capable of transporting man through the air, but many of them are troubled by a doubt; for they ask themselves whether the force of the bird does not exceed that of the known motors. The experiments on that subject may reassure them, for, if we compare the muscular force of the bird with that of steam, we see that one muscle would be comparable to an engine at very low pressure. In fact, the steam which would develop 1·600 kilogramme per square centimetre would scarcely have more than an atmosphere and a half of pressure. But the true comparison to establish between the animated motors and the engines consists in measuring the work which each of these motors can furnish, with equal weight, in the unity of time.

The measure of the work of a motor is obtained by multiplying the effort put forth, by the path which the point of application of that effort traverses. Photochronography expresses at each moment the spaces traversed by the mass of the bird and the displacement of the centre of pressure of its wings, giving thus the factor path in the measure of the work. In this way it is found that for the five strokes of its wing which the sea-gull gives every second, at the moment when it flies away, the labour done would be 3·668 kilogrammes. This calculation is very high; it corresponds to that which an engine would make in raising its own weight to a height of more than 5 metres in a second.

But that is only a maximum which the bird does not attain to except at the moment of flight, when it has not attained much speed. In fact, according as the passage of the bird is accelerated, the air under its wings presents a more resisting fulcrum. I have previously experimentally demonstrated this fact, announced by the brothers Planavergue, of Marseilles, and of which the following is the theory.

When the bird is not yet in motion, the air which is struck by its wings presents, in the first instance, a resistance due to its inertia, then enters into motion, and flies below the wing without furnishing to it any support. When the bird is at full speed, on the contrary, its wing is supported each moment upon new columns of air, each one of which offers to it the initial resistance due to its inertia. The sum of these resistances presents to the wing a much firmer basis. One might compare a flying bird to a pedestrian who makes great efforts to walk on shifting sand, and who, in proportion as he advances, finds a soil by degrees firmer, so that he progresses more swiftly and with less fatigue. The increase of the resistance of the air diminishes the expenditure of labour; the strokes of the bird's wing become, in fact, less frequent and less extended. In calm air, a sea-gull which has reached its swiftest, expends scarcely the fifth of the labour which it had to put forth at the beginning of its flight. The bird which flies against the wind finds itself in still more favourable conditions, since the masses of air, continually renewing themselves, bring under his wings their resistance of inertia. It is, then, the start which forms the most laborious phase of the flight. It has long been observed that birds employ all kinds of artifices in order to acquire speed prior to flapping their wings: some run on the ground before darting into the air, or dart rapidly in the direction they wish to take in flying; others let themselves fall from a height with extended wings, and glide in the air with accelerated speed before flapping their wings; all turn their bill to the wind at the moment of starting.

My experiments have, up to the present, only been able to apply to the flight of departure. In order to study the full flight there are conditions difficult to realize. With a courtesy for which I thank him, M. Eiffel has offered to me on the gigantic tower which he is erecting (at Paris) a post of observation which will leave nothing to be desired. From that enormous height, birds photographed during a long flight will give photochronographic images much more instructive than those which I have hitherto been able to obtain.

Without entering into the dry details of experiments and calculations made,[1] I have aimed at showing that the movements of birds, if they escape the sight, may be faithfully recorded by a new method which is applicable to the most varied problems of rotation and of mechanics.

Photochronography, in fact, gives experimentally the solution of problems often very difficult to solve by calculation.

Imagine a certain number of forces acting in different ways upon a known mass; the complicated way in which those forces are arranged sometimes renders long calculations needful in order to determine the positions which the moving object will occupy at successive moments; whilst if the body itself, submitted to those different forces, can be placed before the photochronographic apparatus, the path which it will follow expresses itself upon the sensitive plate.

Distinguished physicists disputed lately as to the form the free extremity of a vibrating stalk ought to present in which are produced curves and nodes: the greater number of them supposed that between the last node and its free extremity the stalk would present a bent form. Experiment has shown that it is not so, and that the last elements of the vibrating stalk are perfectly rectilinear (Fig. 11).

How many problems whose solution has formerly cost efforts of genius might be solved by a very simple experiment! Galileo in our day would not have needed to lessen the speed of the falling body in order to observe its motion. He would let fall a brilliant ball before a dark field, and would receive from it photographically successive images. Upon the sensitive plate he would have read, in the simplest way possible, the laws of space, of the speed and the accelerations which he has had the glory to discover.

To return to our subject, the laws of the resistance of the air to the living creatures of different forms which move in it ought to be searched into by photochronography. Already interesting results have been acquired: we have been able to determine the path of motion and the speed of small polished bodies (*petits appareils planeurs*) which move freely in the air, and which the eye has not time to follow in their rapid motions. Studies like these, undertaken and methodically carried out, will certainly lead to a comprehension of the still obscure mechanism of the hovering of birds.

TECHNICAL EDUCATION.

WHEN the time comes for the discussion of the new Technical Instruction Bill, attention will no doubt be given to an important series of resolutions (printed on the next page) which have just been passed by the Executive Committee of the North of England Branch of the National Association for the Promotion of Technical Education. The first six of these resolutions were unanimously adopted by the Committee, and the seventh was, on the motion of Mr. T. Burt, M.P., seconded by Mr. J. H. Girling (President of the Trades Council), adopted with one dissentient. The following are the advantages which the Committee desire to secure:—(1) For primary and secondary education a greater freedom of instruction under the existing code preparatory to technical education in the higher schools. (2) A direct or indirect pecuniary aid for superior education in science and art schools and in Colleges which afford technical education. (3) For all apprenticeship schools or trade classes a supervision by members of the trade, but no Government grant, thus to avoid any objections which might be raised by Trades Unions, or any jealousy arising from an apparent protection of one

[1] See the *Comptes rendus* of the Académie des Sciences 1886–37.

or more particular trades. (4) For University Colleges a grant similar to that made to training Colleges for education afforded to persons intending to become teachers.

The resolutions are as follow:—

1. That public funds (rates and taxes) should not be employed to meet the current expenses of teaching specific trades.

2. That it is undesirable that instruction in the use of tools should be introduced into primary schools as a grant-earning subject.

3. That with a view to preparing pupils for technical education later on—

(a) The grant to day-schools should depend, to a much less extent than at present, on the results of the examination of individual pupils in reading, writing, and arithmetic, and should be largely dependent on the inspector's report of the general character of the teaching and the equipment of the school.

(b) There should be greater liberty in the choice of subjects in primary schools, and the same class subject should not necessarily be taken throughout the school.

(c) The grant to evening continuation schools should be regulated by the report of the inspector on the character of the teaching, and on the attendance list, and not upon the result of the examination of individual pupils.

4. That when a technical school is combined with a science and art school, the contribution to the building fund, through the Science and Art Department, should exceed £1000, if, in the opinion of the Department, the requirements of the locality demand it.

5. That it is desirable that, when specific trades are taught in technical schools, the practical teaching of each trade should be under the general direction of a committee, consisting mainly of members of that trade; that the teaching should be given in the evening, and be restricted to pupils actually engaged in the respective trades, and that, when specific trades are taught, any deficiency in current expenses should be guaranteed by the trade of the district.

6. That a certain percentage of persons preparing for appointments as teachers in elementary schools should be allowed to attend lectures and laboratory work at Universities and University Colleges, where a curriculum satisfactory to the Education Department is provided, and that the same grant should be made on account of such students as in the case of ordinary training Colleges.

7. That it is desirable that University Colleges in which higher scientific and technological training are combined should be assisted by a Government grant, provided that evening instruction is given in all the subjects taught, at fees which shall bring the advantages of the College within the reach of all classes. The due administration of the grant should be secured by the appointment of certain nominees of the Government on the Executive Council of the College.

THREATENED SCARCITY OF WATER.

THE appendices to the Weekly Weather Reports for the year 1887, recently published by the Meteorological Office, contain some interesting details relative to the rainfall. It is shown that the mean rainfall for the whole of the British Islands during 1887 was only 25·8 inches, whereas the mean for the twenty-two years 1866 to 1887 was 35·3 inches, so that there is a deficiency of nearly 10 inches over the whole area of the British Islands, or 27 per cent. less than usual. In the wheat-producing districts, which comprise the east of England and Scotland, the south of England, and the Midland Counties, the fall during 1887 was 21 inches, and the average value for twenty-two years is 28·5 inches, showing a deficiency in these parts of the Kingdom of 7·5 inches, or 26 per cent. less than usual. In the principal grazing districts, which comprise the west of England and Scotland, as well as Ireland, the fall in 1887 was 30·5 inches, and the value for the twenty-two years is 42·0 inches, showing a deficiency of 11·5 inches, or 27 per cent. less than the average. In the north-west of England the rainfall for 1887 was only 24·9 inches, which is 15·7 inches or 39 per cent. less than the average, and in the south-west of England the fall was 28·3 inches, which is 16·6 inches or 37 per cent. less than usual. Last year was the driest of any year since 1866, and this feature was common to all parts of the United Kingdom; the amount of rain measured was only about one-half of that recorded in 1872, which was the wettest year of the period. If the comparison is confined to the last ten years, the deficiency is nearly as marked, and 1887 is still found to be about 25 per cent. below the average, but the greatest deficiency in this case occurs in the Midland Counties, where it amounts to 36 per cent. of the average. The reports issued by the Meteorological Office for the first five or six weeks of the present year show the deficiency of rainfall still to be augmenting, and even more quickly than in any period last year. In the Midland Counties the rainfall to February 6 was only 0·6 inch instead of 2·9 inches, so that the deficiency from January 3 is as much as 79 per cent. of the average fall; and at Hereford, where the total fall is only 0·29 inch, the deficiency is 90 per cent. of the average. In the east of England the deficiency is 64 per cent., in the south-west of England 61 per cent., and in the north-west of England 58 per cent. There has been a deficiency of rain in all districts of England each week for seven consecutive weeks since December 19, with the exception of a single district (England N.E.) in one week, and since the beginning of October there have been but four weeks in which the excess of rain was at all general. Out of fifty-seven weeks since the commencement of 1887 there have been but ten in the south-west and east of England with an excess of rainfall, and only eleven in the north-west of England. With these facts to hand, there seems reasonable ground for alarm being felt in some localities at the threatened scarcity of water.

CHARLES HARDING.

PROFESSOR ASA GRAY.

WHEN the history of the progress of botany during the nineteenth century shall be written, two names will hold high positions: those of Prof. Augustin Pyrame De Candolle and of Prof. Asa Gray. In many respects the careers of these men were very similar, though they were neither fellow-countrymen nor were they contemporaries, for the one sank to his rest in the Old World as the other rose to eminence in the New. They were great teachers in great schools, prolific writers, and authors of the best elementary works on botany of their day. Each devoted half a century of unremitting labour to the investigation and description of the plants of continental areas, and they founded herbaria and libraries, each in his own country, which have become permanent and quasi-national institutions. Nor were they unlike in personal qualities, for they were social and genial men, as active in aiding others as they were indefatigable in their own researches; and both were admirable correspondents. Lastly, there is much in their lives and works that recalls the career of Linnæus, of whom they were worthy disciples, in the comprehensiveness of their labour, the excellence of their methods, their judicious conception of the limits of genera and species, the terseness and accuracy of their descriptions, and the clearness of their scientific language.

Asa Gray was born in Paris, Massachusetts, on November 18, 1810, and took his M.D. degree when twenty, at the Medical College of Fairfield, Oneida County. His proclivities were all scientific from a very early age, and he is said to have, whilst still a student, delivered lectures on chemistry, geology, and botany, in private establishments of that county. The two former subjects were at first his favourites—indeed, his earliest