SCIENCE

FRIDAY, NOVEMBER 9, 1888.

THE PAST SEASON has been one of unusually successful activity with the United States Fish Commission, a review of whose work is published elsewhere in this issue of *Science*. Probably the most important accomplishment during the year has been the establishment, at Gloucester and Wood's Holl, of stations capable of hatching four hundred million codfish-eggs, and which, with favorable weather, may be expected to put at least one-fourth of that number of cod-fry into the Atlantic Ocean during the present season. The problem of restocking the coast of New England with inshore cod, which has become so scarce except in Ipswich Bay, has been definitely solved. It is only a question of time, and a very short time at that, before codfish can be made to be more plentiful on the coast of New England than they were years ago, and a lost industry restored that will be worth millions of dollars to that section of the country. The only probable causes of delay are bad weather during the hatching-season, and anchor-ice, which kills the small fishes. It is known that only an infinitesimally small proportion of the fry hatched out at the fish-commission stations, and put into the rivers and lakes and the ocean, ever survive to reach maturity. It is only by planting an enormous quantity of the fry that the supply of fish is increased. It is claimed, that, of those artificially propagated, a much larger proportion survive than when the eggs are deposited naturally in the stream. In order to ascertain whether the number of small fishes to survive might not be enormously increased, Commissioner McDonald placed in a pond in Washington, in June, two million shad-fry. Eight hundred thousand of these are still alive, — breathing fishes from three to four inches long each. These will be kept until spring, and then placed in the Potomac. As a rule, they will by that time be able to take care of themselves. The remarkable success of this experiment may cause an entire change in the methods of artificially propagating shad. A new scheme of gathering up the small indigenous fishes hatched in ponds and lakes on the borders of Western and Southern rivers after their annual overflow, and planting them in the rivers, which, in many cases, have been depleted by over-fishing and the destructiveness of the floods, was put into successful operation this year. A hundred thousand fishes were thus rescued from sure death, when, later in the season, these lakes and ponds dry up. On the Pacific coast the steamer 'Albatross' has done the preliminary work of developing the extremely valuable halibut-fishing grounds that lie off the coast of Washington Territory and Vancouver's Island, convenient to the ports of Puget Sound, defined the boundaries of several deep-sea codfishing banks off the coast of Alaska, and will devote the winter to similar work in lower latitudes. The results of her first season's work are expected to be of very great economic value to the Pacific coast. These are but a few of the branches of work accomplished by the United States Fish Commission during the past season, though probably the most important. This commission is the most profitable of all the bureaus of the government, and ought never to lack for money.

ON NOV. 2 the following telegram was sent from Zanzibar: "Couriers from Tabora bring direct news from the Stanley expedition, a portion of which was met at the end of November, 1887, by Arabs trading between Lakes Victoria Nyanza, Mvutan Nzige, and Tabora. These Arabs met Stanley's rear guard at a point west of Mvutan Nzige, south-east of Sanga, just as the expedition was preparing to cross extensive swamps. The Arabs did not see Stanley. The detachment seen consisted of thirty men. They stated that Stanley was two days ahead. The expedition had suffered greatly on the march through a thick forest, where it was impossible to advance more than a mile and a quarter daily. They had also suffered in the marshes, where many had disappeared or died. Forty were drowned in crossing a great river flowing from east to west. One white man had died. Stanley was obliged to fight some tribes that refused to supply him with provisions. The expedition had often halted in the expectation of receiving re-enforcements from the Kongo. The rear guard, at the time met, had only been on the march five days after a halt of three weeks, due to the illness of Stanley and a great part of the escort, who had been attacked with fever. The Arabs estimate the total strength of the expedition, after all losses, at two hundred and fifty men. The health of Stanley was then good. The rear guard, which consisted of natives of Zanzibar, stated that Stanley had decided that he would no longer advance in a north-easterly direction, but would strike toward the north, hoping to avoid the swamps. After getting a certain distance north, he intended to take an oblique line to the eastward, and go straight to Wadelai, where it was thought he would arrive fifty days later, — about the middle of January, 1888. The Arabs were of the opinion that the expedition was still strong enough to reach Wadelai." We hesitate to accept this news as authentic, as it corresponds too closely to the views recently expressed in numerous newspapers, particularly regarding Stanley's intention to turn northward. Sanga, which is mentioned in this despatch, was visited by Junker in 1882, and marks the south-eastern limit of our knowledge of this region. The Arabs, who claim to have met part of the expedition, must have penetrated beyond the limits of Unyoro. It will be remembered that on Lake Mvutan Nzige and Muta Nzige no information was obtained by explorers regarding the regions farther west, and that there seems to be little communication in this direction. Therefore the report would imply that the Arabs had recently succeeded in opening this country to their trade. Besides this, their route must have led along Lake Mvutan Nzige, where Emin had re-established, a year since, his influence. Therefore it seems somewhat remarkable that no mention is made of Emin Pacha. Another despatch which was received on Aug. 1 in Zanzibar is undoubtedly an invention. It was stated that two messengers had arrived there who had left the interior about the beginning of April, and who reported that Stanley had not arrived at Wadelai up to that time. The messengers stated that in the month of March Emin Pacha did receive some vague and indecisive news of the explorer, which had filtered through from tribe to tribe, but that the reports were very conflicting. Some declared that Stanley, after losing a number of men and a large portion of his supplies, was hemmed in by hostile tribes between the Mabode country and the Mvutan Nzige, while other rumors were to the effect that he had been attacked by the tribes in the Matongora-Mino district, and after several conflicts had diverted his course in an unknown direction. The wording of this despatch is almost exactly the same as that of another received about fifteen months ago, and therefore it cannot be accepted as genuine.

THE ERUPTION OF KRAKATOA.

THE Krakatoa committee of the Royal Society has made its final report,[1] which forms a large quarto volume, and contains a mass of material of the greatest interest. After the remarkable phenom-

[1] The Eruption of Krakatoa, and Subsequent Phenomena. Ed. by G. J. SYMONS. London, Trübner.

ena following the eruption of Krakatoa on Aug. 27, 1883, became first known, and when the optical phenomena attracted increasing attention of the whole civilized world, the Royal Society of England, on Jan. 17, 1884, passed the following resolution: "*Resolved*, That a committee, to consist of Sir F. Evans, Professor Judd, Mr. Norman Lockyer, Mr. R. H. Scott, General Strachey, and Mr. G. J. Symons, with power to add to their number, be appointed, to collect the various accounts of the volcanic eruption at Krakatoa, and attendant phenomena, in such form as shall best provide for their preservation, and promote their usefulness." A history of the work of the committee is detailed in the preface, its expansion by fusion with a committee of the Royal Meteorological Society and by election of new members, and its method of proceedings. At the end of November, 1884, the discussion of the data collected was commenced, which were divided into five portions, each going to a separate sub-committee, and each giving a separate report, which forms the present volume. Thus the work is divided into five parts: 1. 'On the Volcanic Phenomena of the Eruption, and on the Nature and Distribution of the Ejected Materials,' by Prof. J. W. Judd; 2. 'On the Air-Waves and Sounds caused by the Eruption,' prepared in the Meteorological Office, and presented by Lieut.-Gen. R. Strachey; 3. 'On the Seismic Sea-Waves caused by the Eruption,' by Capt. W. J. L. Wharton; 4. 'On the Unusual Optical Phenomena of the Atmosphere, 1883–86, including Twilight Effects, Coronal Appearances, Sky Haze, Colored Suns, Moons, etc.,' by the Hon. F. A. Rollo Russell and Mr. E. Douglas Archibald; 5. 'Report on the Magnetical and Electrical Phenomena accompanying the Eruption,' by G. M. Whipple.

While the Dutch report by Verbeek deals with the local phenomena, the English committee paid specal attention to the meteorological and other occurrences which took place all over the earth.

The most interesting part of Professor Judd's account is his theory as to the part played by water in causing or aiding eruptions. He believes that the disengagement by heat of volatile substances actually contained in the lava is the primary cause of volcanic activity. He proves that the melting-point of all lavas of Krakatoa of different ages, although of the same chemical composition, vary to a great extent according to the amount of water contained in them, their fusibility being greater when water is present. In this case, on melting, they develop a great amount of gases. "In this way the actual nature of the volcanic manifestations at any particular vent are seen to be determined, not so much by the mineralogical constitution of the lava, as by the circumstance of the quantity of water contained in the magma. Where this is great, the lava will be perfectly liquid, and will be almost wholly thrown out in the form of pumice and dust. On the other hand, lavas containing little water will require a very high temperature for their fusion, and they will be characterized by great viscosity rather than perfect liquidity. It is through the introduction of the sea and other surface waters into rock masses by slow percolation from above, and the consequent formation of new compounds, more readily acted upon by subterranean heat, that I am disposed to regard volcanic phenomena as being brought about. In this we find an explanation of the proximity of volcanoes to great bodies of water, which, it seems to me, is far more in accord with the actual phenomena than the supposition that water finds access to volcanic foci by means of actual open fissures."

Professor Judd shows very clearly that the effect of the inrush of water upon lava is quite different, and, especially in the case of Krakatoa, resulted in the formidable violence of the eruption. When the volcano became so far eviscerated as to give access to the water of the sea, the latter cooled the surface of the magma, and as a result the activity of the volcano diminished. As, however, the disengagement of volatile substances actually contained in this material continued, the formation of this crust would have the same effect as fastening down the safety-valve of a steam-boiler, while the fires below were maintained in full activity. This constant augmentation of tension beneath Krakatoa, in the end gave rise to the tremendous explosions which made the eruption of the volcano so remarkable.

In the second part, General Strachey discusses the remarkable atmospheric oscillations, which, starting from Krakatoa, moved as many as seven times over the earth. Their propagation from the volcano to its antipodes and back is shown on a number of interesting maps. The principal results of the inquiry into the movements of this disturbance are, that it had very nearly the characteristic velocity of sound, ranging from 648 to 726 English miles an hour, and that its mode of propagation by an aerial oscillation of comparatively short duration was also closely analogous to that of sound. Waves travelling with and against the direction of the earth's rotation show differences of velocity of about twenty-eight English miles an hour. This may probably be accounted for by the circumstance that the winds along the paths of this portion of the wave would, on the whole, have been westerly, which would have caused an increase of velocity in the wave moving in the opposite direction; so that the observed difference of twenty-eight miles could be produced by an average westerly current of fourteen miles per hour, which is not unlikely.

The author continues, "There is some appearance of a greater retardation of the wave in passing in a direction opposed to the earth's rotation over the northern European stations as compared with those in the south of Europe, which may possibly be due to the lower temperature of the more northern part of the zone traversed. This difference is not to be traced in the wave moving in the opposite direction, which may be accounted for by the path of the wave, when approaching Europe from the west, having lain for a long distance over the Atlantic, where the differences of temperature between the northern and the southern borders of the zone traversed would have been relatively small.

"The path of the wave that passed over the Canadian and United States stations, and Havana, lies nearly on the meridian drawn through Krakatoa, and must have crossed both the polar circles near the poles. The velocities obtained from these stations are peculiar. The direct wave from Krakatoa, which travelled nearly due north and close to the north pole, and its repetitions after passing round the earth in the same direction, had nearly the same velocities as those observed at the European stations, with an apparent decided retardation in the intervals between the first and third passages, and (but to a less extent) between the third and fifth. The wave that passed through the antipodes before reaching the North American stations went nearly due south close to the south pole; and its velocity on this its first partial passage round the earth was very decidedly reduced; but in its next complete circuit the velocity appears to have been much increased, almost reaching the full rate of the true sound-wave. It is difficult to account for this, but the fact seems to be indisputable. Probably an explanation of this peculiar feature of the phenomena may be found in the conditions of the wind and weather in the southern ocean during the days on which the wave passed over it, which are not known to us."

In the second part of General Strachey's report a list of places is given at which the sounds of the explosions at Krakatoa were heard on the 26th and 27th of August. In all directions the sound was heard at a distance of two thousand miles from the volcano, while south-westward it was even noticed at Rodriguez, very nearly three thousand miles from Krakatoa.

Captain Wharton, in his discussion of the seismic sea-waves caused by the eruption, distinguishes two descriptions of waves, — long ones, with periods of over an hour; and shorter but higher waves, with irregular and much briefer intervals. The greatest disturbance which followed the great explosion of the volcano resulted in waves about fifty feet high in the Strait of Sunda, and caused the vastest destruction. The speed of both classes of waves was about the same, and it is remarkable that it was in all cases less than the depth of water would demand according to theory. To the north and east in the Java Sea the long wave can be traced for 450 miles, but it was at this distance reduced to a very small undulation. To the west, on the other hand, the long wave travelled over great distances, and reached Cape Horn and the shores of Europe. The shorter waves did not extend beyond Ceylon and Mauritius. South-eastward the disturbance did not continue beyond the west coast of Australia; the disturbances noted in New Zealand and in the Pacific evidently being caused by other seismic action, and having no connection whatever with the eruption of Krakatoa.

By far the greater portion of the report is taken up by the dis-

cussion of the unusual optical phenomena of the atmosphere, of which so much has been written. This part is divided into a number of sections, of which the first describes fully the phenomena, and is illustrated by two magnificent chromolithographs. In the long discussion on the proximate cause of the unusual twilight phenomena, F. A. Rollo Russell arrives at the conclusion that a dry haze at a great altitude was their cause. The physical conditions of this phenomenon were the reflection of sunlight on small vitreous surfaces when the intervening air is darkened. He rejects the theory that condensed vapor caused the unusual twilight phenomena, for a number of reasons, principally because spectrum observations and the nature of the corona do not support this view. Besides this, the structure of the haze resembled more that of smoke than that of the highest clouds; and previous effects seen in years of great eruptions, and in places affected by an excess of dust in the air, are very much like those observed in 1883 and the following years. In the same section of the report the colored appearances of sun and moon, which were confined to the tropics, the sky haze, and the corona, are discussed. E. Douglas Archibald, who is the author of the last-mentioned part of the report, describes the corona, which is generally known as 'Bishop's ring,' very thoroughly, and shows that it was probably formed in the haze stratum, and that it was formed by diffraction. Its great size proves that this haze was composed of exceedingly small particles, the diameter of which is computed at .00159 of a millimetre. The occurrence of a corona at a very high altitude, as well as the general absence of accompanying refractive halos, tends to show that the particles through which the diffraction took place were solids and dust rather than ice. Although the corona was associated with the twilight glows and colored suns in being produced by the same elevated haze, it was physically distinct from either, and probably contributed only very slightly to the glows after the sun sank below the horizon.

A long list of dates of the first appearance of optical phenomena — a result of a careful scrutiny of numerous periodicals, logs, and of an extensive correspondence — serves as the basis of a study of the geographical distribution of the various sky phenomena, which proves that it spread rapidly westward, having a velocity of about seventy-six miles an hour.

The researches of E. Douglas Archibald on the height of the glow stratum are of great interest. We will not enter here upon his discussion of Professor Kiessling's theories, as this was the subject of a letter recently published in *Science* (No. 298). The principal results of his inquiry are the following: In the brilliant glows which began in the tropics after the eruption of Krakatoa on Aug. 26 and 27, there is distinct evidence of a primary glow caused by the direct rays of the sun, and of a secondary glow succeeding this, and due to reflection of the primary glow through the same stratum. These primary and secondary glows correspond to the first and second crepuscular spaces of ordinary twilight, the main difference between the secondary of the present series and the ordinary second crepuscular space being that the former was colored, whereas the ordinary second twilight is white, and seen only from high altitudes or in peculiarly favorable circumstances. The glow-causing material appeared suddenly and at about its greatest height at first near Krakatoa, and on its subsequent spread into the extra-tropics it appeared at a lessened altitude. The height of the upper or middle part of the stratum progressively diminished from 121,000 feet in August, to about 64,000 feet in January, 1884. By April, 1884, a considerable portion of the larger reflecting particles had sifted out by gravitation, causing a minimum duration and brilliancy of the secondary glow. As this occurred simultaneously with a maximum development of the corona, it appears probable that a large portion of the finer material remained in suspension at nearly the same height as at first, and that, having become more homogeneous than at first, it was rendered capable of exerting its maximum diffractive power. In the autumn and winter months of 1884 and 1885 the brilliancy of the glows was partially renewed, and thus it is rendered impossible to arrive at any certain deductions regarding the rate of descent of the stratum as a whole. The final effects of the glow-causing material were produced by the prolonged reflection from the lofty stratum of rays partly deprived of their red component by the action of the stratum itself, and to a much larger extent subsequently deprived of their blue components by the ordinary dust and vapor particles of the lower atmosphere. It was therefore mainly an intensification of ordinary twilight phenomena, consequent on the presence, at a lofty altitude, of solid particles not usually existent there.

The whole volume is full of information of the greatest value, and the mass of material collected, as well as its thorough discussion and the clear mode of its treatment, deserves our fullest admiration.

THE UNITED STATES FISH COMMISSION'S WORK DURING THE PAST SEASON.

THE United States Fish Commission has accomplished more, both of practical work and in the line of original investigation looking to practical work in the immediate future, this year than during any previous season of its history. A brief review of its work in both of these departments is given herewith.

An account of the shad-hatching operations of the commission last spring, and a description of the experiment of shipping lobsters to California, and the planting of them in the Pacific Ocean north and south of San Francisco, were given in *Science* (xi. 246, xii. 27) several months ago. In connection with shad-hatching, Commissioner McDonald has been trying this summer a very important and interesting experiment. It is well known that the young shad-fry hatched at the United States Fish Commission stations are not kept until they become little breathing fishes. No means of accommodating them have heretofore existed. It is also known that the mortality among young shad is far greater in the earlier than in the later periods of their existence. The longer they live, the better the chance they have of continuing to live. It is known that only an infinitesimally small percentage of the shad-fry placed in rivers in the spring survive and come to maturity; but so enormous is the number hatched and planted, that those that do escape the scores of enemies they encounter are sufficient to stock abundantly, in a few years, the stream in which they are placed.

This year Colonel McDonald secured on a government reservation in Washington the use of a pond about six acres in extent. In this he caused to be placed, in June, two million shad-fry, and there are now in the pond eight hundred thousand young breathing shad from three to four inches in length. These will all be turned into the Potomac next spring, when they will be much larger than now; and the result will be that the number of fishes put into the river at the opening of the next season will be three times as great as the number taken out last season. The percentages of survivals is probably some thousands of times greater than if the fry had been placed in the river soon after they were hatched. In connection with the work of stocking other streams, and in view of the success that has attended this first experiment, much attention will hereafter be given to the propagation of shad in ponds.

During the past summer a new and very important branch of work has been taken up. When a freshet occurs in the Lower Mississippi River, it inundates a belt of country of an average width of about sixty miles, and the territory along its tributaries is covered with water to an extent varying with the topography of the country and the sizes of the rivers. These floods carry with them, of course, enormous quantities of the indigenous fishes of the rivers; and when the waters recede, ponds and lakes are left in the frequent depressions of the surface. These often actually swarm with fishes and with the millions of fry that have been naturally hatched in them. But later in the season a majority of these ponds and lakes dry up, and not only the mature fishes, but the millions of young ones perish. Colonel McDonald this year sent to these Western and Southern rivers the cars of the Fish Commission, with a sufficient force to seine these ponds and lakes, gather up the small fishes, and to plant them in the rivers where they naturally belong, many of which have been depleted by over-fishing and by the effects of the floods. More than a hundred thousand young fishes were thus planted during the past season; and it is the intention of Commissioner McDonald, in restocking the rivers of the West and South with indigenous fishes, to utilize in the way described nature's great hatcheries, instead of incurring the much greater risk and expense of artificial propagation.

The rivers operated upon during the past season were the Ohio