$\pm$ 300 *scale divisions, equivalent to* 6·2 *volts, to begin with in each case.*

Flame.	Length of funnel between burning substance and copper plates.	Leakage in two minutes.	Remarks.
	Centimetres.	Scale divisions.	
Spirit flame	66	292 pos.	Funnel of 15·3 cm. bore all vertical.
,,	,,	287 neg.	,, ,, ,,
,,	112	253 pos.	,, ,, ,,
,,	,,	254 neg.	,, ,, ,,
,,	343	22 pos.	Funnel 114 cms. vertical of 15·3 cms. bore; and 229 cms. horizontal of 3·8 cms. bore.
,,	,,	20 neg.	
,,	236	24 pos.	Same vertical, and 122 cms. horizontal of 3·8 cms. bore.
,,	,,	20 neg.	
,,	160	40 pos.	Same vertical, and 46 cms. horizontal of 3·8 cms. bore.
,,	,,	46 neg.	
,,	244	165 pos.	Same vertical, and 130 cms. horizontal of 15·3 cms. bore.
,,	,,	187 neg.	
Charcoal	,,	54 pos.	,, ,, ,,
,,	,,	57 neg.	,, ,, ,,

conductive quality of the air and fumes ceased within a quarter of a minute.

§ 13. In connection with these last experiments, attention may be directed to an experiment described by Prof. Schuster, in which he uses an insulated metallic tube bent round at the upper end, to prove that "it is not only the flame itself which conducts, but also the gases rising from the flame."[1] He discovers electric conductance in products of combustion mixed with air quite out of sight from the flame.

SURVEY OF THE TIDES AND CURRENTS IN THE GULF OF ST. LAWRENCE.

WHEN the meeting of the British Association was held at Montreal in 1884, the necessity of establishing stations for tidal observations in Canadian waters was discussed, and the Association adopted a resolution drawing the attention of the Government of the Dominion to the matter. A committee was also appointed to collect information and make representations to the Government respecting it. Two years later a large deputation, representing the British Association, the Royal Society of Canada, and the Board of Trade of Montreal, waited on the Minister of Marine. The matter was favourably received, but, owing to financial reasons, any action was for the time postponed. In 1889, however, exploratory trips were undertaken, by direction of the Government, with the view of ascertaining the best points to establish tide gauges; and in 1890 a practical commencement of the survey of the tides and currents in the Gulf of St. Lawrence was made. The object of this survey is to furnish data for compiling trustworthy tide-tables, and to afford information as to the set of the tidal and other currents in the Gulf. The value of such information is shown by the remarks of Lieut. Gordon in his report to the Minister of Marine, in which he expresses the conviction that until an exhaustive examination of the whole system of tidal movements carried out on similar plans to those which have been made on the United States coasts, and on the coasts of Great Britain, has been made, there will always be the liability to heavy maritime losses due to the lack of information. The average loss, he states, is now over half a million of pounds—a large proportion of which is due to a want of knowledge of the currents.

For the purpose of determining the set and cause of the currents, it was necessary to have a trustworthy record of the time and range of the tides; of the variation in the pressure of the barometer; the force and direction of the wind; and the temperature and density of the water at different depths. The survey is under the charge of the Marine Department, with Colonel Anderson, Chief Engineer, at the head. The tidal survey is in charge of Mr. W. Bell Dawson, C.E. Four reports as to the progress of the work have already been issued. In the first season the two entrances to the Gulf were examined at Belle Isle and Cabot Straits, between Cape Breton and Newfoundland; and the general relation of the Gulf to the ocean as regards tide and currents was examined. Next season the entrance between the Gaspé coast and Anticosti was examined, and the nature of the currents was traced across the south-western side of the Gulf to Cape Breton. This part of the Gulf is a steamship route of constantly increasing importance. More recently, the north-eastern arm of the Gulf, from Anticosti to Belle Isle, through which passes all the Atlantic traffic which takes the Belle Isle route, has been under examination. Seven self-recording tide gauges have also been set up, the establishment of the intended stations on the Atlantic coast having been postponed owing to the want of funds. Although the shortest time for obtaining a correct computation of the tides at any port is the lunar cycle of nineteen years, sufficient data have been collected to enable the Department to issue tide-tables for the use of the pilots of the St. Lawrence, and for Halifax.

It has been settled that the current in the Strait of Belle Isle is fundamentally tidal; and, under normal conditions, runs east and west, with velocities of about two knots in each direction. During heavy winds, especially when westerly, the current which runs with the wind becomes stronger than the current against it; and for a time the current may become continuous in the same direction as the wind.

The tides vary in height from four to five feet in the open Atlantic, to twelve feet in the lower part of the St. Lawrence River, seventeen feet at Quebec, and thirty feet over the Bay of Fundy. To correctly observe these, tide gauges fixed at different parts of the coast are required. Owing to the uninhabited condition of a great part of the coast, the difficulty in selecting suitable places and attending to the gauges has been very great. The self-recording gauges used are of the usual design, but special precautioas have had to be taken to guard against the effect of ice and the oscillation due to wave action. At most stations no wharves or quays were available against which the gauges could be fixed. At some of the stations wells had to be sunk at high-water mark to the level of the lowest tides, and a trench, 270 feet long and 10 feet deep, excavated across the rock shore, to admit the tide to the well. The tide was led to the well by wooden piping, made from fir trees, twelve inches diameter, having a hole three inches in diameter bored through the centre, the joints being made tight with sail-cloth saturated with white lead. To prevent the effect of air entering the pipes, due to the surge of the sea in rough weather, an iron pipe was laid out along the bottom for about 100 feet, into water having a depth of twelve feet at the lowest tides. To prevent freezing in winter, a boiler, three feet in diameter, was placed vertically in the well and kept heated, and in this the tide pipes were fixed. These gauges have been occasionally damaged during gales, and in one case the station could not be reached between January and the opening of the navigation in May. At some of the stations, situated on islands, it was necessary to make a telegraphic exchange of time once a week to regulate the driving clocks. To avoid this expense, meridian instruments, named *dipleidoscopes*, have been employed, which, when once set correctly, give the exact time of the sun's meridian passage. These were obtained from a Paris maker.

The currents in the Gulf are affected both by the tide and the amount of fresh water coming down the river. It was found that the under-currents which exist are frequently displaced and brought nearer the surface, either by the effect of wind or by a variation in the temperature. For the purpose of ascertaining the position and force of these currents observations were taken as to their flow, and also as to the temperature and density of the water. From Quebec to Father Point the tidal current occupies the whole width of the river; when the channel widens, a part of it is occupied by a constant downward current which runs parallel to the south shore all the way to Gaspé. The main tidal current enters the Gulf from the Atlantic by Cabot Strait, between Cape Breton and Newfoundland, and does not lose itself in the great expanse of the Gulf, but continues across

[1] Prof. Schuster, on "Atmospheric Electricity," at Royal Institution, February 22, 1895.

it with an increased range in the passage between Gaspé and Anticosti, and from there pursues its way with ever-increasing height up the St. Lawrence to Quebec. The progress of this tidal wave has been traced to the existence of a deep channel which crosses the whole extent of the Gulf from Cabot Strait to the passage between Gaspé and Anticosti, and thence up the St. Lawrence nearly to Saquenay. This channel extends a distance of 500 miles, with an average width of 35 miles and a continuous depth of 150 fathoms.

For the purpose of ascertaining the nature and velocities of the currents, the steamer used was moored with a wire rope hawser, provided with an accumulator, to prevent sudden jerks and strains. This accumulator consisted of a series of sixty rubber discs, five inches diameter, making a total length of twelve feet, which was reduced to eight feet eight inches under the greatest compression. Two kinds of current meters were used: one having small buckets revolving horizontally, on the same principle as an anemometer; and the other of a fan, similar to a screw propeller, revolving in a vertical plane. The former was found to be best for sea work, as it was least affected by the vertical motion of the vessel due to waves. The latter was found to be liable to head up or down as the vessel rolled, and so give an exaggerated record. Both kinds were worked by electricity. The surface currents were taken at a uniform depth of eighteen feet, which was well clear of the keel of the steamer. The meter was allowed to run for half an hour at this depth, then lowered to the desired depth for an hour, and then again run for half an hour at the eighteen feet. At a depth of ten fathoms the Gaspé current was sometimes found to be stronger than at the surface, but usually the velocity decreased regularly with the depth. At twenty fathoms it was only 50 per cent. of the surface velocity; and at thirty fathoms, 20 per cent. The greatest velocity was 2·81 knots. The current fluctuated with the rise and fall of the tide, decreasing during the rise, and increasing during the fall. The constant outward current from the Gulf was found to have a width of fourteen miles, and a depth of forty fathoms near the Gaspé coast, with a surface velocity of from 1·10 to 2·81 knots. The temperature in July was found to range from 53° at the surface to 33° at thirty fathoms; and 32° at fifty fathoms. In the Gaspé region and in Cabot Strait the coldest water forms a layer between the depth of thirty and fifty fathoms, and, while the surface water rises in temperature during the season, no appreciable variation was found from June to September at a depth of fifty fathoms.

The density of the water was ascertained as affording an indication of the quantity of fresh water coming down the St. Lawrence. In the Strait of Belle Isle and Cabot Strait the density of the surface water ranges from 1·0233 to 1·0245, the same as in the Atlantic. On the western side of Cabot Strait, the outflowing water, which occupies a width of about ten miles, has a density of 1·0220 to 1·0235 at the surface. In the Gaspé region the average density for a width of fourteen miles, and between the surface and ten fathoms, was 1·02195: and to a depth of forty fathoms, was 1·02368. The density of the water is disturbed by currents due to wind. Thus during three days, when the wind from the S.S.W. averaged twenty miles an hour, the density contours were displaced to the northward about nineteen miles at the surface, fifteen miles at ten fathoms, and nine miles at twenty fathoms.

The completion of the survey is expected to occupy another three or four years.

AGRICULTURAL EXPERIMENTS IN PLOTS AND POTS.

IN a recent number of the *Agricultural Gazette of New South Wales* (vol. vii. p. 663) there is an article by Mr. N. A. Cobb, written at the request of the Minister for Agriculture, upon the methods employed for experiments with crops and manures. It appears that field experiments are being carried out to a considerable extent by the farmers of the country, but that the results are to a large extent untrustworthy and misleading, owing to innumerable sources of error which the experimenters have failed to perceive and guard against. Science is thus brought into ill repute, doubt is thrown on established truths, and progress hindered. The evidence brought forward goes far to show that this is a true indictment. When, however, the author goes a step further, and speaks of field experiments as almost essentially untrustworthy, we cannot agree with him. The sources of error which he mentions may all be avoided by judicious management, if only the experimenter will guard against them at the commencement of his work, and superintend his operations with proper care.

Inequalities of soil are one of the worst evils in field experiments; the investigator frequently remains unconscious of them, the difference in the results being credited to the effect of the manures, &c. It is *very rare* for proper precautions to be taken against this evil, for the simple reason that these precautions imply delay, and the experimenter is generally in a hurry to obtain results. If, for instance, the comparative effect of different manures on barley is to be ascertained, or the comparative yield of different varieties of seed, the only basis for an accurate trial is to divide the field into the required plots, then sow the whole field with a uniform barley seed, without any manure, and weigh separately the produce of each plot. If the crops obtained are equal, within the unavoidable errors of experiment, the field is one suitable for the purpose of the experiment; if the crops are unequal, the field, or that portion of it in which the inequality occurs, is clearly unsuited for the purpose intended. It is not sufficient, as is often supposed, to inspect the field when under ordinary culture, and because of the apparent evenness of the crop, to pronounce it fit for use; for natural inequalities of soil may not appear in a well-manured field, although plainly manifested when the supply of manure ceases.

The errors due to inequalities of the soil in one series of trials may, of course, be neutralised by making many series of trials, and substantial accuracy may be gained by simply regarding the mean results obtained; but if a field is really unequal in fertility, no ordinary arrangement of duplicate plots will suffice to ensure an accurate result. If the same experiment is repeated throughout a wide district, as is often now done in County Council experiments, it may be quite misleading to take the mean of all the results as expressing the truth for the whole district. We must not bring into the mean the results obtained in different soils and climates, unless, indeed, our aim is to procure general statistics which are of no value for any particular place. Basic slag and superphosphate will compare quite differently upon a clay and upon a chalky soil; nitrate of soda and sulphate of ammonia will compare differently on dry and wet soils. To take the mean of experiments made under such different conditions is simply to misinform every farmer in the district; yet public money is continually wasted in this way.

Mr. Cobb points out that the effect of inequality in the soil may be obviated by substituting rows for square plots. This is true, and the point is well worthy of attention; the suggestion is not, however, novel. In a comparison of basic slag and superphosphate for turnips, conducted by the writer at Rothamsted in 1886, the slag and turnip seed were sown by drill on the top of two ridges down the whole length of the field, and on the return of the drill an equal number of ridges by the side of the first were left unsown. When the sowing of the slag was completed, the same drill sowed superphosphate and turnip seed in all the vacant spaces. There were thus throughout the field two rows of turnips with slag, side by side of two rows of turnips with superphosphate, the repetition occurring many times over. This plan was suggested by Sir John Lawes. This is, for many experiments, a good mode of work, but its use is practically limited to those crops and manures which can be sown by drill; unfortunately, drills are not satisfactory machines for evenly distributing given weights of manure over given areas.

Mr. Cobb next passes to the pot system of experiment: he describes the work at the Darmstadt Experiment Station, with its 1000 pots, and suggests that work on this system should be commenced in Australia.

There is no doubt that for solving certain questions the pot system, when carried out with scrupulous accuracy, is far superior to any other. If we wish to know what is the comparative value to any plant of various nitrogenous manures under the most favourable conditions of supply and use, we arrive at this fact only by pot experiments. The produce obtained per unit of nitrogen in the pot will not, however, necessarily be the produce obtained in the field; and the relative value of different manures, as shown in the pot, will only by mere chance appear in the field, where, in fact, it will be found to vary every year. The essential difference between the two systems is due to the fact that the field results are largely influenced by the season, and especially by the amount of rain, and the quantity of water percolating through the soil; while the pot cultures are carefully protected from such vicissitudes. If, then, the farmer