correspondence between things. A function or one-to-one correspondence is a classification and cross-classification of the things which correspond. For example, a division of a number of models having different markings into two classes by colour and a cross-classification by shape gives a correspondence of the markings in one colour class to the markings in the other. If each marking in one class corresponds to the same marking in the other, we have the correspondence one. Similarly, various circular functions may be illustrated by models, beginning with transpositions. If things which correspond are called operands, and a correspondence of operands a function, then names seem to be needed to mean a correspondence of functions, and for the still higher correspondences which occur. In the usual school course we practically begin with the correspondences of functions, namely, of the numbers one, two, three, &c. It would seem more natural to begin with the correspondence, first, of operands to operands, and then of operands to functions, and define words as power, product, sum in reference to correspondences of operands illustrated by models. For example, a set of things the correspondence of which to another set is under discussion may be called a quantity. Two quantities which correspond to the same quantity correspond to each other; and their correspondence to each other is the product of the correspondence of one to the intermediate quantity and of the intermediate quantity to the other. In the case of vectors, since a vector is a correspondence of points, this would require the term product to be given to what is generally called the sum.

The properties of permutation, association, distribution should be considered in reference to tables of operands before considering tables of functions such as multiplication and addition tables. Space will not allow of discussing the illustration of addition, rule of signs, two-to-two correspondence, &c. The study of irrational numbers and continuous spaces should be postponed to a later stage.

Oundle. C. ELLIOTT.

An Emanation from Sodium.

DURING the course of some experiments upon the contact potential difference between the alkali metals and glass, I noticed that a freshly cut piece of sodium rapidly discharged an electroscope.

Further examination showed that this action occurred only if the gold leaf was charged negatively. Little or no effect was produced if it was positively electrified. The action could be completely stopped by a membrane of celluloid sufficiently thin to give interference colours, and this fact alone points strongly to the discharging action being due to a vapour.

It was found, in fact, that a slight current of air directed so as to carry the supposed gas away from the charged plate of the electroscope enabled the leaf to retain its charge.

The effect is, however, unlike that met with in the case of phosphorus, since the vapour from that substance discharges both positive and negative electricity equally well. It does not, therefore, appear due to the air becoming ionised by a change occurring at the surface of the sodium, but more probably to the emission of an electrified gas. Experiment has shown that the rapid oxidation of the surface has little or nothing to do with the existence of the emanation, and it is very significant that all action ceases after prolonged heating (to melting point) of the metal. After some hours, however, the sodium shows signs of recovering its power to discharge a negatively electrified body.

Since all portions of the same block of sodium do not exhibit the action to the same extent, I am attempting to concentrate those parts which show it most strongly in order to determine whether some new radio-active body is present in the metal or whether there is a radio-active change occurring in the sodium itself.

A slight indication that the emanation is capable of depositing a radio-active layer of matter has been also noticed. The other alkali metals are now being examined and the whole matter fully investigated.

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WIND PRESSURE.

THE importance of a correct knowledge of the pressure exerted by the wind, as affecting the stability of modern structures, was brought prominently before the public by the disaster to the Tay Bridge on the night of December 28, 1879. At that time observatories at which wind pressure was directly measured were rare, the usual observed characteristic of the wind being its velocity as given by the Robinson cup anemometer.

At some stations both the Robinson cup anemometer and the Osler recording pressure plate were installed, and it was for this reason that in the report of the Royal Commission which was appointed in 1881 to consider the question, an attempt was made to state the relation between the probable maximum pressure which would be recorded in a gale and the maximum hourly run of the Robinson cups during that period. Also from records of pressure plates which were considered by the Commission to be not due to instrumental error depending upon momentum, but which represented real phenomena, it was decided that, for structures in exposed situations in this country, a maximum wind pressure of 56 lb. per square foot of surface should be allowed for in the design.

It was, however, felt by engineers at the time that this value, assumed uniform over the whole surface of a large structure, was very excessive, for, as the late Sir Benjamin Baker remarked at a discussion on wind pressure at the Institution of Civil Engineers soon after the report of the Commission was published, if such pressure actually obtained there ought not to be a bridge standing in the country. It was on this occasion that Sir Benjamin Baker stated his conclusions as to the nature of the motion of the wind and the pressures resulting from it, which theory was based, not on elaborate experiments, but on close observation of the behaviour of natural objects in the wind. In his words,

"If leaves and other light objects floating in an apparently steady current were watched it would be found that certain leaves would shoot forward at an increased velocity of 25 per cent. and upwards as compared with the mean velocity. Over a width of 20 feet at the centre of a wide and steady current the mean velocity might thus be constant, whilst over some particular width of 1 foot it might be momentarily fully 25 per cent. higher, and in the case of wind pressure 25 per cent. increase of velocity meant more than 50 per cent. increase of pressure. It was quite possible, therefore, that the large pressure boards might register a notably less pressure than the small boards, and might afford a clue to the reason why railway carriages were not upset when traversing lofty and exposed viaducts."

This appears to have been the first recognition of what may be called the variable structure of the wind as a factor of safety in the stability of structures, and it may be mentioned that the variation predicted by Sir Benjamin Baker was found to exist at points distant 11 feet apart in the experiments of Mr. Dines in 1894.

To test the truth of his conclusions Sir Benjamin Baker erected some wind-pressure plates on the site of the Forth Bridge, each provided with an arrangement for measuring the maximum pressures experienced. One of these gauges was 300 square feet in area, and the others $1\frac{1}{2}$ square feet. Taking the mean of the maximum daily readings for two years, the small-gauge indications were found to be 50 per cent. greater than the large-gauge indications, which was the result anticipated.

In experiments of this kind it is interesting to notice that there is one particular case in which with the assumed structure of the wind the small plate might register a pressure lower than the large one. This is the somewhat rare event when in a gale there is one gust of considerably greater intensity than those which precede or follow it. If during this gust the small plate occupied a region of low velocity, its registered maximum pressure would be lower than that of the large plate. This appears to have happened in one of the gales at the Forth Bridge during the experiments, but its rarity supports the evidence of anemometers, which show that the average gale consists of a series of gusts of nearly equal intensity, so that the probability of the maximum velocity occurring in the region of the small plate is very great. It is important to realise that the above conclusions are in no respect applicable to the pressures which may obtain at any given instant on two plates during a gale, as a little consideration will show that the probability of the small plate occupying the region of lowest velocity at any instant is the same as that of its occupying the region of highest velocity, from which the conclusion follows that the small plate will also register the lowest pressure during the gale.

In the foregoing statements the difference in resistance of large and small surfaces in the wind has been treated as depending entirely on the structure of the wind, that is, it has been assumed that if the wind were a perfectly uniform current in which the velocity over any considerable area was the same, the pressures on the two surfaces would be identical.

This, of course, is not necessarily the case, as there may exist a purely dimensional effect in the resistance of appreciable magnitude, and in the opinion of some authorities the explanation of the Forth Bridge experiments was to be found in this, and not in the structure of the wind.

For this reason, when the wind-pressure experiments were commenced at the National Physical Laboratory in 1904, the determination of the existence or non-existence of this dimensional effect was made the chief feature of the research. These experiments were made on plates and models ranging up to 100 square feet in area, erected on the top of an observation tower 50 feet above the ground, which had a fairly clear space in front of it. After some preliminary work, the method which was finally adopted consisted in the determination of the constant k in what may be called the "equivalent" pressure velocity relation

$$p=kV^2,$$

that is the relation which would exist if the velocity of the wind were uniform.

The determination of this relation when a plate is moved at a known velocity in still air is fairly easy. It becomes more difficult when a plate is suspended in a uniform current of air on account of the trouble involved in forming a correct estimate of the velocity of the current, since, owing to the conditions of flow being disturbed in the region of the plate, it is necessary to place the velocity gauges at some distance from the plate. In the case of a plate exposed to the wind, there is the added complication of the varying structure of the current, and the problem at the National Physical Laboratory was to obtain the "equivalent" pressure velocity relation from observations of the resultant pressure on a plate and the corresponding pressure in a "Dines" tube, which was used as the velocity gauge, distant 10 feet from the edge of the plate. A solution was found in the observed fact that although the pressures at any instant in two tubes facing the wind, and distant 10 feet apart, might differ by as much as 50 per cent., yet if one hundred of these sets of readings were taken at successive intervals of time, the *mean* pressures for each tube were practically identical. From this it was assumed that if a large number of observations of the resultant pressure on the plate and the (simultaneously observed) pressure in the "Dines" tube were made, the means of these experiments would give the equivalent pressure-velocity relation sought. For this purpose 200 observations of this kind were made on each plate tested, two observers operating two sensitive water gauges at the foot of the tower. One of these water gauges was connected by two lead pipes attached to the legs of the tower to the "Dines" tubes, and the other by two similar pipes to an air cylinder in which the pressure varied with the fluctuations of resultant pressure on the plate. The arrangement of the 100-square-feet plate and the "Dines" tube is shown in the photograph (Fig. 1).

The results of experiments on three plates of areas of 25, 50 and 100 square feet gave identical values of the constant k in the "equivalent" pressure-velocity

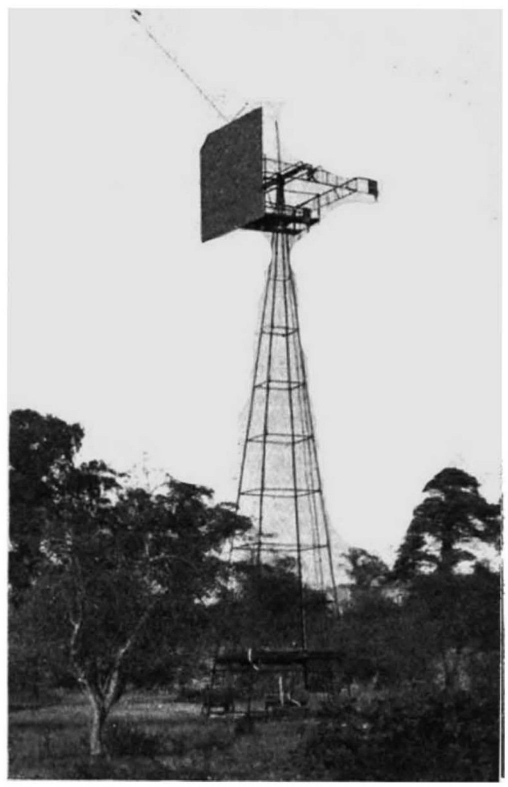


FIG. 1.—Wind Observation Tower with 100-square-feet plate in position.

relation, which in units of pounds per square foot and miles per hour was found to be 0·0032, indicating that for this range in dimensions the purely dimensional effect in the resistance was negligible. There were strong reasons, however, to suppose that it was not negligible for all ranges in dimensions, since the value of k determined at the National Physical Laboratory in 1903 for plates of 2 and 3 square inches in area in a uniform current was 0·0027, and that determined by Mr. Dines in 1890 for a plate of 1 square foot in a whirling machine was 0·0029. This view has been fully confirmed by the publication during the present year of the results of M. Eiffel's experiments on plates let fall from the second stage of the Eiffel Tower. Using square plates varying in area from 10 square feet to five-eighths of a square foot, M. Eiffel found a continuous change in the value of the constant, ranging from 0·0032 for his largest plate to 0·00285 for his smallest plate. The plotted results of M. Eiffel's observations on square plates and those

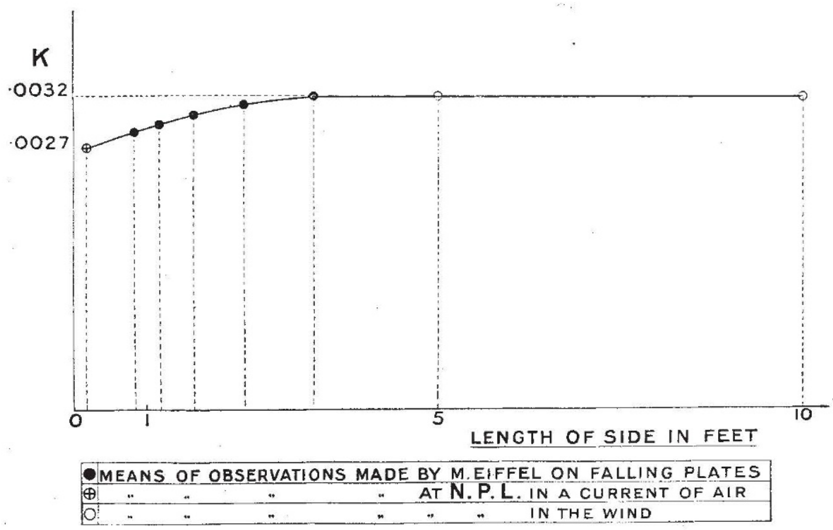


FIG. 2.—Curve showing the dimensional variation in the air-resistance of square plates.

made at the National Physical Laboratory are shown in Fig. 2. There appears, therefore, to be a purely dimensional factor in the resistance of plates, which for the case of square plates has the effect of increasing this resistance up to an area of approximately 10 square feet, when it becomes practically constant.

In the small-scale experiments made in a uniform current of air at the National Physical Laboratory, it was found that although the resistance per unit area of combinations of plates, such as lattice-work, differed considerably from that of square or circular plates, the resistances of similar combinations of plates were approximately the same. To test the possibility of predicting the resistance of a complex structure in the wind from observations on a small-scale model in a current, a model lattice girder was constructed of wood, with a span of 30 feet, and a depth of 3 feet 6 inches. This was placed on the tower (Fig. 3), and a set of observations made on it. A small-scale model of this was made in brass, the linear dimensions being reduced in the ratio of 1 to 42. The resistance of this was determined in the current. On comparing these resistances they were found to have precisely the same ratio as that of the resistances of the large square plates in the wind and the small square plates in the current, that is, the resistance of the large girder was 18 per cent. greater than that of the small one. The conclusion was that the resistance of any structure, however complicated, can be predicted with considerable accuracy from observations on a small model of it, as in the similar problem of the resistance of ships.

The important case of the resultant wind pressure on roofs is more difficult to treat experimentally, owing to the oblique impingement of the wind, which renders the position of the centre of pressure uncertain.

Until recent years it has been customary to treat the forces on a roof due to wind pressure as pressures affecting the windward side only, but from experiments on small models in a current of air, Mr. Irminger, of Copenhagen, has shown that there is a considerable suction effect on the leeward side of the roof, due to the eddies from the ridge. It does not necessarily follow from this that the resultant effect on the leeward side of a roof must be a suction, as this will depend on the pressure inside the building also.

In the National Physical Laboratory experiments a roof model was erected on the tower, having sides each of 56 square feet in area. The results of the observations of resultant pressure on the leeward side showed widely different values, according as the conditions were those of a roof supported on columns through which the wind could pass freely or on walls. In the former case it was found that the reduction of pressure inside the roof due to the eddy from the eaves of the windward side was approximately of the same magnitude as the reduction of pressure outside due to the eddy from the ridge, so that the resultant pressure on the leeward side was practically zero. When the conditions were those of a roof supported on walls, the maximum wind forces were found to exist (*a*) when the doors and windows on the windward side of the building were open and those on the leeward side closed, and (*b*) *vice versâ*. In case (*a*) the maximum wind force was on the leeward side of the roof outwards, and in case (*b*)

FIG. 3.—Wind Observation Tower with model girder 30 feet by 3·5 feet in position.

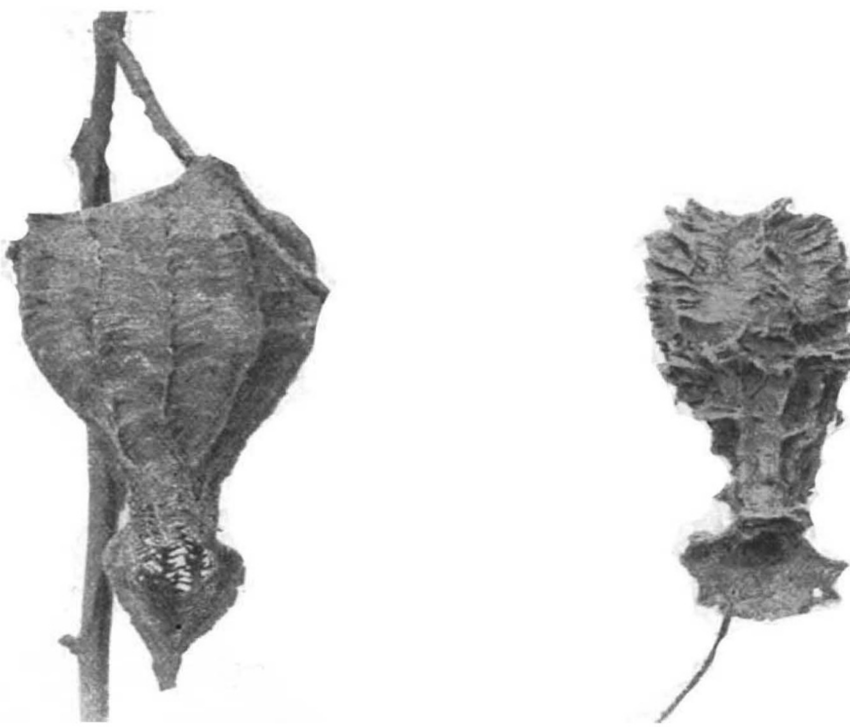
it was on the windward side inwards. It follows, therefore, that in such a building the roof shauld be designed so as to be equally strong in each direction.

It will be seen from this brief sketch that although the difficult engineering problem of the distribution of the pressure of the wind on large structures is not solved, yet when the investigation on the lateral extent of gusts which is now in progress is completed, the only further information which the designer will need is that of the maximum wind velocity which is likely to obtain on the site of the proposed structure.

T. E. STANTON.

BRITISH MUSEUM GUIDE TO INSECTS.[1]

THE publication of this work furnishes a delightful companion to the charming and highly instructive series of insects exhibited in the gallery of the Museum of Natural History. To the naturalist as well as to the layman this exhibition of the bionomics of the Insecta is a living expression of the incessant



Nests of species of Ischnogaster, nat. size. Photographed from specimens in the British Museum (Natural History).

activity of those who are responsible for its display, and although Mr. Charles O. Waterhouse informs us that "considerable time must necessarily elapse before the exhibited series of insects can be completed," and that the guide must be looked upon as a provisional one, yet in its present form it gives groups of properly organised facts which cannot fail to instruct and diffuse knowledge by making the study of these animals clearly interesting and accessible to the public.

A legible plan of the gallery is given, and bold reference numbers in the text will enable the visitor to find with facility any group of insects in which he may be specially interested. Where necessary models are given to illustrate the metamorphoses of various insects, and where possible species likely to be of interest from agricultural or horticultural points of view have been chosen.

The guide is embellished with a number of full-page illustrations, in addition to the numerous figures in the text. With one or two exceptions these have been specially prepared from specimens in the museum, and they help us to an understanding of the text which renders them practically indispensable. In the classification of the Insecta, nine orders are represented in the following sequence:—Aptera, Orthoptera, Neuroptera, Trichoptera, Lepidoptera, Hymenoptera, Diptera, Coleoptera, and Rhynchota. A diagram is given showing the relationship which is believed to exist between these groups, and representatives of a great number of suborders and families are described. Attention is directed to the fact that the guide refers only to the small representative series of insects exhibited in the public gallery; the main collection, which is reserved for the purpose of study in the basement of the institution, contains 1,150,000 specimens, and comprises about 155,000 named species, occupying 13,000 drawers and 602 store boxes. This enormous collection is always available for study, and students at all times receive every attention and assistance at the hands of those who are in charge of the various departments.

In revising this guide we would suggest that reference letters be given to Figs. 14 and 19; that the word *tibia* be added to the diagram in Fig. 18; and that the magnification of Figs. 40, 57, 58, 61, and 62 be indicated.

[1] "A Guide to the Exhibited Series of Insects in the Zoological Department (Insect Section), British Museum (Natural History), London." Pp. 59; with 62 illustrations. (Printed by Order of the Trustees, 1908.) Price 1s.

PROF. K. A. MÖBIUS.

PROF. KARL AUGUST MÖBIUS, for many years director of the Zoological Museum in Berlin, died on April 26 at the age of eighty-three. He was a notable naturalist, with a broad and cheerful outlook, greatly interested in the habits of creatures, and enthusiastic over their beauty. There are few zoologists who do not know "The Fauna of the Bay of Kiel" by Möbius and Meyer, the two volumes of which form a rich storehouse of observations on the bionomics of a shallow sea. Möbius was probably the first to establish a salt-water aquarium in Germany, and he helped to start the famous zoological garden at Hamburg. He had, indeed, a strong practical sense, and made many useful suggestions in connection with fisheries, oyster-culture, and the harvest of the sea in general.

Möbius was born in 1825 at Eilenburg, in the Prussian province of Saxony; he was trained as a school teacher, but his enthusiasm and ambition were roused by reading the works of Alexander von Humboldt, and he went to Berlin, with a light purse, to study natural history. By giving lessons to others he was able to afford a university training, and he sat at the feet of men like Ehrenberg and Johannes Müller. He became assistant to Lichtenstein, who helped him in 1853 to a congenial teaching post in