be determined whether either the safety of the machine or the comfort of the passenger requires a modification of the stability.

Messrs. Bairstow and Nayler have analysed the motion for a complete minute of an aeroplane moving over the ground with steady speed of 60 ft. per sec. in a wind as registered on an open-scale record of velocity changes, obtained at Kew Observatory. The velocity of the wind ranged from 11 to 33 ft. per sec., the average being 20 ft. per sec. Curves are given in the paper showing the changes in the wind velocity during the minute, and the variation in the velocity of the air relative to the machine during the same minute. The similarity of the two curves is marked. Curves are also given which show that if the speed of the aeroplane over the ground in still air is taken as 80 ft. per sec., its speed relative to the gusty air (as shown in the anemogram referred to) varies from 70 to 94 ft. per sec. The aeroplane has not time to respond to the rapid changes in the wind. While the changes in the actual horizontal velocity of the aeroplane are considerable, they occur much more slowly than in the wind-velocity curve; the minor alterations are wiped out; a rise in the wind velocity causes a fall in the velocity of the machine, provided the changes are sufficiently prolonged, but a very rapid rise and fall of the wind velocity is scarcely noticeable. It is assumed that the controls have not been touched while this motion is in progress. Curves are, however, also given, showing the effect of altering the elevator during the gust, and it appears that the elevator can without difficulty be so manipulated as practically to cancel the effect of the gust. The curves deal only with the longitudinal motion of the machine. Messrs. Bairstow and Nayler are now engaged in the similar problem for the lateral motion of the machine, and when this is completed, propose to attack in the same way the motion of a biplane of standard form.

The practical outcome of work of this kind is shown in the Army aeroplane R.E.1. The importance of this machine arises from the fact that it was designed to have inherent stability as the result of calculations based on scientific experiments, such as have been described in this lecture.

The Advisory Committee for Aeronautics has given much attention lately to the consideration of the stresses to which a machine may be subject in flight. The normal stress coming on any part of the machine is usually taken as that which it has to bear in steady horizontal flight, produced, that is, by a loading equal to the weight of the machine; if the breaking stress is N times this, N, according to present usage, is called the factor of safety. A machine, however, in its ordinary use may frequently have to carry a load much in excess of what it bears in steady horizontal flight. It would be more consistent with engineering practice to estimate what is the maximum stress the machine in its daily use may have to bear, and then take as the factor of safety the ratio of the breaking stress to this maximum stress. The factor of safety would thus take account of imperfections of workmanship or of material, not of varying load. If the maximum stress to be allowed for is taken to be equal to a loading N_1 times the weight of the machine (the normal loading in horizontal flight), and the breaking stress is n times this, then the ratio of the breaking stress to that occurring during steady horizontal flight is nN_1. This is called N, so that $N=nN_1$, and N, not n, is the factor of safety as ordinarily but mistakenly used in aeronautics.

The value of N has been determined by calculation and, in some cases, by direct experiment, for a number of machines, and appears to range from 3 to 7 or more. It is shown that a sudden gust may cause stresses on a machine four times as great as those occurring in steady horizontal flight at maximum speed. Another cause of serious sudden increase in loading is rapid flattening out after a dive, and calculation shows that stresses from eight to ten times those due to normal loading may be experienced due to this. From a consideration of these figures it is clear that it is essential to make an effort to strengthen machines so that N_1, the load factor, is at least six. Giving n the value of two (although an engineer would certainly think it too low for his work) the value of N would be twelve. There are great difficulties in attempting to reach so high a value at present, but it is not thought that the degree of safety specified is beyond reach.

THE METRIC SYSTEM.[1]

SINCE its introduction into the United Kingdom the metric system or question has had its ups and downs. Surely it is very curious that, although in 1862 a Parliamentary Commission recommended its introduction—a recommendation since repeated two or three times—and that a Bill was actually passed by the House of Lords, the metric system has not been adopted in this country. Why do people go on agitating? Well, the reason is the necessity for such a system. The facilities for intercommunication between various countries have a great deal to do with the continual agitation to introduce an international system of weights and measures. You may say the first person who put this down in black and white was James Watt. Writing to a friend in 1783 he said it was very awkward that the scientific results of workers in various countries could not be compared readily because of the measurements and weights being so different, and he proposed that they should agitate for the adoption of an international unit of weights and measures for scientific purposes. He wrote to French savants on the subject, and the result of the agitation was that in 1790 Prince Talleyrand brought in a Bill before the Legislative Assembly of France proposing that a Commission should be nominated to deliberate on this subject. It was a provision of that measure that the Royal Society of London and the French Academy should nominate the members of the Commission because it was agreed that the Commission ought to be an international affair and not merely a national one. The Royal Society would not agree to it because, as you know, England and France were at war at that time. Eventually, however, some other countries joined and constituted a Commission.

Another feature of the metric system was also suggested by Watt. He suggested that the unit of length should be cubed, a vessel constructed, filled with water at its greatest density, and that that should be the unit of weight. This cube should be the unit of capacity. In carrying out this idea insuperable difficulties have arisen of an absolutely mechanical nature, and so a kilogram is not any more a decimetre cubed and filled with water, but it is a piece of platinum kept in Paris at a certain temperature and at a certain barometric pressure. But the difference is very slight and does not affect the value of this co-relation between length, capacity, and weight. That is just the same as the standard of British measure—in fact, the real standards of English weights and measures were burned in 1835 in the Houses of Parliament and had to be reproduced afterwards as best they could. Secondary standards have now been made and have been distributed over the country, so that there is no danger of the standards being lost again.

After giving you this short history of the beginning

[1] From a report published by the Decimal Association of an address to the members of the Bradford Textile Society and of other Trade Organisations at Bradford, on November 17, 1913, by Mr. Alexander Siemens.

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of the metric system, I wish to direct your attention to the greatly different circumstances of communication between the various countries from what formerly existed. The interchange of products between the various countries has increased very much, and it is to the interests of everybody that this interchange should be facilitated as much as possible. One of the greatest facilities is that the same weights and measures should be used everywhere. Now the real requirements of such an international system are two in number. One is that the measures and weights should have the same base ratio throughout; that means to say one pound in the English system should be 16 oz.; one ounce should be 16 drams; one foot 16 in.; one yard 16 ft., and so on. That would be a system with the same base ratio throughout. Only 16 is not a good one. I am, of course, aware that people say 12 is a good ratio because there are so many aliquot factors in 12—three times four, twice six—and that consequently 12 is handy. We are, however, faced by the fact that all people on earth who count, count by tens, and that has fixed the base ratio for any international system. If you attempt to put in any other ratio it would lead to confusion, and would not be so convenient. Therefore the base ratio of 10 is essential.

Now as regards a little more of the history of the metric system. In 1861 the old Federation of German States instructed a Commission to propose a national system of weights and measures, and after they had deliberated a short time they came back to the Federation and said, "We must say that the only sensible thing"—the only thing that would justify the upsetting of the old measures which were very confusing in Germany at the time—"the only reason for disturbing people and introducing new weights and measures can be to have an international system." At that time the metric system was not as widely introduced as now, and the Commission very carefully went into the question whether they should adopt the English or the French system of weights and measures. It must be remembered that the superiority of England at that time was still very overpowering. It was a little less so than in 1850, but still it was preponderant. The United States and Colonies of England all had the English system of weights and measures, so this Commission, consisting of sensible men, might have thought: "We will go with the majority of the manufacturing people and adopt their weights and measures." But when they saw the English weights and measures and went into them they unanimously decided that the metric system was the only possible international system. In the metric system there is the same base ratio and divisions everywhere, so you have to learn nothing. It is the same base ratio as you use in calculation. I remember in 1895 I had to give evidence before the Parliamentary Committee on Weights and Measures, and I handed in a German school-book on arithmetic. The Committee said, "How many pages are devoted to the metric system?" I showed them that on the back cover there was a note: "Remember a hectolitre is 100 litres; a kilogram is 1000 grams." The other things were so self-evident that it was considered unnecessary to say anything about them.

The Commission instituted by the old Federation of German States submitted their proposals to the Reichstag in due course; then came the year 1866, which delayed the introduction somewhat, but in 1868 the Act was passed that the metric system should be permissible from January 1, 1870, and compulsory from January 1, 1872. This disposes of the idea that the metric sytem can only be introduced in times of great commotion and so on. The date of the introduction of the metric system was decided upon long before anybody knew anything about the Franco-Prussian War, and was, therefore, introduced rather in spite of it than as a consequence of it. About the same time a Committee was appointed by the English Parliament to report on the introduction of the metric system, and after hearing all sorts of witnesses, they reported in 1862 that "in their opinion it would involve almost as much difficulty to create a special decimal system of our own as simply to adopt the decimal metric system in common with other nations." Furthermore, if we did so create a national system we would in all likelihood have to change it again in a few years into an international system owing to the increase of commerce and intercourse between nations."

More than fifty years ago the upshot was that the Committee said it would be a waste of energy to introduce a special English system because owing to the ever-increasing intercourse between nations the nations would be forced into the adoption of an international system whether they liked it or not. That is the real reason why the Decimal Association believes that the metric system is coming. It may be coming slowly, especially here in England—we cannot help that—but if you consider this point of view, that the international intercommunication is ever increasing, that the nations are becoming more and more dependent upon the produce of other nations, you will see—you must come to the conclusion that an international system of weights and measures is desirable, and that the refusal of such a system will impede progress.

What are the objections? The first that is made is to the decimal point. Owing to the base ratio being 10, and 10 throughout, there is no necessity to use a decimal point. For instance, anybody making drawings puts all the dimensions on the drawings in millimetres. That has two advantages. You need not put millimetres every time as you put feet and inches (′, ″), and it avoids a lot of misunderstanding if the drawing has not been very carefully figured. 1′ 1″ is often taken for 11 in., 2′ 4″ for 24 in., and all that sort of thing, but if you use millimetres you have not that difficulty.

The decimal point objection is really non-existent because you always take the next lower unit if you find that what you want to express is less than the higher unit, and that is generally quite sufficient. The second objection taken is the size of the unit. That really is an argument that shows into what desperate straits the opponents of the system have reached to find an objection, because I cannot for the life of me see that the metre and the yard are so very much different. Nor are a half-kilogram and a pound so very unlike each other.

The next thing is that the opponents of the compulsory introduction of the metric system say:—"Well, you have got all you want, you have permission to use the metric weights, the Board of Trade will verify them for you; they have the standards—so what more do you want?" That is just it. Do not these people see that in compelling manufacturers and traders to have two standards, one for home consumption, and one for dealing with metric countries, they handicap the manufacturers and traders here? And there is another point of view. There was a discussion before the Institute of Inspectors of Weights and Measures on the metric system; they are the people who go about among all the tradespeople and have to verify weights and measures, and they ought to know their business. One inspector said that "from the inspector's point of view there is one point which advocates should not favour, and that

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is the argument that the proposed general Act should be permissive. To have two sets of weights on the shop counter at the same time is not wise. We know what it would be to have a 14-lb. set and a kilogram set alongside the scale; the changes would be rung. The kilogram is very near the size of a 2-lb. weight; the metre near the length of the yard, and the litre near the size of a quart. With these facts before us the Act should, in our opinion, be compulsory."

These are the two arguments:—So long as it is permissive, people who deal with metric countries have to have two standards, and they are handicapped in that way, and poor people are exposed to the danger of being defrauded.

The last objection is on the ground of cost. In order to have a fair idea of what the cost would be it is preferable to examine in detail how various interests would be affected if the metric system were made compulsory after a transition period of, say, two years. Taking first the case of the retail trader with whom the general public have most of their dealings. I think it fair to quote an inspector of weights and measures who spoke in the discussion just now alluded to. He said:—"The change to the metric weights and measures would really be very little cost to the shopkeeper, but he does not realise that this is the case. The shopkeeper imagines that the whole of the weighing machines and weights have to be changed, and it is the weighing instruments that are the greatest factor with him. The effect so far as weights and measures are concerned is very small indeed. It does not cost much to change either his weights or his measures, and I refer to measures of length as well as to those of capacity. With regard to the changing of lever machines, we know as inspectors that it is a very common thing for a weighing-machine maker to have to change the whole of his steel-yard markings and to have to rub out the old markings and to mark it anew. In this case it would be a very easy thing to change the markings, which would also apply to platform machines and counterpoise weights. The cost would be very small indeed." We may take it on the authority of the persons whose business it is to know everything about the weights and measures of the retail trade that the cost of the change would not be an insuperable obstacle.

The next interest to consider is the textile trade. Here, the opponents of the system contend, the cost of the change would be appalling because all present looms would become obsolete and would have to be replaced by new ones adapted to produce metric widths of fabrics. I had better take that with the engineering trade, because about that the same is said. I say in reply to all these arguments, "What are you doing now? Are you not exporting to metric countries, are not engineers exporting to metric countries? Have not we in our works plenty of metric dimensions to manufacture to; have we ever found any difficulty in doing it? Have we ever had to introduce new machinery specially to make a metric thing? Never!" Even leading screws of English pitch can be used to produce screws of French pitch and *vice versâ*. You must put in one wheel with 127 teeth which makes the changes right. You will find you are absolutely correct. When before a Parliamentary Committee I was asked:—"Seeing that in the cotton trade the standard make is what is called 79 in., $37\frac{1}{2}$ yards, $8\frac{1}{4}$ lb. shirting—which is known all the world over—would it not in some way damage the reputation of the shirting if the figures had to be re-calculated in all the markets of the world?" Well, at the time I had not sufficient time in which to make the calculation. What do you get when you re-calculate? Seventy-nine inches are 2 metres within one-third of 1 per cent.; 37·5 yards are equal to 34 metres to within one-third of 1 per cent.; and $8\frac{1}{4}$ lb. are $3\frac{3}{4}$ kilograms. So you see you have been entertaining angels unawares. You have been manufacturing to metric measure. So why say it is difficult? The general experience is that wherever the metric system has been introduced it has at once been accepted as by far the simplest and easiest to comprehend, while it has the great advantage of being international, which is more and more necessary nowadays where the intercourse between countries is increasing.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

BIRMINGHAM.—At a meeting of the council on June 3, a letter from Sir George Kenrick was read, in which the offer was made to endow the Chair of Physics by placing in the hands of the treasurer securities the income from which should be used exclusively for the salary of the professor and objects intimately connected with the Chair, the latter to bear in future the title of the "Poynting Chair of Physics." It was proposed by the vice-chancellor, seconded by Principal Sir Oliver Lodge, and unanimously resolved: "That the council most gratefully accepts the generous offer of Sir George Kenrick to endow the Chair of Physics as a memorial to the late Prof. John Henry Poynting. The council desires to record its great appreciation of this act of munificence which follows so many other proofs of Sir George Kenrick's interest in the welfare of the University; . . . That the Mason Chair of Physics be henceforth called the Poynting Chair of Physics." It is proposed that the title of "Mason Professor" shall be transferred to another Chair specially associated with the late Sir Josiah Mason. We understand that the endowment will consist of securities of the value of 18,000*l.*

Under the will of the late Mr. J. Tertius Collins a sum of 200*l.* has been given to the University, the interest to be applied to the founding of a yearly prize or prizes for proficiency in chemistry or metallurgy or some kindred object in science.

Profs. Boulton, Cadman, and Turner have been appointed delegates to represent the University at the International Congress of Mining, Metallurgy, Engineering, and Practical Geology.

Dr. W. E. Fisher has resigned his demonstratorship in mechanical engineering on his appointment to the engineering department of the Staffordshire County Institute at Wednesbury.

CAMBRIDGE.—During the Michaelmas term Dr. Myers will give a course of lectures in the psychological laboratory on general and experimental psychology, considered especially in relation to medicine.

The Vice-Chancellor has published a summary of benefactions received by the University during the year ended December 31, 1913. The total amount of the benefactions acknowledged by Grace is 20,861*l.*, and this included an anonymous gift of 10,000*l.* for the endowment of a professorship of astrophysics, 3661*l.* from subscribers to the Humphrey Owen Jones Fund, to establish a lectureship in physical chemistry, and 1500*l.* from Mr. C. E. Keyser, for the building fund of the new museum of archæology and of ethnology. In addition a sum of 2496*l.* has been received in smaller sums by the Cambridge University Association.

A studentship on the Arnold Gerstenberg foundation will be offered for competition in the Michaelmas term of 1915. The studentship will be awarded by means

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