"results of observation," judging from an interesting article by Prof. William H. Pickering in the May number of the *Century Magazine.* Messrs. Pickering and Percival Lowell have during the last few years made numerous excellent observations on the planet Mars, and they have greatly increased our knowledge by accurately observing the surface markings and suggesting very plausible explanations of the phenomena observed. Such work was rendered possible by erecting an observatory in a locality where observing conditions were as near perfect as possible. Prof. Pickering has more recently turned his attention to an examination of the lunar surface, and the first results of this work have led him to some very definite and striking conclusions. The first of these is that there seems to be strong, if not fairly conclusive, evidence in favour of the idea that volcanic activity has not yet entirely ceased, and he quotes several instances in which small craters have disappeared while others have sprung up in different regions. The second, and perhaps more startling, announcement is that there is snow on the moon. He has observed that many craterlets are lined with a white substance which becomes very brilliant when illuminated by the sun, and a similar substance is found on the larger lunar craters and a few of the higher mountain peaks. The curious behaviour of these patches under different angles of illumination and their change of form have led him to suggest that an irregularly varying distribution of hoar frost may have something to do with the changes observed. The third remarkable deduction refers to the observations of "variable spots," which appear to be restricted between latitudes 55° north and 60° south; these spots are always associated with small craterlets or deep narrow clefts, and are often symmetrically arranged around the former. The alterations which these undergo have led him to seek the cause in the change in the nature of the reflecting surface, and the most simple explanation according to him is found in assuming that it is organic life resembling vegetation, but not necessarily identical with it. The new selenography consists, therefore, as Prof. Pickering remarks, "not in mere mapping of cold dead rocks and isolated craters, but in a study of the daily alterations that take place in small selected regions, where we find real, living changes, changes that cannot be explained by shifting shadows or varying librations of the lunar surface." Prof. Pickering illustrates his article with numerous excellent and instructive drawings and photographs of portions of the lunar surface, and these give the reader a good idea of the changes referred to in the text.

DUST-FALLS AND THEIR ORIGINS.[1]

FALLS of dust on a large scale are of rare occurrence, but one very often hears that in the south of Europe at such and such a place rain had fallen and had brought with it, and deposited on the ground, fine red or yellow dust. Thus on April 24, 1897, a south wind carried to southern Italy a great quantity of dust which was supposed to be of African origin.

Perhaps the most well-known instance of a fall on a large scale was that which occurred in May and August in the year 1883, when an enormous quantity of dust was hurled into the air during the Krakatoa eruption, and fell and was collected at various distances, the greatest being more than 1100 miles from the seat of the disturbance. The tremendous height to which the finer particles of dust were thrown, coupled with the movement of the air at this great distance from the earth's surface, were responsible for the magnificent coloured sunsets which were observed nearly all over the world. The volume[2] in which all these observations were collected is undoubtedly one of the most complete records of a "fall of dust" that has been published.

The large number of meteorological stations situated over the greater portion of the civilised world give us now greater chances for recording and tracing the paths of these falls of dust, whether they reach the earth's surface with or without the aid of rain. Fortunately, the tracks of the great dust storm of March 9–12 of last year and that of the minor storm of March 19–21 of the same year were restricted to such regions as these, passing over the coast of northern Africa and reaching Sicily, Italy, Austro-Hungary, Prussia, part of Russia, Denmark and even the British Isles.

In the volume before us, Profs. Hellmann and Meinardus have brought together all the information that could be collected by means of the distribution of circulars and communications with all meteorological stations, and discussed them in a very thorough and able manner, presenting us with a complete story, describing the locality from which the dust came, the means, direction and mode of transport, and finally the places over which it was deposited. The arrangement of the discussion is as follows:—The distribution of the dust over the land surface is first described, accompanied by the original accounts of the phenomenon as observed, a list of all places where the fall was recorded, and a map showing the general distribution. The meteorological conditions from March 9–12 are next dealt with, giving full details of the general atmospheric disturbances over the whole of Europe and North Africa, with numerous maps. The authors then give the individual reports on all the microscopic and chemical analyses of the dust from various localities, concluding with a brief account of the second fall of dust from March 19–21 and a general summary of the main results to which they have been led.

In these chapters the discussion of the facts collected has led the investigators to form a very concrete survey of the whole phenomenon, tracing the origin of the dust to dust-storms that occurred on March 8, 9 and 10 in the desert El Erg, situated in the southern part of Algeria, and which carried the dust and transported it northward.

This dust, as is here pointed out, began to fall at Algiers and Tunis in the dry state on the night of the 9th. The subsequent falls gradually took place northwards, first Sicily, then Italy, the Alps, Austro-Hungary, Germany, Denmark and European Russia, practically in the order named, coming in for their share. In Sicily and Italy the dust was noticed to have fallen even without the aid of rain, but in the other countries it was only detected during and after showers.

Not only did the dust-fall occur in these countries in the sequence mentioned, but the quantity that fell became gradually less the more north the places were situated, and the fineness of the dust, as shown by the analyses, increased at the same time. All these facts, as the authors indicate, are strong arguments in favour of the progress of the dust deposition from south to north, and the very minute and careful examination of the meteorological conditions stated here, showing a depression moving from south to north, endorse this point of view. There is little doubt, therefore, that the locality from which the dust originated was situated somewhere south of the northern shore of the African continent.

It is interesting to notice that the dust was not distributed homogeneously over the land areas, but in patches and streaks, some places, such as, for instance, the greater part of south Germany and Russian Poland, being entirely free from it, while others, such as the southern side of the eastern Alps and Holstein, being specially dense. The unequal distribution and different values for the rate of movement of the dust cloud seem to be adequately explained by the variable velocity of the air currents and the changing position of the barometric depression.

The investigation suggests that the dust was carried by a large mass of air which moved with great velocity from northern Africa to the north of Europe, and that this mass of air, cyclonic in nature, was fed on its western side by air currents from the north and on its eastern side by southerly currents; this accounts for the observed facts that the fall of dust was chiefly limited to the eastern portion of the depression.

As regards the total amount of dust that fell to the surface, rough estimates indicated that the weight of it would amount to about 1,800,000 tons, two-thirds of which were deposited to the south of the Alps.

The authors have shown that the most probable origin of the dust was the region to the south of Algeria, so that an examination of the dust that fell in Europe and elsewhere should consist of similar components as those that form the dust of this region. Nearly all the mineralogical, microscopic and chemical analyses point out that the dust is neither volcanic nor cosmic, but simply such as is found on the African continent. From exactly which part of the continent it came is evidently not certain, for some mineralogists suggested that the dust consisted

[1] "Der grosse Staubfall von 9 bis 12 Marz, 1901, in Nordafrica, Sud- und Mitteleuropa." Von G. Hellmann und W. Meinardus. *Abhandlungen des Königlich Preussischen Meteorologischen Institut,* Bd. ii. No. 1. (Berlin: A. Asher and Co., 1901.)

[2] "Report of the Krakatoa Committee of the Royal Society." (London: Trubner and Co., 1888.)

of the finest particles of Sahara sand, while others looked for its origin on laterite ground.

The value of the occurrences of falls of dust is of special moment meteorologically, because they afford us a means of obtaining further knowledge of the actual movements of the air currents in the higher reaches of our atmosphere which cannot be gained by any other such direct methods. Much valuable information was obtained of the movement of the air at great heights by the dust that was ejected during the eruption of Krakatoa, and as this volcano is situated near the equator, where the air currents have a great tendency to rise directly away from the earth's surface, the conditions were favourable for the dust reaching an extraordinary elevation.

Nevertheless, whether the falls owe their origin to dust storms in a desert or eruptions of large volcanoes, it is of great importance to meteorological science that they should be, not only accurately observed, but recorded and discussed. Fortunately, the fall in the present instance occurred where a great amount of useful data could be, and was, secured. In the handling of this material the authors are to be congratulated, for besides considerably increasing our knowledge of the way in which the dust is transported and enlightening us on other peculiarities of this interesting phenomenon, they have given us a volume which will serve as an excellent example for future recorders and observers.

W. J. S. L.

BRITISH VERSUS AMERICAN LOCOMOTIVES.

A NOTEWORTHY Parlimentary paper has recently been issued containing correspondence respecting the comparative merits of British, Belgian and American built locomotives running on the Egyptian railways. The paper is full of interest to the locomotive engineer, bearing out as it does the unsatisfactory results obtained with American locomotives on British, Colonial and Indian railways when compared with the English design of engine, and, what is more, these unsatisfactory results are in all cases certified by the representative of the American firm of locomotive builders, as well as by an official appointed by the Egyptian railway authority, so there can be little doubt as to their accuracy.

Probably the most interesting report in the series is that by Mr. Trevithick, the locomotive engineer, who says:—

"The Mechanical Department of the Egyptian State Railways has recently made some interesting comparative trials between British and American locomotives of the same weight and power. These comparisons have been carried out under exceptionally favourable circumstances, inasmuch as the locomotives employed were typical of their respective countries in design and manufacture, and the trials were personally conducted, and the results conjointly signed, by a representative sent out by the American builders and a locomotive inspector of the Egyptian Railway Administration.

"The first set of trials, consisting of eight runs extending over 1034 miles, was between goods engines, and, in order to secure similar loads and to be able to gradually increase the weight of trains to the maximum that the respective engines could satisfactorily draw, the material transported consisted chiefly of coal.

"The total amount of coal consumed in the eight trips by the British engines was 22·84 tons, which works out at an average of 49·4lbs. per mile, whilst the American engines consumed 28·69 tons, an average of 62 lbs. per mile; in other words, for every 100 tons of coal consumed by the British engines the American engines burnt 125·4 tons, *i.e.* an excess of 25·4 per cent. This economy was effected by the British engines, although they drew a heavier average load, to the extent of 14·2 per cent. than the American, the average train taken by the British engines being 57 trucks, or 868 tons, as against 54 trucks, or 760 tons, the average train taken by the American. The maximum load taken by each make of engine was 61 trucks.

"These trials were followed by others between passenger types of engines, extending over 1345 miles; each make ran an equal number of trips with practically similar formation of trains, with the result that the British engines consumed a total of 18·47 tons of coal, or an average of 30·7 lbs. per mile, as against a total of 27·8 tons, or an average of 46·3 lbs. per mile, in the case of the American engines, which means that where the British engine consumed 100 tons, the American engine consumed 150 tons, or 50 per cent. more. Such a difference at 1*l.* 14*s.* 2*d.* per ton, the average price paid last year by the Railway Administration, represents an additional yearly cost per engine of 400*l.*; which is to say that these ten American engines would cost in coal in one year 4000*l.* more than the ten British engines, an amount almost sufficient to buy two new ones."

The above extract from Mr. Trevithick's report conclusively proves that the British type of locomotive is well able to hold its own in the three important matters of fuel and oil consumption, and cost of repairs. Much has been written lately on the standardisation of the locomotive, but in a progressive age this appears to be unnecessary, since the locomotive of yesterday must always be out of date. Much can, however be done to assist locomotive builders in the way of standardisation of specifications and, more particularly, of the test requirements for the material.

It is absurd to think that consulting engineers cannot agree as to the best test requirements for, say, a crank axle or a steel boiler plate. With standard tests the locomotive builders could buy the material more cheaply, obtain quicker deliveries from the makers, and, probably, in their turn take less time to complete an order.

INTERFERENCE OF SOUND.[1]

FOR the purposes of laboratory or lecture experiments it is convenient to use a pitch so high that the sounds are nearly or altogether inaudible. The wave-lengths (1 to 3 cm.) are then tolerably small, and it becomes possible to imitate many interesting optical phenomena. The ear as the percipient is replaced by the high-pressure sensitive flame, introduced for this purpose by Tyndall, with the advantage that the effects are visible to a large audience.

As a source of sound a "bird-call" is usually convenient. A stream of air from a circular hole in a thin plate impinges centrically upon a similar hole in a parallel plate held at a little distance. Bird-calls are very easily made. The first plate, of 1 or 2 cm. in diameter, is cemented, or soldered, to the end of a short supply tube. The second plate may conveniently be made triangular, the turned-down corners being soldered to the first plate. For calls of medium pitch the holes may be made in tin plate. They may be as small as ½ mm. in diameter, and the distance between them as little as 1 mm. In any case the edges of the holes should be sharp and clean. There is no difficulty in obtaining wave-lengths (complete) as low as 1 cm., and with care wave-lengths of 0·6 cm. may be reached, corresponding to about 50,000 vibrations per second. In experimenting upon minimum wave-lengths, the distance between the call and the flame should not exceed 50 cm., and the flame should be adjusted to the verge of flaring ("Theory of Sound," 2nd ed., § 371). As most bird-calls are very dependent upon the precise pressure of the wind, a manometer in immediate connection is practically a necessity. The pressure, originally somewhat in excess, may be controlled by a screw pinch-cock operating on a rubber connecting tube.

In the experiments with conical horns or trumpets, it is important that no sound should issue except through these channels. The horns end in short lengths of brass tubing which fit tightly to a short length of tubing (A) soldered air-tight on the face of the front plate of the bird-call. So far there is no difficulty; but if the space between the plates be boxed in air-tight, the action of the call is interfered with. To meet this objection a tin-plate box is soldered air-tight to A, and is stuffed with cotton-wool kept in position by a *loosely* fitting lid at C. In this way very little sound can escape except through the tube A, and yet the call speaks much as usual. The manometer is connected at the side tube D. The wind is best supplied from a gas-holder.

With the steadily maintained sound of the bird-call there is no difficulty in measuring accurately the wave-lengths by the method of nodes and loops. A glass plate behind the flame, and mounted so as to be capable of sliding backwards and forwards, serves as reflecting wall. At the plate, and at any distance from it measured by an *even* number of quarter wave-lengths, there are nodes, where the flame does not respond. At intermediate distances, equal to *odd* multiples of the quarter wave-length, the effect upon the flame is a maximum. For the present purpose it is best to use nodes, so adjusting the sensitiveness of the flame that it only just recovers its height at the

[1] A Discourse delivered at the Royal Institution on Friday, January 17, by the Right Hon. Lord Rayleigh, F.R.S.