some years that one or more large ice-breakers be built to keep the ports of Cronstadt and St. Petersburg open all the winter; as, practically up to the advent of the *Ermack*, these ports were closed by ice for about five months in each year, with consequent loss to commerce, the locking up of the naval arsenals of Cronstadt and St. Petersburg, and the placing of the Baltic fleet in winter quarters. Such a stupendous undertaking naturally caused much discussion and opposition amongst those interested; and especially excitement amongst the inhabitants of Cronstadt, which, being an island, would be

cut off from the mainland by the canal cut by the *Ermack*, the traffic across the ice to Cronstadt from the mainland being exceptionally heavy. It was also well known that the ice-packs in the Gulf of Finland in some winters were of very large dimensions, and much difficulty was expected in breaking them down, the opponents of the scheme hoping that no ice-breaker could possibly crush through them; and as no certain *data* had been obtained of the Baltic ice up to the arrival of the *Ermack*, some little anxiety was felt by those on board as to the results.

Among other means in the earlier stages that Admiral Makaroff adopted to bring his views before his countrymen was the reading of a paper before the Geographical Society of Russia in St. Petersburg on the subject of large ice-breakers. His Majesty the Czar saw a report of this lecture in one of the papers, and spoke to his Minister of Finance, Mr. de Witte, on the subject, telling him to investigate the matter and report to him. The upshot was that a commission was formed for the building of the vessel, and tenders were obtained, with the result that the contract was placed and the vessel built on the Tyne.

The *Ermack* is 335 feet in length, 71 feet beam, and about 8000 tons displacement, with her coals and stores on board. She was propelled by four sets of triple expansion engines of 2500 indicated horse power each, and has six very large double-ended boilers of 160 lbs. pressure for generating steam. One of the engines was situated in the bow of the vessel, but is now removed to give a better form for ice-crushing at the fore-end, as although the bow engine was useful in Baltic or one-year-old ice, the conditions of the large and harder ice of the Polar regions required a more powerful form of wedge-shape at the bow. The *Ermack* is capable at half power of putting 1300 tons of weight on the ice to crush it down; this is at her ordinary ice-breaking draught of 22 to 23 feet. The other three engines are placed near the stern of the ship. It is, of course, absolutely necessary that the moving portions of the machinery, the shafts and propellers, should be made enormously strong to withstand the heavy shocks and blows met with in negotiating the ice; and so far the machinery and propellers have withstood the tremendous trials to which they have been subjected. The boilers are clothed all over, and special means are adopted to prevent cold air entering the boiler-rooms and causing sudden contractions on any portions of the boilers. The ship is built of steel, having a complete double skin fore and aft, so that, should the outer shell be pierced by the ice, the ship would float on her inner skin, and, as there are a very large number of compartments, the amount of water let in would be reduced to a minimum; by this form of construction great strength is given to the vessel to resist the shocks when ice-breaking. The bow is enormously strong, and for a considerable distance the frames are only 12 inches apart; the ice-belt in the shell plating is 1½ inches thick, and the connection of the plating to the stem-piece is of the strongest description. The ice-belt at the bow portion of the vessel extends to the keel, and at the sides of the ship is 27 feet deep. The angle of the bow is 70 degrees, the sides are at 20 degrees, and the whole ship is built and shaped to withstand ice pressure, whether lateral or vertical.

There are ample means for heating the vessel by steam, also the circulating water, and for keeping the sea inlets clear of ice. The circulating water can also be discharged at the bow or stern to wet and melt the snow, so as to prevent it sticking to the ship and producing great friction. Pumping arrangements were also put in of very large capacity for "heeling" the ship, for "tipping" her fore and aft, and to clear and move her when fast in the ice; and salvage arrangements are fitted to pump out large quantities of water, or to salve another ship in distress. The accommodation is very luxurious when compared with other vessels that have hitherto been to the Polar regions. The ventilation is of the most scientific description, and was found to act admirably in the cold weather. So marvellously is the vessel constructed, that she is practically ice-proof and nearly unsinkable —qualities that give her a vast superiority over any ship which has hitherto navigated the Polar ocean.

The vessel left the Tyne on her maiden voyage for Cronstadt early in March 1899, under the command of Captain Vassilieff, Admiral Makaroff also being on board. On the Sunday week after sailing, the ice blink was seen just before dark came on, and at nine at night the first drift-ice was met off the western end of the harbour of Reval. As a heavy gale was blowing it was thought more prudent to wait until the morning before entering the ice, and it was during this wait that we saw an enormous meteor fall in Finland about 40 miles from us, making night as brilliant as day: portions of this meteor were shown in the Paris exhibition of 1900. I would here explain that out in the Gulf of Finland the small drift-ice is first met; this gradually grows to a paste which in calm weather soon solidifies into floes, which get larger until the solid ice is met, and in this the packs of ice are found. Early on Monday the ship was again steered for the ice, entering the drift about 4.30 A.M., which we continued to pass through until 7.30 A.M., when the field-ice began to be met, and shortly afterwards the ship was ploughing her way steadily through the solid ice. The packs of ice from here to above the island of Sescar were very thick and heavy, with only little water showing in places; and, as much snow had fallen, we had some trouble in getting along, the newly fallen snow being a great hindrance; but when clear of packs of ice the ship travelled at a great speed. That night we proceeded until after ten o'clock, the ice being illuminated by the electric projector, and the sight from the bridge of this illumination was wonderfully fine as the vessel passed through the ice, a dense fog finally bringing us to a standstill. At times the ship would get into a water-lane, and the effect of the ice at the edges of the canal is most interesting. The sea ice in the Baltic is a bright emerald green, and the lines of cleavage of the ice are well seen in the lanes. Of course the vessel gained great speed in these canals, and the smashing of the ice at the end was grand, the vessel driving large masses of ice apart as she tore through them.

The next morning an early start at 4 A.M. was made, and this day was characterised by the large number of packs we had to pass through; at places the whole face of the ice was a series of packs. The water at

this portion of the Gulf of Finland is, at the time of the forming of the ice, continually on the move, so that as the ice forms it is broken adrift by currents, winds, and the sea, and re-forms in packs mainly in line across the gulf, and therefore across the line of the ship's course, packing in places to 20 and 30 feet in thickness, the packs being above the line of the field from 4 to 7 feet.

On the rocks and islands in the Gulf of Finland the ice forms to an enormous thickness; on some of the islands where the lighthouses are situated, large walls have been built to prevent the ice, by pressure, from overflowing the islands and destroying the dwelling-houses and lighthouses. On this day the ship came amongst the fishermen who live on the ice during the early months of the year; this population numbers from one thousand to twelve hundred persons. They have wooden huts to live in, holding from ten to twenty persons each, and are packed in them at night like "sardines in a box." The roads on the ice through the snow are staked with bushes to guide them during fog and snowstorms. The fishermen collect the fish from the fishing-holes in small hand-sledges, which in turn are brought together in large pony-sledges and taken to St. Petersburg for sale. Often we had to stop to allow a train of sledges to pass, and considerable care is required in navigating the vessel at night not to strike one of the huts, or the small bush-shelters (behind which the hardy little ponies stand with nothing over them in this dreadful climate). These fishermen for the most part are agricultural labourers, who have nothing to do during the winter, and comparatively few of them follow a seafaring life.

The noise occasioned at the bow of the steamer when ice-breaking is in progress is considerable; but such is use, that after the first day it was scarcely noticeable, and the vibration set up in the structure of the bow is very small indeed.

As the ship proceeded up the gulf, the ice gradually changed to fresh-water ice of a bluish tinge, very hard, which broke with a sharp report. The packs were left behind, and the whole surface became smooth. Through this ice the ship passed quickly, and great was the pleasure of all on board when the spires and chimneys of Cronstadt were in view, lit up in the setting sun of as brilliant a day as can be imagined, snow-glasses for the eyes being necessary from the early morning, owing to the brilliancy of the sun. That night the ship stopped a few miles from Tolboukin lighthouse; about 10 P.M. the pilot arrived, having come in his sledge from the pilot station, the first pilot to assist a ship under such strange conditions.

The entrance of the ship into Cronstadt was the occasion of great excitement, especially as up to the time of her arrival in sight of the port it was firmly predicted that the feat was an impossibility. The weather was brilliantly fine, and as we approached the harbour many sledges came to meet us, and a large multitude of people, also a company of a regiment on "ski," making a most picturesque sight. Some hundred men or more who were at work blasting rocks were drawn up in line, and cheered lustily as the ship passed them. The ship could easily break her way through the ice below Cronstadt at eight knots

an hour, the field-ice being from 18 to 24 inches thick, with 6 inches of snow upon it. The entrance into the harbour was deftly managed, and the ship was berthed among a large crowd of persons on the ice without the assistance of even a rope, and Cronstadt with its navies was an open port for the first time in its history.

Three days after the arrival of the *Ermack* at Cronstadt, she was ordered to Reval to save steamers that were in danger of being crushed by the ice, and to open up the harbour. The return, as far as Hogland, was accomplished down the canal that we had broken on the upward voyage, the ship going easily through this at half speed. After passing Hogland, we were very much delayed by fog and snow. The navigation of the Gulf of Finland is difficult at all times, but when covered with ice and fog, navigation in such dangerous waters is indeed troublesome; soundings can only be taken under very great difficulties. Reval Bay was reached the next afternoon: there we found that an enormous ice-pack had been formed across the entrance to the bay, fifteen miles from the town of Reval. The pack had formed during a NW. gale that had blown the drift-ice from the Baltic into the bay, packing it $3\frac{1}{2}$ miles across, about one-third of a mile wide, and from 20 to 25 feet thick, completely closing the harbour. The top of this ice was very rough and difficult to get across. On arriving near this pack we found that the field-ice had eased, leaving a water-lane some 500 feet wide, and through this at about 3 P.M. we steamed at full speed, striking the ice on the other side at fourteen knots an hour. Close to the place where we entered, a steamer (the SS. *Fairhead*) was fast: the concussion of the *Ermack* with the ice liberated the vessel, which came astern into the water-lane, and then followed us up the canal which we were making. By 5 P.M. we were through the large pack, which took some fourteen charges to accomplish, the newly fallen snow being a great obstruction. We immediately liberated the Reval ice-breaker and another steamer that had been fast ten days, and then proceeded down our own canal to liberate three steamers belonging to the Copenhagen Steamship Company that were in great danger near rocks below Sourop lighthouse, one of them without a propeller, a second with only one bade left, and the third (which had come to their assistance) fast close astern of the others. The cutting out of these vessels was a grand sight, as the *Ermack* had to break three large semicircles out of the ice from the water-lane before she could get sufficiently close enough to them to crack the ice up to their hulls: great care had to be exercised that we did not squeeze them and crush in their sides. This operation was carried out after dark under the electric light, all the vessels having ample means of lighting on board, and was indeed a splendid spectacle. The next morning we liberated three more vessels, and then proceeded to take them all up to Reval, breaking a channel as we went. The entrance to the Reval harbour was made the occasion of great rejoicing by the town, and large numbers of people in sledges and on foot came to meet the fleet, making a most exciting scene as we came "tearing" through the crowd at full speed. As there were many steamers in the harbour and others expected, it is easy to understand how the opening

of the port by the *Ermack* was the cause of much pleasure to its inhabitants.

We left Reval early on the Saturday morning before Easter day to search for two steamers that were fast in the ice out in the entrance to the Gulf of Finland, and reported to be in danger. We steamed across through the ice to about twelve miles off the port of Hango in Finland, where the ice-breaker *Sampo* came to meet us, and she gave us the approximate position of the lost steamers. As this was 9 P.M., we steamed through the ice by the aid of the electric projector until it was judged that the distance was run; during the night it came on to blow a heavy gale, with snow falling. At daybreak on Easter Sunday we saw a steamer (which we liberated), but found she had only been fast two days. We then steamed westward, and at last sighted one of the lost steamers. With some careful handling we broke the ice round about her, and steamed off again with this boat following. In half an hour we found the other steamer and liberated her. By this time the gale was blowing strongly, and the ice in this part of the gulf broke up immediately after the second boat was liberated, and but for the timely arrival of the *Ermack*, these boats and every soul would have been lost, as the break-up of the ice would have crushed in their sides. They had been sixteen days fast, and the chart of their drift is very interesting. The crews in both boats were on the verge of starvation.

The *Ermack* shortly afterwards returned to Cronstadt and proceeded to St. Petersburg. During the limited time she was on the station that spring, the *Ermack* was instrumental in salving eighty-two vessels that were fast in the ice.

Arctic Expedition.

The object of the Arctic expedition was to test the capabilities of large ice-breakers amongst the polar ice. The *Ermack* left the Tyne on the 23rd of July 1899 and proceeded to Advent Bay in Ice Fiord, Spitzbergen, there to meet our tender (the ss. *Virgo*) an ice-breaking steamer of small dimensions. She was loaded with coals and other spare things likely to be required. The *Ermack* was fully provisioned for twelve months in case of her becoming fastened in the Arctic ice and being unable to get free until the following summer of 1900. There were altogether 125 souls on board, the larger portion belonging to the engine-room staff. Amongst others were the scientific staff, consisting of hydrologist, meteorologist, astronomer, and artist. The duties of deep-sea sounding were undertaken by the chief officer, and dredging at great depths was superintended by Admiral Makaroff and the head doctor. On the voyage out and home to Advent Bay a complete set of stations were taken, position, depth, materials of the bottom of the ocean, the currents and the temperatures of the water, and other matters all being most carefully recorded. The taking of the temperatures of the ocean at varying depths down to 1600 fathoms being a most interesting study. The stops for each station occupied over two hours. All these objects going forward together gave us much to do. On

arriving at Advent Bay we found not only our tender, but also the small tourist steamer *Lofoten*, from Tromsoë; a large steam yacht, the *Erl King*, and two small Norwegian sealers—making quite a fleet in this far-away corner of the earth. We left Advent Bay on Saturday, August 5th, and on Sunday we encountered the first polar drift-ice at 7.20 A.M., and shortly afterwards we bade adieu to our tender. We were then well amongst the ice, and the fight commenced in real earnest, collisions with enormous masses occurring continually. Where possible the ship was steered so as to push the larger floes aside, but as they became thicker and older as we proceeded north, it was soon a question of ice-breaking and charging all the time.

In speaking of charging it must be understood that the vessel when stopped by ice retires a hundred yards or more, and gets up speed to strike the strong spot, and continues to do so until the obstruction is broken down. The *Ermack* is also designed for charging astern when it is desirable. Of course, when an opening in the ice could be seen, we steered for that place. The reflection of the water is seen in the sky in the Polar regions at a considerable distance, and by this means the vessel can be steered to these places. In some of the water-lanes it is curious to note how the ice had separated in a vertical cleavage, leaving walls of solid ice on each side of the canal from 12 to 20 feet thick: one can see the packed ice below the water-line for a considerable distance. In these translucent waters on a clear day the eyesight reaches down about 40 feet, but when you let the lead down, the ice is found at 80 feet, and even more, showing how the great ice is packed. At times the "floes" are easily broken up, that is, when the ship strikes the ice on the line of cleavage. On other occasions some hard blows are necessary to force a passage, and as the ice is covered with snow it is very difficult to judge a soft place. Generally speaking, a soft place (to all appearances) turned out to be quite the reverse. However, all this time the ship was steadily proceeding north. The object in entering the polar ice immediately to the north of Spitzbergen, instead of further to the eastward as has been customary heretofore with Arctic expeditions, was that should any accident happen to the propellers, the ship would—through time—if disabled, drift out of the ice with the Polar stream to the eastward of Greenland.

The *Ermack* with half boiler power could force her way through polar ice of 12 to 14 feet thickness at $2\frac{1}{2}$ to 3 knots an hour: where the ice was slack, this speed was exceeded.

The first occasion of seeing a polar bear caused much excitement among all hands, rifles and cameras doing great execution. This bear was shot whilst swimming from one floe to another, and from this time we saw many others. A polar bear is not dangerous until wounded, or unless he is very hungry, and even then he prefers to run away if he can. It is most interesting to see the mother's care of her cubs: when startled by the ship the she-bear always kept her cub on the side away from the ship. On one occasion a family of three paid a visit, and the cub was first wounded; the desperate attempts of the parents to help this young bear over the ice were most pathetic, but a lucky shot killed the cub; the

she-bear then rounded on the male and punished him most severely, thinking, no doubt, that he was the cause of the death of her cub. This *contretemps* allowed the hunters to come up, and all three bears were secured. The skins of these and others were preserved in barrels, and the flesh, which was generally fat, was salted and preserved for use in some of the first-class restaurants of St. Petersburg, where it is considered a dainty. The heads were boiled until nothing but the skull remained, and are trophies of an interesting and rare character. The cub above mentioned was stuffed, and now is a splendid ornament in the main entrance of the vessel.

A large amount of scientific work was undertaken, among which deep-sea sounding in the Polar ocean, and the taking of temperatures of the atmosphere and water, and samples of sea water at varying depths are the most important. The samples of sea water are obtained by an instrument called a "matometer" (the invention of Admiral Makaroff). It is a metal bottle encased in indiarubber, with automatic valves at the top and bottom. As this is lowered into the sea the water flows through the bottle, but as soon as the downward action ceases, the valves close, and the sample is retained, and as the bottle and valves are insulated by the indiarubber coating, the temperature remains constant until the operator has an opportunity of testing it by the thermometer. The temperature was also taken by automatic deep-sea thermometers, but these are not very reliable owing to their liability to fracture. It is a long and tedious operation sinking the matometer by hand to 1600 fathoms and bringing it up again.

Astronomical observations for the true position of the Meridian had also to be made when the sun condescended to show himself. The astronomer had to go more than a mile from the *Ermack* to be beyond the influence of the magnetic force of the ship. His instruments, a tent to shelter him from the wind, his kettle (a Primus, the same as Nansen used), and rations for himself, and his two guards, were all packed on a sledge which was drawn or carried over the ice in an ice-boat. It was necessary to send two men to keep guard over him, as his observations (if the atmosphere kept clear) extended during the greater part of the day, and the guards had to keep a look-out for bears, fogs, or the parting of the ice-floe. Even the guards had to be fifty yards from the astronomer to prevent magnetic influence from the rifles disturbing the instruments. Simultaneously a "look-out" was kept from the crow's nest at the ship, so that should fog, or snow, or ice-parting occur, all was in readiness for a rescue. The observations of the atmosphere, the force, the wind, direction of the currents, and the drift of the ice, sketching and painting the ice-fields, photography, and recording the pressure and depth of the ice, were an all-absorbing study, to which the whole time of those on board was devoted. The scientific investigation of the ice took up a large amount of time, and 129 samples were tested for specific gravity, salinity, buoyancy, strength, both in compression and tension, melting temperatures and the configuration of the ice; this latter is a great problem, as the formation of the ice is of so many different descriptions, and no doubt the surrounding conditions affect it

in a very great degree. Masses weighing five tons were brought on board for investigation; the refreezing of the ice that had been melted produced some very pleasing results. When time allowed, snow-shoeing was much indulged in, most of us coming croppers at the commencement; going for walks and climbing the hummocks, shooting bears and seals were other sources of exercise.

The divers were sent down occasionally to see that all was well below the water-level, and great care and attention had to be given at these times, for should the ice close tightly to the vessel the diver would have lost his life.

Of animal life, at high latitudes, the polar bear is most common, then seals, walrus, and narphals, and we have even seen a shark: he came after a bait we had out, but missed it, and whilst turned over on his back the hunter (Permikoff) jabbed a boat-hook into him, and rushed him on to the ice, where he was secured. This specimen was 7 feet long, and had a splendid mouth of three rows of teeth, top and bottom. His flesh was excellent eating. Of birds, as soon as we passed through the drift to the solid ice, we left all the various divers behind, and only the large grey gull, the ivory gulls, and the little auk remained. This interesting little bird was with us at all times, and his shrill cry sounds very weird in these lonely and quiet regions. The only other bird far north was the beautiful ivory gull, spotless white, with a yellow beak and black legs. He is easily shot, as, having never seen human beings, he fearlessly approaches the vessel. We have seen these gulls following the ship when under way, and gorging themselves on a small fish that lies near the surface, and as the ice is disturbed he can feed on these until he can eat no more.

A keen look-out was kept for "Ross's gull," but we were never fortunate enough to see one.

The sight from the bow and bridge of the *Ermack* when she is forcing her way through the ice is at all times remarkable, and so fascinating that one is quite unable to tear oneself away from watching the scene of the moving floes pressing on one another, turning edge upwards, the destruction of the hummocky ice, the rip of the solid ice when the ship breaks it, and the yawning blue chasm that forms as far down as the keel until the ice opens at the bottom of the fracture, and the sea rushes up.

At times it was necessary to push the large floes apart: in such cases the *Ermack* was put at a spot where we thought the floes would part, and then after some minutes of pushing, we would notice one floe beginning to move from the other. On occasions we have seen these floes of great size: in the Paleocristic ice we very seldom saw a floe less than 500 tons in weight, and amongst this class of ice considerable judgment had to be exercised in handling the vessel. On this ice it is easy to examine the propellers when standing on the edge owing to the transparency of the sea. Large ponds, or lakes, of fresh water melted from the snow and frozen over are met with in many places, sometimes a number of them with canals in the ice from one to another. When the sun shines melting soon commences, and large masses of water

collect on the ice. We pumped a great deal of fresh water into the tanks of the vessel from these ponds for the use of the boilers and washing purposes. A fresh-water lake and ice were always of the brightest and deepest ultramarine blue, but a lake or pond that had a communication with sea water was emerald green. The packs of ice are at times of very large dimensions: we have met them 25 feet high above the field in places, in some packs even more.

Some very good cinematograph pictures were taken, and when shown they give a very graphic idea of the ship charging amongst the ice, and the manner in which it is tumbled and pushed about by the vessel. Occasionally a large piece of ice would come up from below and strike the *Ermack*, making the ship shake.

We met icebergs, but one does not visit icebergs too closely with a steamer owing to the extreme hardness of the ice and other dangers. On one of them where we landed there were large remains of the "Moraine," and some specimens were brought away for geological research. Some of the icebergs were of enormous size, standing up like mountains two hundred feet high—to all appearance like islands amongst the ice.

The time came when, owing to the freezing of the new ice going on continuously, and the ship being some 200 miles into the polar ice, and the absolute necessity of getting south in time for the *Ermack* to return to her station in the Baltic, the ship's head was turned homewards, and then commenced our greatest struggle, as the ice had closed tightly around us, and it was a long continuous fight to the clear water. At times we have been charging and hammering at floes of rough packed ice of enormous hummocks for one or two hours before breaking down the obstruction, and having almost to retrace our course to get round some hummock of large dimensions.

During this time it was bitterly cold, and the snow accompanied by wind made the atmosphere far from pleasant. The ice pressure appears to be more affected by wind than other causes, such as currents. No doubt land—even at a great distance—and the rise and fall of the tides, especially the spring tides, have much to do with these pressures, but patience is always rewarded in course of time by an easing of the ice, and at times the pressure must have been gigantic to result in the enormous packs and rough ice observed.

After leaving the ice the ship proceeded to Advent Bay, as this was our rendezvous, and we had to advise our tender of our return. The climate had changed much during our absence, and winter was upon us. In Advent Bay we found the large yacht *Princesse Alice*, belonging to His Highness the Prince of Monaco; visits were exchanged, and as the Prince is much interested in oceanic study and problems, his yacht is fitted out in a very scientific manner. He had been cruising on the ice edge to the north of Spitzbergen during the summer months.

Advent Bay, situated 22½ miles from the entrance to "Ice Fiord," is a most desolate spot surrounded by mountains, whose heads are nearly always in the clouds, but when the sun shines the scenery is truly magnificent. There is absolutely nothing green, as the island and the valleys are filled with huge glaciers, but coal of fair quality is

plentiful in "Ice Fiord," the seams coming to the water's edge; the Norwegian sealers often call here to fill up with it. There is very little game, as the reindeer has been nearly shot out. The fishing is poor, and the blue and white fox are very scarce. Gulls and sea-birds abound during the short summer. On the rubbly spit of land at the entrance to the bay is seen the small cemetery where those who have died far from home are buried, and the remains of two huts that have in years past sheltered shipwrecked crews who have had to pass the winter in this scene of desolation. The intense stillness of the spot seems almost to numb one's senses, and produces a peculiarly restful feeling of the body and nervous system.

Our stay here was short, and after a very stormy passage, we were, I believe, all glad to be once more inside the Tyne, and feel that no accident had happened, and that all who left with the ship had returned safely.

THE RIVER SPEY.

By LIONEL W. HINXMAN, B.A., of H.M. Geological Survey.

THE physiography and geological history of the river Spey present several points of interest which, as far as I am aware, have not been discussed by previous writers on the Physical Geography of Scotland.

It is unnecessary in the case of so well-known a river as the Spey to enter into any geographical details as to watershed and course that can be followed on any good map. It will be sufficient to state that the drainage basin of the river—that is, the area from which it derives its waters and the rock-waste which it carries to the sea—is approximately 1300 square miles in extent. The upper portion of the basin includes a wide tract of high mountainous ground, that in its greatest breadth measures 25 miles from north to south. The length of the river, measured along its windings from Loch Spey to the sea, is 97 miles, or almost exactly that of the Tweed.

On looking at a map of the drainage basin of the Spey one is at once struck by the fact that the river does not occupy the centre of the area, but lies considerably nearer to the northern than to the southern boundary. It will also be noticed that the southern tributaries are more numerous and important than those flowing in on the northern bank, and that the former have a course more or less at right angles to the main stream. The only northern tributaries of any size, the Dulnan and Calder, flow for the greater part of their course through longitudinal valleys, parallel to that of the Spey. The southern side of the basin includes a large extent of mountainous country, most of which has a greater mean elevation than the ground north of the river. This implies a greater fall for the streams flowing in from the south, as well as a greater rainfall. Hence they have been able to cut a long way back into the original high-level plateau, and thus drain a larger area than those on the north side.

The upper course of the Feshie, one of the largest tributaries of the