TERRESTRIAL MAGNETISM.

If a magnetized steel needle is suspended by its center of gravity, or placed upon a point, it will take a determinate direction towards a point of the horizon which is very nearly north and south. The force which produces this direction is called terrestrial magnetism. It is one of the modes of manifestation of the natural sources of electricity, since magnetism itself is only a particular form of electricity. The magnetic force of our globe is manifested at its surface by three classes of phenomena, namely, the declination of the magnetized needle, its inclination, and the intensity with which the force acts. The declination is the angle that is formed with the direction of the meridian of the place by the direction of the magnetized needle placed upon a vertical pivot. The inclination is the angle that is formed with the horizon in the magnetic meridian by the direction of a magnetized needle sustained by its center of gravity, around which it is able to turn freely in a vertical plane. These three elements, declination, inclination, and intensity, not only vary from one place to another, but in the same place with time. They also manifest irregular and accidental variations, designated under the name of disturbances, the existence of which is connected with the presence of some natural phenomena, such, in particular, as that of the aurora borealis. It is well established that the forces which act upon the magnetized needle emanate directly from the terrestrial globe, and we are naturally led to regard the earth as a great magnet, and as having one pole situated to the north of us, attracting the north pole of a needle in that direction.

If we suspend a magnetic needle by its center of gravity, so that it may move freely either in a vertical or horizontal plane, the extremity which turns towards the north will incline below the horizon, making at New York an angle with the horizon of about 72°. Hence we conclude that, if the earth be a great magnet, giving direction to the needle, its pole must be situated, not on the north horizon, but almost vertically beneath us.

If the earth is really a magnet, the magnetism of soft iron ought to be decomposed by it, in the same manner as is done by a bar magnet, and such is the fact. If a bar of soft iron is held in the direction which a magnetic needle assumes when freely suspended, its lower end immediately becomes a north pole, and its upper end a south pole, as is shown by bringing a small magnetic needle near each end of the bar. On inverting the bar, it will be found that its poles have immediately changed, the lower end being again a north pole, and the upper one a south pole. If the bar is held horizontally, pointing east and west, no such effect takes place.

A similar but slightly diminished effect is produced on a bar of iron suspended in vertical position; and iron rods which have remained long in a vertical position frequently acquire permanent magnetism.

When a bar of iron is rendered magnetic by the influence of terrestrial magnetism, a stroke of a hammer will sometimes fix the magnetism, and the poles will not be reversed when the bar is inverted. But if several blows with the hammer be struck when in the inverted position, its magnetism may be destroyed or its poles be reversed.

The action exerted by the earth upon a magnetic needle is simply to give direction to the needle, for the weight of a needle is not increased by its magnetism. Hence it is concluded that the attraction of the earth for one pole of the needle is exactly equal to its repulsion for the other. If a magnetic needle be placed upon a cork floating on water, it will soon adjust itself to the magnetic meridian; but it has no tendency to travel either toward the north or south.

Although a magnetic needle, when fully suspended, generally points nearly north and south, it is found in almost all parts of the world that the north pole of the needle deviates a few degrees from the astronomical meridian. This deviation is called the magnetic declination. The declination is said to be east or west, according as the north pole of the needle deviates to the east or west of the true meridian. The declination of the needle is very different at different places on the earth's surface. There are places where the declination is 10°, 20°, 30°, and even 90° west; and there are places where the declination is as much to the east. At most places on the earth's surface, the dipping needle will not rest in a horizontal line, one pole pointing downwards and the other upward. This dip varies at different places from 0° to 90°, and observations to determine its amount have been made in almost every part of the world. In order to represent all these observations conveniently upon a chart, a line is drawn connecting all those places where the dip is the same. A line connecting all those places where the needle rests horizontally is called the magnetic equator. This line exhibits numerous sinuosities in its course around the globe, but does not depart much from a great circle. It crosses the terrestrial equator near the western coast of Africa, attains its greatest southern latitude in South America, where it is 15° south of the geographical equator, crosses the equator again near the meridian of New Zealand, and attains a north latitude of 12° near the southern part of Hindostan.

As we travel northward from the magnetic equator, the north end of the needle inclines downward, and the dip continually increases at the rate of about 1° for 1° of latitude, until we reach the north magnetic pole, where the needle stands vertically, in latitude 70° 5′ N., longitude 96° 45′ W.

As we travel southward from the magnetic equator, the south end of the needle inclines downward, and this dip continually increases until we reach the south magnetic pole.

That terrestrial magnetism is not produced, in any important degree, by magnetic forces external to the earth is probable, because, if there were an external cause for magnetism, it is scarcely conceivable that some large part of it would not act in planes parallel to the geographical equator: and if so, its effects at any one place would undergo very great changes in the earth's diurnal revolution, every part of the earth being presented, in the course of the day, in different aspects toward forces so acting. Now the fact is that the diurnal changes are very small, only about $\frac{1}{300}$ part of the whole horizontal force. It would seem certain therefore that external bodies or spaces do not produce any sensible part of the magnetism in the planes to which the earth's axis is normal.

That terrestrial magnetism does not reside, in any important degree, in the earth's surface, is probable, because of the non-magnetic property of the materials of which the earth's surface is composed, and upon the general absence of any perceptible change in magnetism depending on the change of soil.

Humboldt adopted the idea that the principal phenomena of terrestrial magnetism could be explained by the action of a powerful magnet, of limited dimensions, near the center of the earth; but it was found that the theory upon which this idea depended, though well representing the broad facts of terrestrial magnetism, failed in accuracy when applied to many special cases.

Hansteen suggested the theory of two large magnets within the earth, but this failed to meet the facts of observation.

Gauss attempted to explain the cause of terrestrial magnetism by supposing that magnets are distributed irregularly through the earth, and the results of observations generally accord with the necessities of his theory.

Regarding the earth as a heterogeneous compound of different substances, which may possess in some degree the properties of different metals, and conceiving (as is the opinion of many physicists) that there is in the interior a great store of caloric, which may heat the points of contact, some of them steadily and some by occasional bursts of flame, it seems within the range of possibility that such a combination, of heat with dissimilar substances, may be the cause of terrestrial magnetism. But there is no evidence of this beyond mere conjecture. It is worthy of remark that the isothermal lines on the earth's surface bear a striking resemblance to the lines of equal magnetic intensity. On the whole, we must express the opinion that the general cause of the earth's magnetism still remains one of the mysteries of cosmical physics.

A YEAR'S EXPERIENCE IN BOILER INSPECTION.

Last year there were upwards a hundred boiler explosions in the United States and Canada of a nature sufficiently serious to be reported in the newspapers. By these explosions 183 persons were killed and about 200 wounded.

By many, such unhappy occurrences, or the most of them, are regarded as pure accidents, mysterious, unaccountable, and therefore unavoidable. The managers of the Hartford Boiler Inspection and Insurance Company say: No. While it is not always possible to point out the particular cause of a particular explosion, for lack of knowledge in the premises, boiler explosions as general phenomena are not mysterious, and not unaccountable. It is neither wise nor safe to assume occult causes for such effects when known conditions are at least apparently sufficient. Unforeseen and unforeseeable occurrences will arise, the most careful of engineers is liable to make mistakes and oversights; yet they hold that, with proper construction, intelligent management, and frequent thorough inspection, the frequency of explosions can be immensely diminished, possibly, in time, prevented altogether. At any rate, given these conditions, they are willing to assume the risk of an explosion in any case at a low figure.

Their experience certainly gives the opinion of these gentlemen very great weight. During the past year they have collected through their inspectors the results of upwards of twenty-nine thousand boiler inspections (more than a third of the number being thorough internal and external examinations), under a wide range of conditions of structure, age, use, etc. One result of these inspections was the direct condemnation of one hundred and sixty-three boilers as unfit for use, the majority of them worn out beyond repair. The distribution of the defects is exhibited in the following classification, the second term of each couplet denoting dangerous defects, or those in which the liability to accident was so great that a guaranteed certificate could not be issued until the defect was corrected:

Furnaces out of shape 602—108 dangerous; fractured plates 1,127—564; burned plates 867—302; blistered plates 2,368—374; deposits, incrustation, and scale 4,816—645; external corrosion 937—250; internal corrosion and grooving 642—268; water gages defective 548—100; defective blow-out 267—79; safety valves overloaded and defective 343—140; pressure gages defective 1,809—315; without gages 714—26; deficiency of water 78—26; broken braces and stays, and insufficient bracing 685—289. Thus the company's inspectors discovered upwards of three thousand dangerous defects in the boilers under their care, and about five times as many as that would no doubt have become dangerous if neglected. The saving in life and property effected by the timely discovery and removal of these germs of destruction is simply incalculable.

It might be expected that the experience gained in a private undertaking of this sort would be carefully withheld from the public for personal profit. It is not so in this case. The President's annual report, from which our statistics have been taken, gives some twenty large pages to the discussion of the causes of the different kinds of defects, with suggestions for their prevention and cure. Practical engineers can judge the value of observations based upon such an extensive range of experience.

Particular attention is given to the causes of sedimentary deposits, incrustation, and scale, and means for removing them, and considerable space is devoted to the action of solvents. Potatoes are mentioned as having good results, in some instances, as a preventive. Crude petroleum has been used in many cases with uniformly good results. It is not recommended for general and indiscriminate use, for it may do harm. Catechu, nutgalls, oak, hemlock, and other astringents containing tannic acid have also been found of service in removing scale where carbonates are present. They fail, however, with sulphate of lime, and tannic acid is further objectionable in that it is liable to attack the iron of the boiler, though less so than acetic acid. One of the most successful solvents used is carbonate of soda, incrustations of both sulphate and carbonate of lime yielding to it. It should be used in quantities varying from one to two pounds a day. Mixed with catechu, in about the proportion of one part catechu to two parts of soda, the action of this solvent has been particularly happy. Stress is laid upon the necessity of the frequent thorough cleaning of boilers where solvents are used. "If the condition of the boiler is particularly bad, blow out the boiler once a week and remove all portions of scale which have been detached." Generally, solvents should be used under special advice adapted to the local conditions.

In the discussion of the cause of internal corrosion, we find the suggestion that it may be due to galvanic action excited in the presence of acids in the water by chemical differences in the iron of the different plates. "It is well known that iron ore, even from the same mine, is not always chemically the same; certain impurities will be found in some places which do not exist in others. And in the manufacture of boiler iron, there is no doubt but that the sheets are chemically slightly different: hence when the boiler is constructed, the presence of acids in the water may excite galvanic action. This would account for the different manner in which boilers are affected. Some are attacked at the front end, while others will be attacked at the back end, and in other cases the rivet heads will be attacked.

"If it is found that the feed water is from a source that is contaminated, it should be changed at once. Ponds and streams on which cotton and woolen manufactories are located are apt to be very impure from the quantities of refuse and spent dies emptied into them. These generally are bad sources from which to take the feed water of boilers unless it can be brought in pipes from above the factories."

The comments on the bursting of experimental boilers for the discovery of the causes of boiler explosion are severely skeptical. "I would not disparage experiments intelligently made," the President remarks. "The experiments of the Franklin Institute made years ago are valuable to-day; and those made by the late Sir William Fairbairn have laid steam users under great obligations. Later experiments on the strength of materials have decided important questions about which there was much controversy; but to suppose that the cause of boiler explosions, as they occur in different parts of the country, where the boilers are indifferently cared for—fed with bad water and having few or no reliable attachments—is to be definitely settled by bursting experimental boilers, surrounded with none of the conditions to which boilers are subjected in daily use, is investing such experiments with an importance worthy the unbroken silence pervading the councils of the commission appointed by government to expend $100,000 in gaining information bearing on this subject."

AN ENORMOUS PEACH CROP.

The estimates of the coming peach crop all point to the same being of remarkable magnitude, the aggregate number of baskets being fixed at from eight to ten millions from the Maryland and Delaware peninsula alone. Strenuous efforts are being made to find markets for the yield, and a degree of enterprise is manifesting itself among the fruit growers which can hardly fail to win merited remuneration. A special train will be dispatched daily over the Baltimore and Ohio railroad to carry supplies to the cities of the West; 1,150 cars have been chartered to transport the fruit to New York and other eastern cities, and it is stated that the American Steamship Company of Philadelphia are fitting up huge refrigerators in their vessels, so that from 25,000 to 30,000 baskets may be carried to Liverpool at each trip.

The necessity of transporting so large a quantity of perishable freight in warm weather, quickly, seems to us to offer a good opportunity of practically testing the preservative properties of compressed air. On another page will be found a full description of M. Bert's important discovery. It is a very easy matter to render a portion of a car airtight, and to force in air by a simple hand pump until a pressure of three or four atmospheres is reached. This could without difficulty be maintained over a long trip; and if the effect stated by M. Bert—namely, complete preservation of the material—is obtained, an enormous saving in the cost of ice and in labor may at once be made. We should be glad to learn of the results if any one should adopt these suggestions.

Back Numbers for the Current Year.

We would state, in answer to numerous inquiries whether all the numbers of the SCIENTIFIC AMERICAN can be had for the year 1875, that they can be furnished from January to the present time, in sheets, or in volumes of 416 pages, bound, up to July 1. The price for the bound volume is $3; in sheets, from January to July, by mail, $1.60. New subscribers can have all the back numbers if they wish. But, unless requested otherwise, all subscriptions will be commenced at time of receiving the order.