between the steady increase in membership and the absence of any marked deviation in the number of members who have contributed to the material of the association, excepting at the eighth annual meeting. This is all the more striking in view of the fact that the association receives communications 'by title,' and these are relatively few in number. The average attendance at the annual meetings is almost thirty-five. The average number annually elected to membership is almost twelve. But the average number of contributing members is only about twenty, a number which remains well-nigh constant.

A more forceful, and thus a more interesting, way of showing the aggregate individual distribution of the industry that has found place among us annually is given in the following summary, which includes two or three instances of joint authorship. Eighty-nine members have been the total contributors, of whom thirty-four have presented one unit, as paper, report, etc., each; twenty-three have presented two units each; ten have presented three each; eight have presented four each; five have presented five each; three have presented six each; two have presented seven each; one member has presented fourteen, one seventeen, one nineteen and one twenty-three units.

The remaining fifty-nine members have been inactive, *silently* paying their annual dues. It is, indeed, a serious question whether the association can hasten its realizations by carrying forty per cent. empty baggage, or whether this phase of the situation should not be radically changed. Almost twenty-six per cent. of the total contributions offered has been the work of four members, who are laboratory men. It will not be overlooked that they have simply stood as sponsors mostly for the work done by the student body of researchers working under their direction. No one would, of course, give an unequivocal sanction to much speaking as a psychological test. But such a summary shows the lines of inevitable fruitfulness.

Again the inevitable query bears in upon us: What of the value of the material which has been thus variously presented from time to time? But we must continue to set it aside. If one attempts to judge its worth, and the advance of science through its worth, he runs into the danger of maintaining that the field over which we have trod remains *sub judice.* And, moreover, it might reveal an immodest immaturity, to say the least, should one attempt to anticipate our psychological posterity in its function of judging of the offerings which have been brought hither year by year.

There is one function which the association can properly undertake more seriously, which would tend to secure a steady advance in the value of the newer material psychological researches may bring forth. At present the indefinite and uncertain method of 'natural selection' or mere survival of interest in individual cases is the only mode of checking off results. An improvement over this method would be a planful arrangement whereby the association could see to it that the annual output of new conclusions and formulæ is intelligently and critically evaluated. This would effect a great saving of individual labor on the part of each psychologist.

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(*To be continued.*)

PROFESSOR ALEXANDER GRAHAM BELL ON KITE–CONSTRUCTION.

It is fortunate for those interested in aeronautics and the exploration of the air

that Professor Alexander Graham Bell has joined the band of experimenters and is lending his inventive genius to the cause. Professor Bell has been for several years experimenting with kites, led to this line of experiments, he thinks, because of the intimate connection of the subject with the problem of the flying machine.* Professor Bell began his experiments with the box-kite of Hargrave, whom he recognizes as the pioneer in modern kite-construction. His objections to the box-kite are that, "It requires additions to the framework of va-

even if made of the finest wire, so as to be insignificant in weight, all comes in the way of the wind, increasing the head-resistance without counterbalancing advantages.''

These remarks of Professor Bell concerning guys, etc., do not apply to the original Hargrave kites which have no guys, but only to a style of Hargrave kite invented and patented by me. This style is the one which has come into universal use under the name of the Hargrave kite, and is the one with which Professor Bell
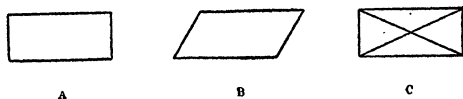

FIG. 1.

FIG. 2.

rious sorts to give it sufficient strength to hold the aeroplane surfaces in their proper relations and prevent distortions of the kite-frame under the action of the wind. Unfortunately the additions required to give rigidity to the framework all detract from the efficiency of the kite: first, by rendering the kite heavier, so that the ratio of weight to surface is increased; and, secondly, by increasing the head-resistance of the kite. A rectangular cell like A (Fig. 1)† is structurally weak, as can readily be demonstrated by the little force required to distort it into the form shown at B. In order to remedy this weakness, internal bracing is advisable of the character shown at C. This internal bracing,

* His experiments are described in a communication made to the National Academy of Sciences, in Washington, D. C., April 23, 1903. Also *National Geographical Magazine* for June, 1903.

† The numbers of the figures differ from the original because many of the figures are omitted here.
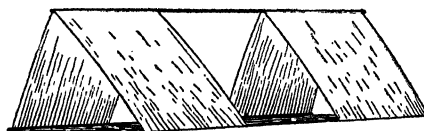
began his experiments rather than with the original Hargrave structure, few of which have been made.

Continuing, Professor Bell says: "In looking back over the line of experiments in my own laboratory I recognize that the adoption of a triangular cell was a step in advance, constituting indeed one of the milestones of progress, one of the points that stand out clearly against the hazy background of multitudinous details. The following (Fig. 2) is a drawing of a typical, triangular-celled kite, made upon the same model as the Hargrave box kite. * * * A triangle is by its very structure perfectly braced in its own plane, and in a triangular-celled kite, like that shown in Fig. 2, internal bracing of any kind is unnecessary to prevent distortion of a kind analogous to that referred to above in the case of the Hargrave rectangular cell (Fig. 1). The lifting power of such a triangular cell is probably less than that

of a rectangular cell, but the enormous gain in structural strength, together with the reduction of head-resistance and weight due to the omission of internal bracing, counterbalances any possible deficiency in this respect.''*

''Triangular cells also are admirably adapted for combination into a compound structure, in which the aeroplane surfaces do not interfere with one another. For example, three triangular-celled kites, tied together at the corners, form a compound
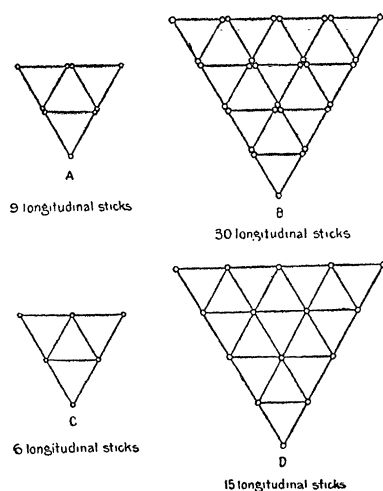

FIG. 3.

cellular kite (Fig. 3, *A*) which flies perfectly well. The weight of the compound kite is the sum of the weights of the three kites of which it is composed, and the total aeroplane surface is the sum of the surfaces of the three kites. The ratio of weight to surface, therefore, is the same in the larger compound kite as in the

* Some experiments, made by us at Blue Hill in 1896 with some of Hargrave's models of triangular-celled kite, led us to think the rectangular cell much superior in efficiency to the triangle, owing to the sheltering of the upper surface at the corners of the triangular-celled kite.

smaller constituent kites, considered individually.

''It is obvious that in compound kites of this character the doubling of the longitudinal sticks where the corners of adjoining kites come together is an unnecessary feature of the combination, for it is easy to construct the compound kite so that one longitudinal stick shall be substituted for the duplicate sticks. For example: the compound kites *A* and *B* (Fig. 3) may be constructed, as shown at *C* and *D*, with advantage, for the weight of the compound kite is thus reduced without loss of structural strength. In this case, the weight of the compound kite is *less* than the sum of the weight of the component kites, while the surface remains the same. If kites could only be successfully compounded in this way indefinitely, we should have the curious result that the ratio of weight to surface would diminish with each increase in the size of the compound kite. Unfortunately, however, the conditions of stable flight demand a considerable space between the front and rear sets of cells; and, if we increase the diameter of our compound structure without increasing the length of this space, we injure the flying qualities of our kite. But every increase of this space in the fore and aft direction involves a corresponding increase in the length of the empty framework required to span it, thus adding dead load to the kite and increasing the ratio of weight to surface.

''While kites with triangular cells are strong in a transverse direction (from side to side), they are structurally weak in the longitudinal direction (fore and aft), for in this direction the kite frames are rectangular. Each side of the kite *A*, for example, requires diagonal bracing of the

character shown at *B,* in which the framework forms the outline of a tetrahedron. In this case the aeroplanes are triangular, and the whole arrangement is strongly suggestive of a pair of bird's wings raised at an angle and connected together tip to tip by a cross bar.

"In the tetrahedral kites, shown in the plate (Figs. 4 and 5), the compound structure has, itself, in each case the form of the regular tetrahedron, and there is no reason why this principle of combination should not be applied indefinitely so as to form
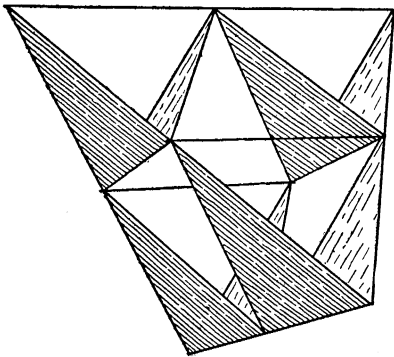

FIG. 4.   Four-celled tetrahedral kite.

still greater combinations. The weight relative to the wing-surface remains the same, however large the compound kite may be. The four-celled kite (Fig. 4), for example, weighs four times as much as one cell and has four times as much wing surface.

"This, at first sight, appears to be somewhat inconsistent with certain mathematical conclusions announced by Professor Simon Newcomb in an article entitled, 'Is the Air-ship Coming?' published in *McClure's Magazine* for September, 1901—conclusions which led him to believe that 'the construction of an aerial vehicle which would carry even a single man from place to place at pleasure requires the discovery

of some new metal or some new force.' The process of r asoning by which Professor Newcomb arrived at this remarkable result is undoubtedly correct. His conclusion, however, is open to question because he has drawn a general conclusion from restricted premises.

"He says: 'Let us make two flying machines exactly alike, only make one on double the scale of the other in all of its dimensions. We all know that the volume, and therefore the weight, of two similar bodies are proportional to the cubes of their
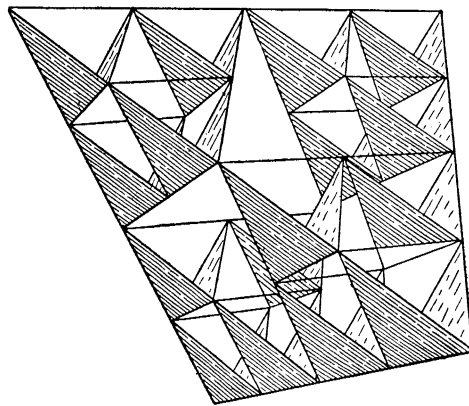

FIG. 5.   Sixteen-celled tetrahedral kite.

dimensions. The cube of two is eight: hence the larger machine will have eight times the weight of the other. But surfaces are as the square of the dimensions. The square of two is four. The heavier machine will therefore expose only four times the wing surface to the air, and so will have a distinct disadvantage in the ratio of efficiency to weight.

"But Professor Newcomb's results are probably only true when restricted to his premises. For models *exactly alike, only differing in the scale of their dimensions,* his conclusions are undoubtedly sound; but where large kites are formed by the multiplication of smaller kites into a cellular structure the results are very different.''

The experiments on kites at Blue Hill have led me to the conclusion that the conditions which confront the experimenter are not so favorable as suggested by Professor Bell, nor so hard as suggested by Professor Newcomb.

I made some experiments in 1898 with a compound kite built up of a number of small rectangular kites such as are called the Blue Hill Naval Kites. In addition to the necessity of giving greater space between the cells with increasing size, I found two other difficulties: (1) When several small kites are combined into one, the pull of all the kites is concentrated on certain points which need to be strengthened by using larger sticks. This may be partly overcome by tying a string to each unit and bringing the separate strings to a single flying line at some distance from the kite. But in such a case there is a crushing strain on the central units due to the inward pressure of the outer units, so that the kite must be strengthe. ༦ by trusses or larger sticks if the compound kite is to fly through the same range of wind-velocity as the unit. (2) When a compound kite strikes the ground the unit which first reaches the ground has above it the combined weight of all the other units and is instantly crushed in conditions where the unit flying alone would not have been injured in the slightest. This effect was so serious an objection that it led me to abandon the effort to build a compound kite out of units.

On the other hand, the weight of kites built on the same model does not increase so fast in practice as Professor Newcomb's law implies. The experience at Blue Hill is that if one can build a kite four feet high sufficiently strong for practical work, and it weighs one and one half ounces per square foot, then one can build a similar kite eight feet high which will weigh two ounces per square foot and be sufficiently strong for practical work. Mr. C. H. Lamson built a kite thirty feet high with two cells similar to the kites used at Blue Hill, and it weighed only about four ounces per square foot. This kite easily lifted a young man weighing about 130 pounds into the air, and, unloaded, flew beautifully in a wind of fifteen to twenty miles an hour, as witnessed by Mr. A. L. Rotch, Mr. S. P. Fergusson and myself.

The reason of this departure from Professor Newcomb's law is that only the sticks of the kites increase in size (and the necessity of this is usually partly overcome by internal bracing), while the thickness of the surfaces remains the same through wide limits.

But independent of these considerations, Professor Bell's principle of tetrahedral construction seems a promising one and further experiments are awaited with much interest, while the structure he has already developed may be found of great use by experimenters.

H. H. Clayton.

Blue Hill Observatory.

SCIENTIFIC BOOKS.

The Rôle of Diffusion and Osmotic Pressure in Plants. By Burton Edward Livingston, of the Department of Botany. The Decennial Publications, Second Series, Volume VIII., Chicago. The University of Chicago Press. 1902. 8vo. Pp. xiv + 150.

As stated in the preface: "The present volume will deal with the past and present of diffusion and osmotic pressure from the standpoint of plant physiology. It has a double *raison d'être.* First, it was felt that there was need of some direct and not too exhaustive account of the essential physical facts and theories of the subject. The interest of the physical chemist here has lain mainly in the light which these phenomena have been able to throw upon the ultimate nature of matter and upon electrolytic proc-