weights and by means of metallic or air springs. In the former case it is easy to see how the counterweight can be so arranged that the work represented by the falling of the gun may be exactly balanced by the work of lifting the balance weight; the energy of recoil, therefore, need only be drawn upon to overcome the friction of the descent and the subsequent friction of ascent, together with the accelerating force necessary to start the gun into smart upward movement. The total amount of work expended in friction does not probably exceed 20 per cent. of the work of raising the gun, and consequently the old muzzle-loaders, with their comparatively small charges and low muzzle velocities of projectile, yield ample power to allow the guns to be lowered completely beyond the reach of hostile shot.

This is a consideration of great importance, because year by year a large number of excellent muzzle-loading guns of all calibres will be returned into store from the Navy, and may at once be utilised for strengthening our coast defences, for they are quite powerful enough to act against unarmoured vessels, light-draught transports, and such like, as well as against the unprotected parts of ironclads; while as howitzers they would be invaluable for preventing landing from boats, and for this service would be quite as effective as the longer, more costly, and more delicately-made breech-loaders, which, however, should be associated with them to resist ironclads. It so happens, also, that the short muzzle-loader is particularly well suited to the Moncrieff carriage, because the men engaged in loading, training, and elevating, working completely under the parapet, are in absolute safety from the enemy's fire, and the only man exposed is he who lays the gun, and even that exposure, as we have already remarked, can often be dispensed with. The muzzle-loaders are also much more simple weapons to manage than the modern, more powerful guns, and would therefore be better fitted for coast batteries, which would undoubtedly have to be manned and worked by Volunteers and men not so highly trained as the Artillery of the regular army.

Some years ago, the War Office definitely adopted the Moncrieff counterweight carriage, and mounted, successfully, guns as large as the 9-inch of 12 tons weight; but after a time evil counsels prevailed, inveterate prejudice triumphed, and the nation has been saddled with a vast expenditure on forts, which are already obsolete, for by no sort of ingenuity can they be made to carry artillery fitted to cope with that which will be opposed to them. Not that the system was ever rightly applied: Colonel Moncrieff, though attached to the War Department for the express purpose of developing his views, does not appear to have been consulted as to the arrangement of his batteries, or, if consulted, his views were ignored, and the consequence is that, in the case of the comparatively few guns which have been mounted, most of the emplacements are made as conspicuous as possible, and in that way the inestimable advantages of concealment have been thrown away.

The counterweight system, however, becomes very cumbersome when guns exceed some 20 tons in weight. Recourse can then be had to compressed air as a means of storing the energy of recoil. But the work done in compressing air reveals itself in the form of heat, which raises its temperature, and is slowly dissipated as it cools. Again, the air, in expanding to raise the gun, is cooled by the amount of heat converted into work, and its pressure is thereby reduced, so that the losses on these two accounts, added to the somewhat increased friction of the machinery, set a limit to the height to which the stored energy of recoil can raise the gun: the increased charges used in modern artillery, however, compensate for these losses, and it is possible by hydro-pneumatic arrangement to give efficient cover to the heaviest guns. The natural fear arises lest the introduction of water and compressed air may not add elements of danger in the facility with which dirt and debris, not sufficient to injure an ordinary mounting, may affect the more complicated arrangement. There is no doubt that a breech-loading gun requires more care in its use than a muzzle-loader, and a hydro-pneumatic mounting is not so simple as a carriage with an ordinary friction or hydraulic compressor, but experience with the 6-inch hydro-pneumatic siege carriage has shown that the system is capable of enduring very rough usage, and is by no means easily deranged.

The Australian colonies, acting under the advice of the late General Scratchley and General Steward, seem to be more intelligent and far-seeing than the mother country, and have acquired a considerable number of breech-loading guns, mounted on the system recommended, and carried out completely in all its details. It is difficult to see how official opposition can long brave the assaults made on it by common-sense, and the glaring defects of the old methods.

(To be continued.)

THE TEMPERATURE OF THE CLYDE SEA-AREA.

I.

IN the spring of 1886 a regular system of temperature observations was commenced in the water of the Clyde sea-area, by the staff of the Scottish Marine Station, under the personal superintendence of Mr. John Murray of the *Challenger* Commission. The work has since proceeded steadily, and will probably be continued to the close of the present year. Previous to 1886, few temperature observations had been recorded dealing with the deep water on the west coast of Scotland; these were almost entirely the work of Mr. J. Y. Buchanan on occasional summer cruises.

The scope of the present investigation is limited chiefly by the capabilities of the Marine Station's steam-yacht *Medusa*. She is a vessel of 30 tons, yacht measurement, steaming 6 knots in ordinary circumstances; but not adapted for working amongst the tremendous tidal currents of the North Channel except in the calmest weather. On the other hand, her small size, and the convenient arrangement of a steam-winch for working the sounding-line enables observations to be made with great rapidity in quiet water. Inside of Cantyre, soundings have been obtained in almost every kind of weather, and the present article will deal with this part of the west coast only.

The Clyde sea-area[1] comprises all the connected water-system, 1300 square miles in extent, lying to the north of a line drawn from the Mull of Cantyre to Corsewall Point in Wigtownshire. This line corresponds nearly to the 50-fathom contour; outside it the depth increases rapidly to over 80 fathoms; towards the inner or northern side it diminishes at first, and then remains at about 27 fathoms over an area of 270 square miles. This bank is termed the Clyde Barrier Plateau; it crosses from Cantyre to Ayrshire, past the south end of Arran, and around Ailsa Craig. The shallowest water covers a ridge at a depth of about 20 fathoms from the surface. The water deepens on the inside of the Plateau to form the Arran Basin, which in form resembles the letter λ, surrounding Arran on the west, east, and north, and running up into Lower Loch Fyne. The depth in this basin exceeds 50 fathoms over 100 square miles; the deepest water, 107 fathoms, occurs off Skate Island, near Tarbert. A much smaller depression runs in a straight line from the Cumbraes to Dog Rock at the mouth of Loch Goil. It is known as the Dunoon Basin, and has an average depth of 40 fathoms and a maximum of 56. Of the numerous lochs, reference will be made to two only, Upper Loch Fyne and Loch Goil. The former measures 25 miles from Otter Ferry to the head; it consists of a basin 30 fathoms deep, bounded by channels having an

[1] For detailed description and map see *Scottish Geographical Magazine* for January 1887.

average depth of less than 15 fathoms at Otter Ferry and Minard Narrows, and of a much longer and deeper basin beyond; the maximum depth of the latter (80 fathoms) is found off Strachur. Loch Goil, only 7 miles long and 47 fathoms deep in the centre, is cut off from the Dunoon Basin by a barrier rising to within 10 fathoms of the surface, and is thus exactly similar in its situation to Upper Loch Fyne. The average depth over the whole Clyde sea-area is 31 fathoms, and it contains approximately 150,000 million tons of sea-water. The estuary of the River Clyde is both narrow and extremely shallow, and the river does not appear to affect the Firth to such an extent as the Forth does the firth bearing its name.

The submarine features of the Clyde sea-area are varied and complicated; and this character is shared by the surface of the intervening land, producing a diversity of mountain, glen, and plain, and corresponding effects of sunshine, cloud, and mist, that lend to the temperature cruises a picturesque charm such as rarely invests physical research.

The cruises take place at intervals of about 50 days, and each occupies a little more than a week. Observations are repeated at about sixty stations, distributed over the whole area. The temperature is ascertained at the surface, at 5 and 10 fathoms, and at distances of 10 fathoms down to the bottom. Whenever a considerable difference is noted in the readings of two adjacent thermometers, observations are repeated at close intervals between them, so that when the curve of vertical distribution of temperature is drawn, points are most numerous where they are most wanted, at the regions of change of curvature. All temperature observations are made with Messrs. Negretti and Zambra's patent standard deep-sea thermometers. These are mounted in the Scottish frame, and are reversed by the fall of a brass messenger. Three thermometers are used on the line at once. The readings may be relied upon to one-tenth of a degree Fahrenheit, except when the sea is rough; then the very lively motion of the *Medusa* introduces a little uncertainty, on account of the difficulty of reading. A slight correction for change of volume of the detached column of mercury is necessary when the temperature of the water differs more than 5° F. from that of the air; the air-temperature being observed by the wet-bulb sling-thermometer.

A slip water-bottle is used on the line along with the thermometers, and samples of water are secured from various depths.

The entire set of observations made on the Clyde sea-area, up to November 1886, have been published in the last number of the Scottish Meteorological Society's Journal; and for the purpose of giving a general idea of the main results as yet ascertained, it will suffice to describe the varying seasonal conditions in three typical regions, and then to indicate the general distribution of temperature in the whole area throughout the year.

In the *North Channel*, near the Mull of Cantyre, observations could only be made on five cruises, and of these only two could be extended far enough to reach deep water, that of April 16, when the weather was remarkably fine, and that of September 22, when Mr. Mathieson, of Liverpool, was kind enough to give the use of his large steam-yacht *Oimara* for the purpose. The result of all the observations is shown graphically in Fig. 1. The distribution was always uniform from surface to bottom (except for a variation of not more than 1° in the superficial layer); and, as the accompanying figures show, there was a steady rise of temperature from April to September, while by December there had been a marked fall. It is noticeable that in all cases except December the surface water was a little warmer than that beneath; in December it was a little colder. Temperature:—

April 16	June 19	August 12	September 22	December 25
42°·0	47°·4	52°·5	54°·5	48°·5

The annual range, so far as observations go, appears to be about 12°·5 F. The uniformity of temperature throughout the mass of water continues over the Plateau, but gives place to a slightly different distribution in the deep Arran Basin.

Off *Skate Island* eight observations have been made between March 1886 and February 1887, and the curves presenting their results are given in Fig. 2. The actual figures observed for surface and bottom are:—

	March 27	April 19	June 21	Aug. 10
Surface	41°·4	43°·8	48°·3	53°·6
Bottom	41°·5	41°·3	44°·0	45°·6
	Sept. 26	Nov. 16	Dec. 29	Feb. 7
Surface	54°·7	49°·3	46°·6	43°·7
Bottom	47°·4	51°·1	47°·4	44°·3

The range of temperature on the surface thus appears to be 13°·3, and on the bottom 9°·8. The maximum surface

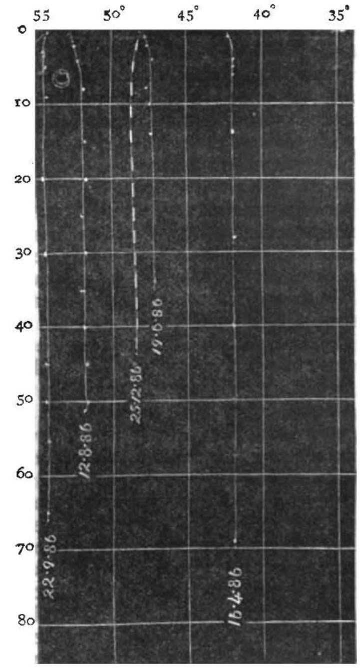

FIG. 1.—Channel.

temperature was observed in September, the maximum bottom temperature in November. The continuous curves (Fig. 2) show the course of heating; the broken lines that of cooling. They illustrate the development of conditions hinted at in the curves for the Channel. Starting with a practically uniform temperature of 41°·4 in March, the water had heated considerably on the surface, and cooled very slightly at the bottom, by April. From that time it warmed throughout, the surface most rapidly, and a mass of water next the bottom was warmed uniformly. The depth of this mass steadily decreased, until in September there was an unbroken gradient of temperature, falling from surface to bottom. By November the surface had chilled considerably; but at 24 fathoms the temperature was the same as in September, and below that depth higher; there being little change from 30 fathoms to the bottom. In succeeding months the fall of temperature has proceeded nearly uniformly, the curve approaching the form of a straight line, gradually becoming more nearly perpendicular. It will be noticed that the curves are not in all cases perfectly regular, but the deviations are so slight that they might almost be attributed to errors of observation, or to the use of slightly erroneous corrections for the thermometers. This is not the true explanation, as the next group of curves illustrates.

Strachur is near the deepest part of Upper Loch Fyne; the water which the depression contains is cut off from communication with the outside by the double doors of Otter and Minard with a shallow hollow between. Eight sets of observations have been made, as follows:—

	April 20	June 21	Aug. 11	Aug. 25
Surface	42°·6	49°·2	54°·1	53°·5
Bottom	41·9	44·1	44·2	44·2

	Sept. 27	Nov. 17	Dec. 29	Feb. 4
Surface	52°·4	46°·4	41°·0	43°·0
Bottom	44·1	44·2	44·7	45·9

The surface range was 13°·1, with a maximum in August;

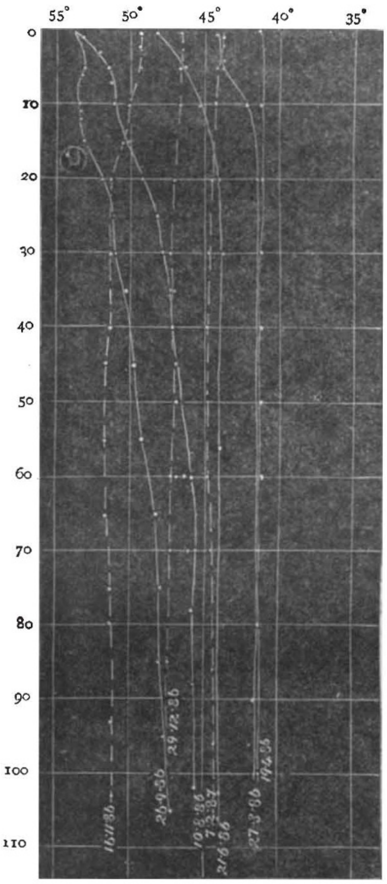

Fig. 2.—Skate Island.

the range of temperature on the bottom has as yet been only 4°; but it is impossible, until further observations have been made, to speak definitely about this. The most remarkable thing apparent from the above figures is that from June to December there should only have been a change of half a degree Fahrenheit in bottom temperature; but an examination of the curves in Fig. 3, will bring out some other curious relations. In April a uniform temperature of 41°·9 was found under 10 fathoms, and this was quite analogous to all the other April observations. In June the surface was found greatly warmed, but at 15 fathoms the temperature was only half a degree higher than it was two months before (42°·5): beneath that point there had been considerable rise of temperature (to 44°·1), so that the phenomenon was presented of a layer of cold water with warmer water above and beneath. It may be mentioned in passing that but for Negretti and Zambra's outflow thermometers this singular distribution could not have been traced out, perhaps not even detected; as, using the deep-sea thermometers on Sixe's principle, the natural induction would have been that below 15 fathoms the temperature was uniform at 42°·5. In August this minimum had almost disappeared, though a trace of it remained at 35 fathoms, the point where the August curve merges with that for June. By September surface cooling had begun, but below 2 fathoms and down to 50 there was

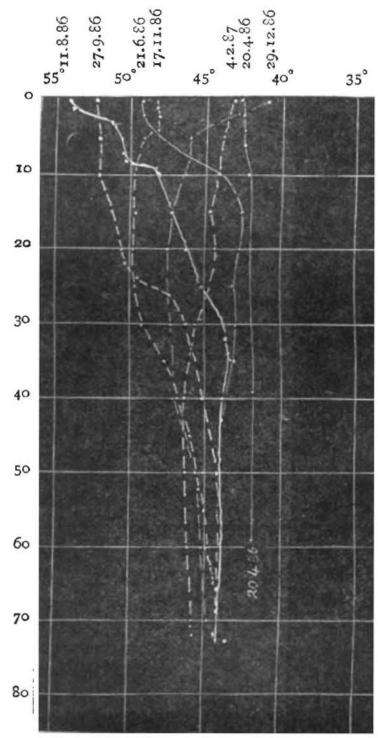

Fig. 3.—Strachur.

a rise of temperature. At the latter depth the temperature became constant to the bottom at 44°·2 as before. November and December showed the gradual cooling of the surface, and the still more gradual motion downwards of the point of maximum temperature. In December the bottom water had begun to warm, and in February the much attenuated maximum had reached to 45 fathoms, and the remains of summer heat had fairly influenced the bottom temperature. Many more very interesting relations will become apparent from the study of the interlacing curves of Fig. 3, which, with some modifications, are applicable also to Loch Goil, a rock basin "similar and similarly situated" to Loch Fyne.

Hugh Robert Mill.

(To be continued.)

DR. JUNKER.

NOT since Greely told his story to the Royal Geographical Society has there been so crowded and enthusiastic an audience at Burlington Gardens as assembled on Monday night to welcome Dr. Junker, who, during the last ten years, has done so much good work for geography and science in the important region between the Upper Nile,