pared with the former, though according to Helmholtz's theory their tones should be alike. It may be objected to these illustrations that in all natural sources of tone one never finds a whole series of partial tones every member of which is equally loud as the fundamental tone. It is more nearly true for most musical instruments that the higher up one goes in the series of partial tones the feebler are they in comparison with the fundamental tone.

Accordingly, Kœnig has combined, as in Fig. 2, a series of partial tones corresponding to the respective frequencies 1, 3, 5, 7, 9, making the amplitude of each partial tone inversely proportional to its frequency. The separate curves are shown in Fig. 2, both grouped about a horizontal line, and also as successively superposed upon the fundamental. The uppermost of the set of curves exhibits the final resultant; which, in this case, where the difference of phase is taken as *nil*, and all the components rise from zero together, is seen to consist of bold, well-rounded sinuosities. In Fig. 3, curves identical in wavelength and amplitude, but differing in phase by $\frac{1}{4}$, are compounded together; but the final resultant shows a wave-form that is practically a zig-zag. Now if these bold sinuosities and zig-zags be cut out in thin metal and curled up into circumferences so as to adapt them to use as wave-sirens in the manner before-mentioned, it is again found that the zig-zags corresponding to differences of phase $\frac{1}{4}$ and $\frac{3}{4}$ yield always harsher and louder tones than the rounded sinuosities that correspond to 0 and $\frac{1}{2}$.

These observations are very remarkable, and have important bearings that must be left for discussion in the next article on Kœnig's work.

For the present we will conclude by observing that more than once it has been pointed out that a certain perception of difference of phase did exist. Sir W. Thomson has suggested that there is evidence of this in the phenomenon of slow beats which by a curious acoustic illusion almost always suggest the idea of something revolving. The writer of this notice had also previously pointed out that in certain cases where a compound sound was led separately to the two ears a difference of phase between the components could be detected.

It may not be generally known that Dr. Kœnig has quite recently republished under the title of "*Quelques Expériences d'Acoustique*" the most important of his recent researches, including those on the Wave-Siren and on the Beats of Imperfect Consonances. The figures herewith presented, and those which will accompany the continuation of this notice, are taken by Dr. Kœnig's courteous permission from this his very valuable contribution to experimental acoustics. S. P. T.

THE RAINFALL OF THE GLOBE

PROF. LOOMIS has recently contributed a paper on this subject to the *American Journal of Science* of no small interest and value. The paper gives the mean annual rainfall at 713 places in all parts of the globe, and the results are graphically represented on a map of the world as closely as can be done by five tints of one colour. These tints represent respectively annual amounts of rain under 10 inches, from 10 to 25 inches, 25 to 50 inches, 50 to 75 inches, and above 75 inches. It is stated that the map is merely a provisional one, it being Prof. Loomis's expressed intention to publish a list of additional observations with a revised edition of the map; and in the meantime he invites the assistance and criticism of meteorologists in furtherance of the work.

The map shows unquestionably the broad features of the geographical distribution of the rainfall of the globe, so that any changes that will be made in a future issue, however interesting and important these may be locally, will only be rectifications of the iso-hyetal lines in some of their subordinate details.

Leaving out of consideration all exceptionally heavy rainfalls confined to limited spots, such as those of Cherapunji, in Assam, which amounts to 492 inches annually, and the Stye, in Cumberland, which is about 190 inches, the heaviest rainfall is met with in the rain-belt, which surrounds nearly the whole globe lying between the north-east and south-east trade-winds. Absolutely the largest rainfalls over large regions are to be found where the trade-winds, after having traversed a great breadth of ocean, are forced against and over a breadth of land, of some elevation and extent which lie across their path. Of these the best examples are the highlands of Java, Sumatra, and Assam, in the Old World, and parts of the north of South America, and of the steep slopes of Mexico facing the Gulf of Mexico in the New World, over which the trades or monsoons discharge their moisture so copiously as to raise the rainfall over large tracts up to, and in cases considerably above 200 inches annually. The influence of height is well illustrated by the rainfall of Mauritius; thus, while at the observatory it is 46 inches, it amounts at Cluny to 149 inches on a mean of the same 19 years. Similarly in St. Helena, while near the sea-level it is only 5 inches, at a height of 1764 feet it is 48 inches. In Ascension, no part of which rises to any considerable height, the annual rainfall is only 3 inches, and the whole island is little else than a burned-up desert.

The rainfall is particularly large in mountainous regions in both hemispheres above lat 40°, situated on the eastern shores of the great oceans, and consequently in the full sweep of the strong westerly winds of these high latitudes. Thus large portions of Scotland north of the Clyde, one or two small patches in England, a few spots in Ireland, large tracts between California and Alaska, the south of Chile, and the west coast of the south island of New Zealand have an annual rainfall exceeding 80 inches. Nay, even at Bergen, lat. 60° 23′ N., bathed in the warm, moist, westerly winds of the Atlantic, the rainfall is 73 inches annually, which is the largest rainfall yet observed anywhere at so high a latitude. Those headlands, even though of comparatively small height, which ran out into the sea, meeting the moist oceanic winds, have rainfalls very considerably above the average—owing doubtless largely to the greater friction of land than water on the winds, thus partially arresting their progress, and inducing a more copious precipitation.

As causes of deficient rainfall, Prof. Loomis enumerates five, viz.: (1) a uniform direction of the winds during the year, such as prevails within the regions of the trades, illustrated by the rainfall of Ascension, Sahara, and South California; (2) the prevailing wind having crossed a mountain range, thence descends on the leeside, illustrated by desert of Gobi, Chili, and large tracts in Spain; (3) ranges of mountains so high as to obstruct the free movement of the surface-winds towards the interior, as parts of Central Asia and California; (4) remoteness from the ocean measured in the direction from which the wind proceeds, illustrated by the gradual diminution of the rainfall on advancing eastward into Europe; and (5) high latitudes, since beyond lat. 60°, at a little distance from the ocean, it seldom exceeds 10 inches, and there are apparently large tracts in North America and Asia, where the rainfall is less than 10 inches. As regards this last statement, observation scarcely bears it out, since in Europeo-Asiatic continent, only two stations in latitude the above 60°, viz. Kola in Russian Finland, on the Arctic Sea, and Yakutsk, show rainfalls less than 10 inches, and these are doubtful owing to the short periods over which the observations extend.

The truth is there are other causes powerfully influencing the distribution of the rainfall than these, which an examination of the rainfall of the individual months, notably January and July, best discloses. These causes have their explanation in the systems of low and high pressures, which appear and disappear with season. Of these the most prominent are the low pressures which occupy the centres of continents in the summer months, and the northern portions of the Atlantic and Pacific Oceans in the winter months; and on the other hand, the high pressures which fill the centres of the continents in the winter months, and the high pressures in the oceans immediately to the west sides of the great continents, about lat. 36°, as shown by the Admiralty's physical charts of the Atlantic, Pacific, and Indian Oceans.

To take, as an example, the great summer barometric depression of Central Asia with the winds, flowing in upon it on all sides vortically, carrying with them the moisture of the ocean from which they come. Thus East Siberia is then swept by south-east and east winds, which distribute to westward as far as Irkutsk, in July, a monthly rainfall of 3 inches and upwards. Now since the annual rainfall of this region is all but wholly determined by the rains of the summer months, the extension of these rains inland wholly determines the position of the annual iso-hyetal lines. Again, to westward of long. 100° in Siberia, the rains have their origin in the Atlantic and Arctic seas, and since west and north-west winds prevail from Archangel to Central Asia, they bring with them comparatively so large a share of moisture from the ocean, as to raise the annual rainfall over the greater part of these northern regions to about 20 inches, or even more. On the other hand, on the east side of the Ural Mountains, which drain these winds of much of their moisture, the summer rainfall is much less. From north of the Caspian and Aral Seas, southward to the Persian Gulf, and eastward to the Indus, the summer winds are north-west, and since they thus advance over regions rapidly rising in temperature, little if any moisture is deposited in their train, thus rendering this extensive region one of the largest arid tracts of the globe.

These, with other considerations, indicate that the courses of several of the iso-hyetal lines, where observations are sparse, should be regulated to a greater extent than has been done in the map before us, by the positions of river-basins and mountain ranges in their relations to those seasonal winds, which really determine the annual amounts of the rainfall.

One of the most important points to which attention is drawn by Prof. Loomis, is that more rain falls on the eastern than on the western sides of continents. This remark holds good everywhere, until we reach the higher latitudes of both hemispheres, where the predominating winds become westerly. Thus the rainfall at San Francisco is only from a half to a third of the amount which falls on the coast of Pennsylvania in the same latitude; and about the same proportions, or even proportions still more striking, are seen on comparing Morocco with the Chinese coast, and the west with the east coasts of South Africa, Australia, and South America. The explanation is to be found in the portions of the areas of low and high pressures, with their accompanying winds, during the season whose rainfall determines the annual amounts. On the east side of the continents the prevailing summer winds are south-west, south, or south-east, which having traversed a large extent of ocean, and constantly advancing into higher and colder latitudes, spread a copious rainfall over the regions they traverse. But on the other hand, since the west side of continents in the same latitude lies between the region of abnormally high pressure in the ocean immediately to westward, and the low pressure of the interior, north-west winds in the northern, and south-west winds in the southern hemisphere prevail there; and as they advance into lower latitudes or over regions of a constantly increasing temperature, they deposit little or no rain in their course. Hence, owing to the failure, more or less complete, of the summer rains, it follows that the annual rainfall of these portions of the continents is small.

In preparing the second issue of the map, attention should be directed, in addition to the regions already indicated, to the rectification of the lines of equal rainfall over Iceland, the south-east of Norway, the Gulf of Guinea, the temperate regions of South America, and Northern, Central, and Western Australia, and we feel assured meteorologists will heartily co-operate with Prof. Loomis, and give him all possible assistance in completing the important work he has so successfully begun.

NOTES

THE name of Prince Leopold (Duke of Albany) has been added to the General Committee of the Darwin Memorial Fund, subscriptions to which, we may remind our readers, are still being received at the Royal Society, Burlington House, by the Hon. Secretaries, Prof. T. G. Bonney and Mr. P. Edward Dove.

THE communication from Greenwich which appeared in our last number, p. 175, showed that in the double magnetic storms of April, the Greenwich times of commencement of disturbance were, for Greenwich, April 16, 11h. 32m., and April 19, 15h. 35m.; and for Toronto, Canada, April 16, 11h. 34m., and April 19, 15h. 34m. The communication in question was followed by one from M. Dechevrens, reporting the magnetic disturbance as commencing suddenly also at Zi-ka-wei, China, at 7h. 36m. on the morning of April 17, and as being as suddenly renewed at 11h. 40m. on the morning of April 20; equivalent to April 16—11h. 30m., and April 19, 15h. 34m. Greenwich time. The outbursts thus occurred at the same absolute time at Toronto, Greenwich, and Zi-ka-wei.

THE Prince and Princess of Wales opened the handsome new Technical School at Bradford on Friday. The Prince, in the various speeches he gave showed that he has a real appreciation of the necessity for scientific training in this country, if we are to keep on a level with the other great nations in our industry and commerce.

THE Commission appointed by M. Ferry to report on the construction of the rotating dome for the large refractor of the Paris Observatory, has held numerous meetings at the Conservatoire des Arts et Métiers, Col. Laussedat, director of the establishment, being in the chair. Only two projects have been reserved for final choice. M. Eiffel proposes to use a saline solution in a horizontal circular channel placed on the wall to diminish the weight of the rotary roof.

WE are glad to learn that owing to the exertions of Admiral Mouchez, magnetical observations will soon be resumed at the Paris Observatory, in subterranean chambers which have been excavated in the newly annexed grounds. These observations will be self-registering by photography, in conformity with the instruments established by M. Mascart at the Collège de France. Direct observations will also be conducted with the old instruments which were used by Arago, which were famous for his prognostications of Auroræ, at a period when, the electric telegraph not having been invented, many days must elapse before the arrival in Paris of news from the northern parts of Europe.

IN the course of a few weeks all the International circumpolar observatory parties will have arrived at their different destinations, or be on their way thereto, and on August 1 the observations will commence simultaneously on the common plan framed by the different conferences held in Hamburg in 1879, in Bern in 1880, and in St. Petersburg in 1881. By the present arrangement Russia has three stations, the United States and Germany two each, whilst England, Austria, Sweden, Norway, Denmark, France, Holland, Italy, and Finland maintain one each, of which three—the French, the Italian, and one German —will be established in the Antarctic regions. The total number