LETTERS TO THE EDITOR.

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The Stability and Efficiency of Kites.

IN NATURE of March 17 Mr. Dines suggests that the instability of kites may be due to changes in the relation of the weight to the velocity of the wind, or to deformation of the kite by excessive pressure, or that there is a critical velocity at which the forms of the stream-lines become so altered that instability results.

My own experience leads to the opinion that deformation by a strong wind is practically the only important cause of instability. At the Blue Hill Observatory, where the conditions for experimenting are unusually severe, the Clayton modification of the Hargrave kite is the only one that can be employed. In this form the longitudinal sticks are continuous from one cell to the other, and the lateral sticks form the front and rear edges of the cells which prevent the fluttering of the cloth unavoidable in kites the rigidity of which depends upon the tension of the covering. The Clayton-Hargrave kite is rigid, but there is no strain or tension anywhere except when flying, and it has proved itself to be sufficiently stable. Relief from sudden and excessive strain is necessary, and to secure this the bridle is made elastic, so that in strong winds the angle of inclination becomes smaller. Thus equipped, the kite is not uniformly efficient in strong winds, for, as the angle of inclination becomes smaller, the pressure of the wind upon the edges of the cells becomes relatively greater, and the altitude is reduced. A normal altitude of 55° to 60° may be lowered to 40° by an increase of wind of 15 to 25 metres per second. If the front cell of the kite is equipped with rigid curved lifting surfaces the efficiency is greatly increased, the mean altitude exceeding 60°, and the loss due to increase of wind is unimportant in velocities up to 25 metres per second.

Some of the lightest of these kites have flown in the strongest winds encountered while experimenting, the velocity in some instances having exceeded 30 metres per second. An interesting example of this kind occurred on April 14 during the international ascension. Two kites, weighing 600 and 850 grams per square metre, and having lifting surfaces of 11 and 7 square metres, respectively, were employed to lift the line. The outer section of the line was 1500 metres of wire having a tensile strength of 140 kilograms, and the next was 2500 metres long, having a tensile strength of 180 kilograms. The large light kite was placed at the outer end of the line, and the other at the junction of the two sections. At a height of 2000 metres, with 3500 metres of line out, two gusts of wind resembling thunder-squalls were encountered, the mean velocity for twenty minutes exceeding 30 metres per second, and the maximum reaching 33. The strain on the line at the ground did not exceed 90 kilograms, and, allowing for the weight of the line, probably did not exceed 110 at the second kite. The pull of the larger kite in a 10-metre wind is usually about 45 kilograms, and that of the smaller about 35, and, allowing for the pressure of the wind on the line, this, apparently, was not greatly exceeded. The large kite will fly in a wind of 5 metres per second, and was perfectly steady in a velocity of 33 metres per second. The pressures corresponding to these velocities are, respectively, 2 and 80 kilograms per square metre of surface exposed normally; hence it seems improbable that a well-made kite could become unstable through disproportionate weight or some unusual property of a high wind. It should be said that the velocities given are "true" velocities, and not to be compared with those from the large Robinson anemometers, in which the factor 3 is employed. The maximum velocity referred to, expressed in English units, becomes 74 miles per hour "true" velocity, 90 when reduced to the U.S. Weather Bureau standard, or about 100 miles per hour when reduced to the same scale as the Kew pattern when the factor 3 is employed.

In 1900, while comparing different wires for use as kite-lines, I found that, theoretically, the larger wires were the more efficient, although slightly weaker, weight fo. weight, than the smaller. The reason for this is that the pressure of the wind is more effective upon the small wires than on the large. A No. 10 wire weighing 2·16 kilograms per 1000 metres usually breaks at 85 kilograms. Its diameter is 0·61 mm., and the surface presented to the wind is 1 square metre for each 1650 metres of length. If we wish to double the strength of our line we employ a wire 0·93 mm. in diameter, weighing 5 kilograms per 1000 metres of length. The cross-section, however, has increased only one-half, the surface presented to the wind being 1 square metre for each 1100 metres of length.

An opportunity to secure experimental data did not present itself until January, 1908. Since then, in conducting the monthly kite ascensions at Blue Hill, I have employed small kites flown with small wires, and large kites flown with large wires, to determine the relative efficiency of the two systems. The results show very conclusively that the system of large kites and large wires is the more efficient, not only for the sizes experimented with, but very probably for much larger sizes. The lifting surface of the kites employed has varied from 3 to 13 square metres, and the line has been made up of pieces of wire varying from No. 10, of 85 kilograms, to No. 21, of 235 kilograms, tensile strength.

The opinion, held by many, that large kites are inferior to small kites in meteorological work is not sustained by these experiments. The Clayton-Hargrave kite when built with three sections can be made stronger for the same weight than when made with two or four sections. The increase of weight as the size increases is unimportant in meteorological experiments, for kites with lifting surfaces exceeding 15 square metres need not weigh more than 650 grams per square metre. The ability of these larger kites to withstand high winds apparently is greater than that of small kites, for the large and heavy sticks necessary in the framework, like the large wires, present relatively a smaller cross-section to the wind for a proportionate weight and strength.

Increased stability may be secured by placing two diverging vertical planes in the rear cell of a kite. If these planes are adjustable, the kite may be caused to fly on either side of the mean direction of the wind, or any errors of flight may be corrected.

The entire question of stability appears to be one of eliminating unequal strains and unnecessary resistances.

F. P. FERGUSSON.

Hyde Park, Mass., U.S.A., April 20.

I AM much interested in Mr. Fergusson's letter, and his long experience with kites, about double my own, makes me very diffident about expressing an opinion contrary to his.

Doubtless deformation is a very fruitful source of instability, but after carrying out some thousand kite ascents from a steamer and on land, I am of opinion that it is not the only cause. However, my position is that we do not know with certainty the cause of instability, and it is very desirable at the present time that we should know beyond dispute.

I agree with Mr. Fergusson as to the advantages of large kites; they are more stable than small ones, and, as he has shown, since the wind resistance on the wire is the one serious obstacle to reaching great heights, it is obviously desirable to make that resistance small in proportion to the other forces. But there are practical objections. Large kites and thick wire require a stronger and more expensive outfit, and more assistance at starting and landing; also, should an accident occur, the risk of its being serious is far greater.

I do not agree with Mr. Fergusson that the Clayton-Hargrave kite is the only one that can be used when the wind is strong. The conditions in England in the winter are probably more severe than at Blue Hill, and have been particularly severe during the last winter. Nevertheless, the strength of the wind has on no occasion prevented our