

hands of the Secretary of State in prescribing a standard of sufficient ventilation for factories and workshops based upon what it deems to be an adequate objective criterion of what constitutes reasonably "sufficient" ventilation, viz. the proportion of carbonic acid in the air. Looked at from the point of view of the Inspecting Department of the Home Office, it was necessary, at the outset, to determine whether it was practicable to make use of this proportion as a legal standard of "sufficient" ventilation, or whether such estimations, if made with the requisite accuracy, might not prove to be both expensive and troublesome.

Determinations of atmospheric carbonic acid are mainly carried out on the principle first made use of by Dalton and worked out by Hadfield, that is, absorption of the carbonic acid contained in a known volume of the air by a suitable alkaline solution, the amount so absorbed being ascertained by volumetric analysis. This process was first extensively applied by Pettenkofer, and is generally known by his name. With proper precautions it is capable of a very high degree of accuracy, and, indeed, practically all our knowledge concerning the distribution of carbonic acid in the atmosphere, whether in the free air or in inhabited places, has been obtained by its means. The apparatus needed is somewhat bulky on account of the necessity of using large volumes of air in cases where the amount of carbonic acid is relatively small, as in ordinary atmospheric air. At the same time, when it is merely necessary to determine whether the air of an inhabited room or that of a factory or workshop contains an excess of carbonic acid over the quantity that could reasonably be prescribed as an official limit, vessels holding a couple of litres would suffice for most purposes. It would be readily possible to put together for the use of inspectors a Pettenkofer "kit" which should be light and not too bulky, and would enable the estimation of carbonic acid to be carried out rapidly and with approximate accuracy.

The committee recommends *inter alia* that the limit of carbonic acid should be fixed, except on very foggy days, when no tests should be made, on account of the vitiated state of the outside air, at 12 volumes of carbonic acid per 10,000 of air, and that when gas or oil is used for lighting, the proportion should not exceed 20 volumes after dark or before the first hour after daylight, the only exception to this rule to be in cases where the extra carbonic acid is produced in other ways than by respiration or combustion, as in breweries, &c. It is further recommended that arrangements be made by the Factory Department of the Home Office for the analysis, by a specially qualified person or persons, of samples of air collected by inspectors, and that any analysis on which a prosecution immediately depends should have been performed by such qualified person or persons, and also that arrangements should be made for inspectors of factories to have the use, when desired, of a properly tested portable apparatus for estimating on the spot the proportion of carbonic acid in air.

Dr. Haldane has devised an apparatus for the use of inspectors of factories, a specimen of which has been submitted to us for examination by Messrs. Müller, Orme and Co., of 148 High Holborn, and this seems to fulfil all the necessary conditions. A description of it constitutes appendix iii. of the report before us. The estimation of carbonic acid is made by measuring the contraction in the volume of the air to be tested by bringing the air in contact with a 10 per cent. solution of caustic potash or soda. As the volume of the air taken for the test is only about 20c.c., it is evident that special provision needs to be made, and great care in manipulation needs to be exercised if even approximate accuracy is aimed at. It is im-

possible in the absence of the diagrammatic representation of the apparatus which accompanies the report to explain the details of its construction, or to make clear the successive steps in its manipulation. We have had, however, an opportunity of making a number of experiments with it, and we are able to state that the amount of carbonic acid in the air of an inhabited room may be quickly ascertained, with sufficient accuracy, by means of it. An intelligent manipulator who understood the scientific principles involved would be able to obtain results accurate to within about one part in 10,000 with air containing ordinary proportions of carbonic acid, and to about two parts with air so highly vitiated as to contain, say, from 30 to 50 volumes of carbonic acid per 10,000. A trained gas analyst would, no doubt, obtain more accurate results. A determination is made in a few minutes when once the apparatus is put into working order.

Whether experiments of this kind should be entrusted to those factory inspectors who have had no training in physical science is perhaps open to question.

One possible source of considerable error was indicated during the experiments. After standing several days the potash solution used in the apparatus was found to be coloured yellow, doubtless from the action of the alkali upon the rubber tubing of the apparatus. Any sulphur thus dissolved would form alkaline sulphides which would absorb oxygen from the air under experiment, and so vitiate the result. As a matter of fact, the figures given when the apparatus was in this condition were wholly untrustworthy.

The following experiments may be cited in illustration of the degree of accuracy which may be obtained:—

I. *Experiments on the air of a laboratory.*

		Results. CO ₂ per 10,000 of air.
1st experiment.—At about 9.45 a.m., before		
any burners were lighted		5.0
2 or 3 Bunsens burning during the whole time of these experi- ments.	2nd. About twenty minutes later	5.9
	3rd " " " " " "	6.3
	4th " " " " " "	7.3
	5th " " " " " "	7.0
	6th " " " " " "	7.4
	7th " " " " " "	8.0

II. *With air containing 24.4 volumes of CO₂ per 10,000.*

1st experiment	23.3
2nd " "	21.7

III. *With air containing 45.2 volumes CO₂ per 10,000.*

1st experiment	42.3
2nd " "	41.6

GRAHAM BELL'S TETRAHEDRAL CELL KITES.

IN the June number of the *National Geographic Magazine* is a very interesting and instructive article by Dr. Graham Bell on the tetrahedral principle in kite structure. The article itself is so concise, and depends so much upon illustrations which are reproduced to the number of twenty in the text and seventy in an appendix, that an effective representation of the contents in an article of smaller dimensions is scarcely possible. Still the line of thought that runs through the work which the article represents is so clear and so suggestive that even an imperfect outline of it may be useful. Dr. Bell indicates certain stages in the development of his ideas as "milestones" of progress, and since the ultimate stage of the development is the possibility of building up very large kite structures by combining unit cells in such a way that the proportion of weight to wing area in the structure

is nearly the same as that of the constituent cell, the successive stages are noteworthy. They sketch out in a most interesting manner a reply to Newcomb's criticism of the limits of application of the *aéroplane* based upon the argument that increase of size means diminished efficiency because, for similar structures, the weight varies as the cube while the area, upon



FIG. 1.—A Winged Tetrahedral Cell.

which the lifting force depends, varies as the square of the linear dimensions.

The original stage, the ordinary kite, is a single plane structure. The first step in advance is the Hargrave box kite, with its upper and lower *aéroplanes* for its support, and side planes for stability. To stiffen the framework of the box kite it must be braced longitudinally and transversely; accordingly Graham Bell's development commences by replacing the rectangular framework of the box kite by a framework of triangular section which is by construction

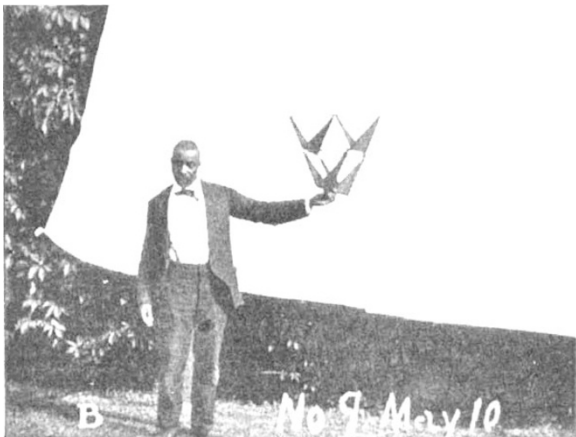


FIG. 2.—A Four-celled Tetrahedral Kite.

stiff so far as the cross section is concerned. The inclined sides are by the vector principle of resolution of forces regarded as equivalent to their geometrical projections, and, in so far as the principle applies, the inclined faces represent the combined effect of *aéroplanes* of the area of the projections.¹

¹ This principle to be generally applicable would require the normal component of wind pressure to be uniform and independent of the angle between the plane and the wind. This is not the case with an *aéroplane* (see Rayleigh, *NATURE*, vol. xxv. p. 108); and for the principle to be applied approximately in the case of the kites some convention as regards the angle of exposure of the *aéroplanes* to the wind would be required.

The box kite of triangular section is, however, not stiff as regards longitudinal shear, and the next "milestone" marks the reduction of the triangular or prismatic form to the tetrahedron, an essentially stiff framework for all directions. A tetrahedron of rods with two adjacent faces covered with fabric forms a tetrahedral kite cell which, on the principle of projec-

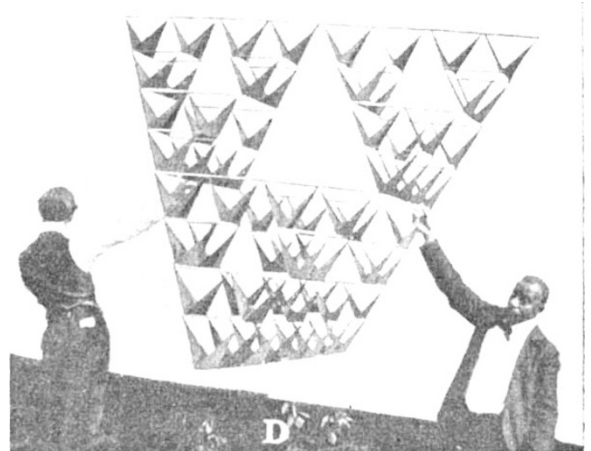


FIG. 3.—A Sixty-four celled Tetrahedral Kite.

tion before referred to, is equivalent to three *aéroplanes* represented by the projections of the covered sides upon planes at right angles.

The further development of pure tetrahedral construction is obvious. Four cells can be combined to form a tetrahedron of double linear dimensions without additional framework; the weight and wing area are both simply proportional to the number of cells, and not to the linear dimensions. For each set of four cells thus combined there is an octahedral free space in the interior which corresponds to the free space between the two cells of the Hargrave kite. The tetrahedral

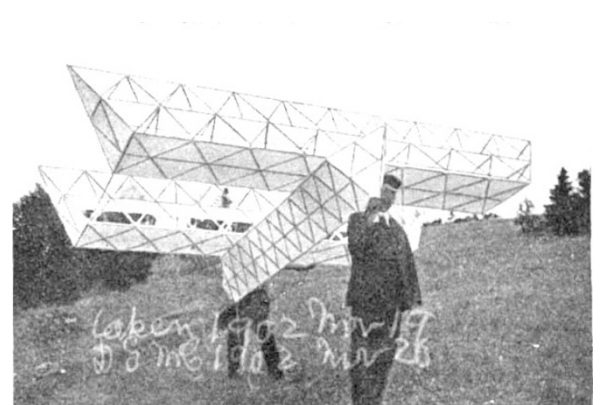


FIG. 4.—The Aërodrome Kite.

kites that have the largest central spaces preserve their equilibrium best in the air.

Combining four multiple cells to fill the outline of a tetrahedron of double size, again, we get a sixteen-cell kite, and repeating the process again a sixty-four cell kite, occupying a tetrahedron eight times the dimensions of a single cell. The building up of multicellular kites from the units is represented in Dr. Bell's article. Fig. 1 represents the unit cell, Fig. 2 a combination of four cells, Fig. 3 of sixty-four cells.

The kites fly with the points of the wings upward; the line of junction of the covered faces of the tetra-

hedron forms a kind of keel. No details as to the heights attainable are given. The most convenient place for the attachment of the flying end is said to be the extreme point of the bow. If the cord is attached to points successively further back on the keel, the flying end makes a greater and greater angle with the horizon, and the kite flies more nearly overhead; but it is not advisable to carry the point of attachment as far back as the middle of the keel. A good place for high flights is a point half way between the bow and the middle of the keel.

"Tetrahedral kites combine in a marked degree the qualities of strength, lightness, and steady flight; but further experiments are required before deciding that this form is the best for a kite or that winged cells without horizontal aeroplanes constitute the best arrangement of aéro-surfaces.

"The tetrahedral principle enables us to construct out of light materials solid frameworks of almost any desired form, and the resulting structures are admirably adapted for the support of aéro-surfaces of any desired kind, size, or shape."

The diagrams illustrating the article show various examples of the formation of complex kites from tetrahedral cells. One form suggested by Prof. Langley's aërodrome, but different in construction and appearance, is shown in Fig. 4, reproduced from an illustration in the article. That some of these complex kites are on a very large scale is evident from a case cited, in which an aërodrome kite, which was struck by a squall before it was let go, lifted two men off their feet, and subsequently broke its flying cord, a Manila rope of three-eighths inch diameter.

The simplicity of the construction of the cells, and the obvious possibilities of their combination, lend an additional fascination to a subject which is already full of interest.

BIBLE AND BABEL.

IN the number of the Johns Hopkins University *Circulars* for June (vol. xxii. No. 163), Prof. Paul Haupt has published an article entitled "Bible and Babel," referring to the somewhat heated controversy on Babel and the Bible which has raged recently in Germany, with which our readers are probably familiar. The line which he takes up is briefly that all the heterodox views which were expressed by Prof. F. Delitzsch in his famous lecture delivered in the august presence of the German Emperor had already been promulgated by himself, Prof. Haupt, at various periods during the last twenty-four years. Prof. Haupt claims to have made correct deductions in respect of the origins of the Biblical accounts of the Creation, the Deluge, &c., long before Prof. Delitzsch's lecture was delivered, but it must be clearly pointed out that, although such may be the case, he was not the first, even twenty-four years ago, to prove that the narratives usually accredited to Moses are merely modified recensions which we owe to the prophets of the captivity in Babylon. Whatever credit is due either to Paul Haupt or Prof. Delitzsch in this matter, it must never be forgotten that all important statements made by them with regard to the Creation and Deluge tablets are derived from the works, writings, and oral remarks which were made by the late General Sir Henry Rawlinson, G.C.B., and the late Mr. George Smith, of the British Museum. Both Profs. Delitzsch and Haupt are skilled laborers, but in our opinion they are not discoverers, and certainly neither of them can be placed side by side with such publishers and translators of text as the two famous Englishmen we have already mentioned. Still less can either be regarded as the author of the heterodox views and statements which so thoroughly shocked His Majesty the German Emperor.

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NOTES.

IN connection with the tenth meeting of the Australasian Association for the Advancement of Science, to be held at Dunedin next January, particulars of which we gave in our issue for May 28 (p. 85), we learn from the *Otago Daily Times* that the colonial Government is rendering the Association material assistance. The New Zealand honorary secretary, Mr. G. M. Thomson, has received from Sir J. G. Ward, Colonial Secretary, a letter which states that the Government will assist the association in the following respects:—(1) A sum of 500*l.* will be placed on the Estimates of the present year towards the expenses of the January meeting; (2) the Government printer will be instructed to do all printing required by the association free of cost to the association; (3) railway passes will be issued to visiting members of the association; and (4) any assistance that it may be in the power of the permanent departments of the Government service to render to the association will be readily afforded on application being made.

AN entire skull (partially restored) of the remarkable Egyptian Eocene mammal *Arsinotherium zitteli* is now exhibited in the central hall of the Natural History Museum. This magnificent specimen was obtained by Dr. C. W. Andrews during his last trip to the Fayum district, and has been cleaned and restored in the museum. Behind the enormous nasal horns are placed a pair of quite small horns, recalling the rudimentary back-horns of the giraffe. The dentition, although including a full series of incisors and canines, recalls that of the Proboscidea. It is hoped that the skull of the Siberian rhinoceros (*Rhinoceros antiquitatis*) recently dug up in Salisbury Square, E.C., may ultimately find a home in the museum, since it is by far the finest example hitherto discovered in this country.

AT an extraordinary general meeting of the members of the Jenner Institute of Preventive Medicine, held on Friday last, the resolution recently passed on July 22 to alter the name of the institute to "The Lister Institute of Preventive Medicine" was unanimously confirmed.

THE fourteenth annual general meeting of the Institution of Mining Engineers will be held on Wednesday, September 2, in the University College, Nottingham.

THE Amsterdam Academy of Sciences has awarded its Buis-Ballot medal, given once in ten years, to Prof. Richard Assmann and Dr. Arthur Berson, of the Aëronautic Institute at Tegel, near Berlin.

REUTER states that a scientific expedition, to explore the northern parts of the Pacific Ocean, will leave Stockholm next April by railway for Port Arthur by way of Siberia. At Port Arthur the expedition will embark on a ship under the leadership of M. Kolthoff, who will be accompanied by five or six other Swedish naturalists.

SIR TREVOR LAWRENCE, president of the Royal Horticultural Society, has announced that Sir Thomas Hanbury, K.C.V.O., has purchased for presentation to the society the estate and garden of the late Mr. G. F. Wilson, F.R.S., at Wisley, near Woking. The total area of the estate is 60 acres.

AT the meeting of the Wilts County Council on August 4, a letter was read from Sir Edmund Antrobus, the owner of Stonehenge, to Lord Edmond Fitzmaurice, M.P. (chairman of the council), in which Sir E. Antrobus said he was willing to sell Stonehenge, and eight acres of land surrounding it, to the nation for the sum of 50,000*l.* The council decided to send the letter to the Chancellor of the Exchequer.