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TECHNICAL NOTES

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No. 134

STANDARDIZATION AND AERODYNAMICS.

By

William Knight,
Prof. L. Prandtl, Göttingen,
Prof. von Karman, Aachen,
Col. Ing. G. Costanzi, Rome,
W. Margoulis, Paris,
Lieut. Col. Ing. R. Verduzio, Rome,
Dr. Ing. Richard Katzmayr, Vienna,
E. B. Wolff, Amsterdam,
Dr. A. F. Zahm.

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STANDARDIZATION AND AERODYNAMICS.*

By William Knight, M.E.

In the last two years while I was the Technical Assistant in Europe to the National Advisory Committee for Aeronautics, I have discussed several times with various people interested in aerodynamics the vital necessity of getting together representatives of aerodynamic laboratories both in Europe and in America for the standardization of the work performed in such laboratories.

Aerodynamics being a new science and not having the traditions which burden the older sciences can easily be standardized and the methods of work adopted in the various laboratories brought into line.

These results, I am convinced, cannot be obtained unless a congress is called of representatives of leading aerodynamic laboratories, without any discrimination between former enemies and former allies and the appointed task of such a congress should be to reach an understanding as to the coordination and standardization of laboratory work which is, in my estimation, absolutely essential to the progress of this new science.

In fact, if we compare the results of tests made on the same models by different laboratories, we shall see that very frequently these results do not agree. I will give two typical examples of this.

1st. The results of tests on wings made by the National Physical Laboratory (N.P.L.) regularly give better polars than

* From Aerial Age, June 20, 1921.

those obtained by the Eiffel Laboratory (E.L.). Having noticed this fact, the E.L. tested wings having R.A.F. sections Nos. 14, 15, and 16, the same as those tested by the N.P.L.: the dimensions were, 90 x 15 cm (2' 11.4" x 5.9"); the tests being made at the speeds of 12.2 and 25 m/sec (40' and 82' per sec). The models tested by the N.P.L. had the dimensions: 45.7 x 7.6 cm (18' x 3') and were tested at a speed of 12.2 m/sec (40' per sec).

The comparison of the diagrams obtained by plotting the experimental results, shows that the models tested by the N.P.L. are better, not only when compared to the plots of the E.L. experiments obtained at 12.2 m/sec (40' per sec), but also when compared to those obtained at 25 m/sec (82' per sec).

During the war, the French Military Aeronautical Technical Section sent to airplane manufacturers the results of the tests made on wings in both laboratories, and the difference between the two results led the manufactorers to believe that the wing sections tested by the N.P.L. were better than those tested by the E.L., the truth being, however, that the sections were geometrically similar and that the difference was due either to errors in measurement, or to errors in the determination of the speeds.

2nd. The Göttingen Laboratory, comparing its results as obtained in a closed circuit tunnel, with those obtained in tests on spheres made at the E.L. in a tunnel with a sucking fan, and with those made at the St. Cyr Laboratory in a tunnel with a blowing fan, noted that for certain values of VL/μ the coefficients

found were much greater than those found by the E.L. and the St. Cyr Laboratory. The Göttingen Laboratory explains this difference by the aerodynamical nature of the air current, turbulent at the E.L. and at the St. Cyr Laboratory, and non-turbulent at Göttingen.

I may add that the St. Cyr Laboratory has found in two tunnels of different diameters with sucking fans at the diffuser end, the same results as those obtained at Göttingen. We thus see that differences in results may be due, not only to errors in testing, but what is of much greater importance, to the aerodynamic nature of the airflow adopted.

It is out of the question that the present state of things is fraught with danger to the Science of Aerodynamics. As a matter of fact, when these divergencies are brought before the public, and especially before airplane manufacturers, as they must inevitably be, confidence in the work of the laboratories will be utterly shaken.

The matter is, therefore, very urgent, and the appointed task of the proposed congress should be to seek out the truth. For this purpose the congress should have first to compare together the results obtained up to date, and then decide on what comparative tests should be made, and what methods could be employed, to ensure uniform results. These should, however, be such that the laws of similitude to be applied in passing from experiments on models to those on full size airplanes shall be of greater simplicity.

The congress should also have to decide on the types of models and on the conditions of tests. Too many laboratories still use models which are too small, or speeds too greatly reduced, thus leading to results which cannot be utilized, either as to quantity or quality.

The science of aerodynamics should not only seek to obtain uniform results in experimental investigations: it should also serve to facilitate the practical application by technical men of the experimental results obtained in the laboratories. The congress should therefore take up the question of the standardization of symbols and notations.

As regards the symbols employed, we may divide the laboratories into two groups. One group, including the N.P.L. and the Göttingen Laboratory, uses non-dimensional symbols. The other group, comprising the American, French, and Italian laboratories, uses dimensional symbols expressed either in fundamental units such as used in the Kg.-meter-sec system, or the ft-lbs-sec system, or practical units such as km/hour or mile/hour, and HP (metric or British).

Besides the divergency in the system of units employed by the laboratories for expressing coefficients, there is also divergency in the coefficients used for representing certain experimental results.

As a matter of fact, though everyone agrees to represent wing tests by the coefficients Kx and Ky, the divergency begins with the ratio assigned to these two values, some giving the value of Kx/Ky, others that of Ky/Kx.

For propellers, the results are represented by some by the values of

$$\frac{\text{Power}}{(Rp's)^3 \times \text{Diam}^5} = f(V/nD);$$

by others, by the values of $\dfrac{\text{Torque}}{(Rp's)^3 \times \text{Diam}^5}$.

I would also mention divergencies in the aerodynamic characteristics of a streamlined body, which are sometimes referred to the area of the maximum cross-section, and sometimes to the 2/3 power of the volume; also to the disagreement existing in the expression of the mechanical efficiency of wind tunnels, etc.

This multiplicity of coefficients thoroughly bewilders the readerzof works on Aerodynamics and puts him under the necessity of transforming the expressions, a labor, moreover, which he rarely undertakes, preferring rather to lay down his book or to read it in a cursory fashion.

The same remarks apply to the notations, that is, to the symbols representing the various values used in the formulas. It is certain that if all laboratories were to adopt the same system of notation, the result would be a great economy of time for everybody concerned in aerodynamics, and the reading of the various reports on the subject would be a pleasure instead of being a burden, as it must be, so long as different notations are used.

We cannot too strongly insist on the fact that when, in reading a Report, we are stopped either by the meaning of a symbol

or by the value of a coefficient, it is impossible to follow the sequence of ideas, and the report is usually thrown aside. In the same way, the standardization of graphical methods of representation would be exceedingly useful. Here too at present we find a complete lack of agreement.

To take a very simple example: for wing tests, the N.P.L. gives four curves Kx, Ky, Ky/Kx in function of the angle of incidence, and Ky/Kx = f (Ky). The E.L. gives the curve Ky in function of Kx on which the angles of incidence are marked.

For the representation of propeller tests, the Central Aerodynamic Laboratory of Rome gives 15 curves: five for thrust, five for power, and five for efficiency, corresponding to five different wind velocities, in function of the speed of rotation.

Dr. Durand of the Stanford University, California, gives two curves Pm/n^3D^5 and P/n^2D^5, two curves Pm/v^3D^5 and P/v^2D^2 (where Pm = Effective Power and P = Useful Power), and one curve for the efficiency, all these curves being expressed in terms of V/nD.

For ordinary tests we should adopt not only the same methods of graphic representation, but also the same scales.

This standardization can be no possible hindrance to development, since, if the suggested Congress meets from time to time it will be perfectly free to modify any previous decision, should such modification be justified by new knowledge and experience acquired.

Another useful task of the proposed Congress would be to adopt a standard method of classification of all publications on Aerodynamics. This would be of great assistance in research work on any given subject.

In advancing the suggestion I wish to emphasize what I said before regarding the participation in such a Congress of representatives of all leading aerodynamic laboratories without any discrimination of nationalities.

I think it is time for everybody to realize that science has no particular nationality.

Unfortunately at the present time in Europe there still exists a tendency in certain quarters to snub and to pretend to ignore the wonderful progress made by the Germans in aerodynamics during the war and for this reason it is not likely that, if the move for calling such a Congress should be originated in Europe, the Germans should be invited to attend it.

Why not take the initiative in this country?

STANDARDIZATION AND AERODYNAMICS.*

By Prof. L. Prandtl,
Head of the Aerodynamical Laboratory, Göttingen University.
With an Introductory Note by William Knight.

Introductory Note.

In the last June 20 issue of the Aerial Age I pointed out the desirability of reaching some sort of agreement between the various research aerodynamical laboratories and other scientific aeronautical organizations both in this country and abroad about the symbols, graphical methods and other means of representation used in technical and scientific aeronautical publications giving the results of the research work done by the various investigating aeronautical agencies in the United States and in Europe.

Such work is useful only if the results obtained in the laboratories are presented under such a form as to allow to be readily used by aircraft designers and constructors and by students of aeronautics. At the present time there is such a confusion of symbols, terms and meaning of graphical methods used by the various aeronautical research agencies in the world and such a lack of well organized cooperation among the leading aeronautical laboratories that it is no wonder that aircraft designers, engineers, contractors and students of aerodynamics fail to benefit to the fullest extent of the excellent work which has been done and is being done by the various aerodynamical research laboratories in the United States and in Europe. The results of such a state of affairs are a waste of energy and a consequent retard in the progress of aeronautics.

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* From Aerial Age, October 3, 1921.

A remedy to these unfortunate prevailing conditions could be worked out if a leading scientific research organization in this country as, for instance, the Bureau of Standards or the National Advisory Committee for Aeronautics should take the initiative in suggesting to the various aerodynamical laboratories and other scientific aeronautical research organizations both in the U.S. and in Europe the adoption of the same symbols and the same terms for expressing the same thing everywhere; in other words, applying standardization to aerodynamical works.

An agreement could easily be reached because the importance of reaching an agreement is very badly felt by every student of aerodynamics. All that is needed is to have a leading scientific aeronautical organization posing the problem and to invite a free discussion of the various standards used by the various European nations and by ourselves. From the discussion, which can take place by correspondence, a common ground of agreement can be found and after such an agreement has been reached an international conference between the representatives of the various organizations which have discussed the matter can be called and the adoption of international standards on aerodynamics can be decided upon. Also a function of this international conference should be to devise a means of bringing about a much desired closer cooperation between the various research laboratories so as to present as much as possible the dispersion of good efforts.

The National Advisory Committee for Aeronautics or the Bureau of Standards are the best suited for taking the lead in such a

vitally important matter because, fortunately enough, we are free from post-war hatred and we would not be inclined to discriminate between scientists of formerly allied nations and scientists of formerly enemy nations as might probably be the case if the lead in this matter should be taken by some European aeronautical organization under government control.

I know for a fact that American leadership in this matter would be greatly welcomed by everybody in Europe interested in the scientific progress of aeronautics and by making such a step we would greatly contribute to such a progress.

In the meantime, while eagerly waiting for something being done in the direction pointed out above, I have taken up the matter with leading aerodynamical research workers and I have asked them to express their views on the subject of "Standardization and Aerodynamics."

The following paper from Professor L. Prandtl of Göttingen, Germany, who has contributed to a very large extent to the present knowledge of aerodynamics is published with his kind permission. The point of view of other European leading aerodynamical research workers will be published later for the purpose of showing that all of them have useful suggestions to make and that all that is needed to bring about results is to take the lead in bringing them together and letting them decide something which will be agreeable to everybody and especially to manufacturers and designers of aircraft who are the only ones for whom the research work is done in the laboratories and books and for whom technical reviews are published.

PROF. PRANDTL'S COMMENT.

1. The Wind Tunnel.

In order to accomplish any comparative results in wind tunnel tests it is of prime importance to have the air currents comparable. This of necessity calls not only for an accurate air current at the place, where the test is to be made in size as well as direction, but that the wind eddies are kept at a minimum. In the Göttingen Laboratory this was one of the main requirements. Fig. 1 shows an easy way to obtain an air current with minimum wind eddies quieted as much as possible in a great profile through a honeycomb and then contracted in a much smaller cross section. The tests are made on the place marked Exp. Fig. 1.

I maintain that this arrangement is very important and firmly believe that only this or any equivalent arrangement will give comparative results. It is of less importance, whether the wind tunnel has closed circulation, or whether a tunnel with suction blast is used, and whether the measurements are made in a free air current or between stationary walls. In regard to horizontal buoyancy the free air current, as first introduced by Eiffel, is in my opinion to be preferred. Through special formation of the outlet the velocity can be made constant even at a short distance from the mouth of the outlet surface. Through determination of the drag of a big ball the wind eddies of the air current are accurately determined. As known, below a critical velocity the drift coefficient is approximately 0.24, above this critical ve-

locity about 0.10. The critical velocity - the critical $\frac{VL}{\nu}$ - is that much smaller as the eddy is greater. The Göttingen measurements correspond very much to the Italian measurements, where a ball was dragged through calm waters. And the conclusion can be drawn that the small wind eddies here in Göttingen do not change the results very much. As example of the agreement between measurements with different wind tunnels, which are constructed on the same principle, I give in Fig. 2 the results of two measurements with balls, one with a ball 28 cm diameter in the great wind tunnel (4 m^2), the other with a ball 20 cm diameter in the small tunnel (1.2 m^2). The almost perfect agreement of both series can be noticed.

2. Size of models and Air Velocity.

For approximately correct agreements of model measurements with actual conditions, it is important not to select models and also the air velocities too small for the measurements. In the Göttingen measurements a span of from 1 to 1.2 m and a wind velocity of 30 M/sec gave the best results. Even in this ratio the agreement is not perfect, although it is comparatively safe to have the deviations not very great. The modern wind theory allows a calculation of the influences exerted by the walls of the test tunnel or by the limitations of the free air stream. And if this correction is taken into consideration one can safely with the span of the models go even a little beyond half of the air current diameter.

3. Placing of the Models.

The manner in which the model is fastened during the test is of greater influence than at first suspected. The difference between the Eiffel results and the N.P.L. results at Teddington is easily accounted for. By the Eiffel tests the wings were fastened with compact screws on the suction side, while by the Teddington tests the models were fastened on the pressure side. As known, any disturbing element on the suction side entails quite a drag which increases with the angle of the incidence while any disturbing influence on the pressure side brings a decidedly lower and with increasing angle of incidence a decreasing drag. Therefore I believe that from this point of view the Göttingen arrangement (6 very thin wires) is the most satisfactory.

4. Drift coefficients and the results.

In regard to drift coefficients, we will perhaps in time come to the agreement to give the absolute coefficients, since in the quality as dimensionless quantities they have the same value for each rational measuring method. Then it would be easy to calculate the coefficients adapted to individual countries. More satisfactory perhaps it would be if the engineers would adapt the absolute system in its entirety.

In the absolute system itself there are two different definitions. One, only used in Germany and Austria so far, pertains to drift, to velocity head (dynamic air pressure) $1/2\ \rho\ V^2$, i.e. the pressure appearing as maximum pressure before an obstruction. In English-speaking countries the drift stands for double this aero-

dynamic pressure (velocity head), also ρV^2, resulting in the coefficients being half as great as the German coefficients. In favor of the German system let me say, that this quantity $1/2\ \rho V^2$ is obtained directly by speed measurements with Pitot tubes and the relation of air resistance to the Pitot pressure is especially natural. Then again, the drift coefficients of many objects (level, circular disc, circular cylinder, etc.) are by this method approximately 1.

To demonstrate these test results we have developed here in Germany already complete solid forms, for the testing of wings and airplane models, as well as for propellers. For wing tests, the lift coefficient as a rule is taken as starting point. This complies in one way with the results of the wing theory, where the lift presents the given quantity, and in the other way for the technical measuring reason that by usual measurements the lift determination is more accurate than the determination of the angle of incidence, which before was used mostly as an independent changeable., added to this, that the definition of the angle of incidence 0° is often arbitrary. The now usual method of wing measurement is shown in Fig. 3. As introduced by O. Lillienthal, lift and drift are carried at right angles to each other, thereby giving the drift, according to the Eiffel method, as 5 times scale of the lift. The result is the so-called polar curve. Alongside of this the theoretical polar curve is shown, which according to the wing theory would correspond to a wing with equal aspect ratio but without profile resistance. The distance between this theoretical

parabola and the measured curve shows the profile resistance, which according to our test results is quite independent of the aspect ratio, and shows to be very satisfactory for judging the quality of the profile. The angle of incidence, in many calculations occupying a very negligible place, is written on the individual points of the polar curve.

To show the position of center of pressure the moment coefficient on the leading edge (absolute coefficient for this moment) is given and indeed as being independent on the lift as the deciding quantity. The moment curve is therefore to be preferred, because it runs almost in a straight line, and makes the interpolation of values between the given values very easy. But by the curve, giving the position of center pressure direct, any interpolation is often very difficult, because the lift curve 0 is infinite. The position of center pressure can anyway be deduced from the moment curve through a simple construction.

The ratio lift-drift, given in English literature mostly, need according to our method not be shown especially, since it can be obtained by simply drawing a straight line from point 0 to the respective place on the polar curve.

And this ratio is at that not the deciding factor to determine the quality of an individual profile, because it is dependent quite a lot on the aspect ratio, and because that point, which gives maximum lift-drift in a certain plane, is only determined by the parasite drift of the airplane.

The showing of propeller test results have in the last few years been brought down to uniformity as well. Details are given in an article by F. Bendemann and A. Madelung in Technische Berichte Bd. II PP 53, etc. Its main drawing (table 40) approaches the methods of Eiffel and Rith. The absolute torque is taken as function of flying speed ratio to periphery velocity ratio in logarithms and the efficiency is shown in numbers.

It is my desire to have this article lead to a discussion of interested aeronautical experts and further through this discussion the question of standardization in Aerodynamics.

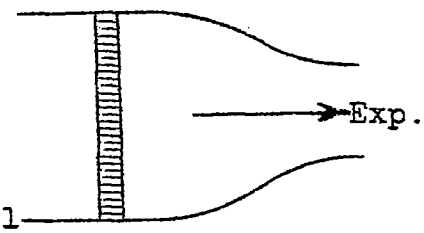

Fig.1

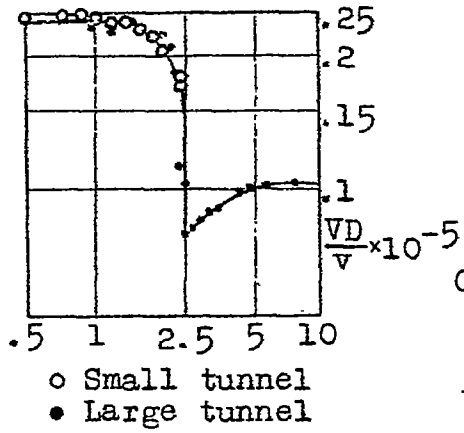

Fig.2

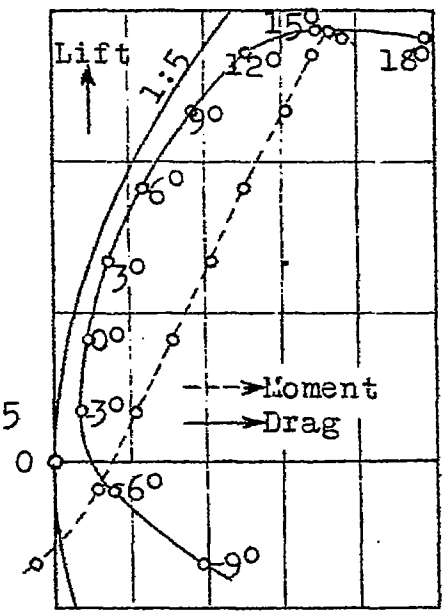

Fig.3

STANDARDIZATION AND AERODYNAMICS.*

By Prof. von Karman,
University of Aachen. (Germany).

Introductory Note.

The suggestions offered by W. Knight in the Aerial Age of June 20, 1921, as to the desirability of calling a conference in the United States among representatives of leading aeronautical scientific organizations with a view of reaching an international agreement on the subject of Standardization and Aerodynamics was taken up by Prof. L. Prandtl of the University of Göttingen, Germany, and in the October 3rd issue of the Aerial Age his views on this matter were given. Prof. Dr. von Karman of the University of Aachen, a most brilliant scientist who has been prominent in the development of aeronautics in Austria during the war and who is now at the head of the Aachen aerodynamic laboratory, writes to Mr. Knight the following letter and gives his views on "Standardization and Aerodynamics" which are presented to the readers of the Aerial Age.

Dear Mr. Knight,-

I am sending you herewith attached a few notes giving my views on the very important point that you have recently raised in the Aerial Age on the subject of Standardization and Aerodynamics, which you may publish if you think it worth while.

There is no doubt that if you can succeed in bringing together former allied and former enemy scientists for discussing a problem

* From Aerial Age, January 2, 1922.

which interests everybody, you shall have greatly contributed to the scientific development of aerodynamics.

In my opinion it should be desirable, to begin with, to have a preliminary conference between a few of the most prominent scientists and technical men interested in this matter for discussing the best means for creating an international scientific aeronautical association which is the best suited for bringing about a much desirable cooperation among aerodynamical research workers.

I think that an association organized along the same general lines as the International Society for testing materials shall admirably serve our purposes.

This preliminary conference that I am suggesting for laying the foundation of a permanent international scientific aeronautical association should be desirable if it took place in Europe, in some place having an international character, and I suggest for this purpose the southern Tyrol (Italian Tyrol), at Bozen or Mezan.

Yours very cordially,

von Karman.

Prof. von Karman's Suggestions.

In its early stages a new science labors under the advantage of the possibility of having its development directed from the beginning in an orderly and systematic manner. The primary requirement to this end is the international standardization of definitions and symbols, and it would be of great value to aerodynamics

if America were to take the lead in this matter. The most important problems that should be taken up in such an undertaking, in the writer's opinion, are the following:

1. Standardization of Coefficients.

The standardization of nomenclature and derivation of coefficients is not a purely objective matter, as it is based upon a thorough understanding of the theoretical foundations of aerodynamics. In spite of the apparent simplicity of the French system, I believe that preference should be accorded to "abstract" coefficients, independent of dimensions, as the laws of mechanical similarity are more clearly evident by their use. Ever since the importance of Reynold's index has been clearly recognized, most laws of resistance can only be applied when this number is contained as a parameter, in which cases the use of abstract coefficients is evident. Many complicated phenomena, such as surface friction or heat-transference in turbulent gases and liquids, would have been explained much sooner if early investigators had expressed their results by empirical formulas in terms of concrete entities and abstract coefficients.

2. Standardization in Methods of Measurement.

For the correct measurement of airspeed it is essential to establish standard methods, if results obtained in different laboratories are to be compared with safety. Measuring instruments such as the Pitot tube, should be standardized as to shape with the eventual selection of a "standard" at some central point for comparative reference. Unfortunately (as expressed in the article

by L. Prandtl in the issue of October 3, 1921), the speed thus measured is not a true expression, depending, as it does, on the magnitude of the vibrations or the so-called degree of turbulence. It would be a thankful task for a laboratory to build apparatus for the determination of these factors. Meanwhile it would seem advisable to follow the suggestion of Mr. W. Knight to have a few simple bodies experimented with in all important laboratories and have the results thus obtained compared and reduced to a common proportionate expression.

Thus it would be possible to determine accurately the resistance of a circular disc or a sphere of a given diameter and adopt that dimension as a standard. In fact, in view of our limited knowledge of the influence of surface conditions or unavoidable variations in the making of similar models it would be best to have the same model make a round trip to every laboratory adapted for such work.

3. Standardization of Definitions and Symbols.

Next to the standardization of coefficients and their relationships an agreement should be reached as to definitions and symbols. For example, take the definition of Angle of Incidence, which in Austria and England is defined as the angle between the direction of the air stream and the so-called maximum chord (a) (Fig. 1) while in other countries the lower tangent to the profile passing through the trailing edge is taken as a basis. (b) Many other elements can be conceived in different ways and are therefore of doubtful interpretation. In speaking of wing-surface and wing-

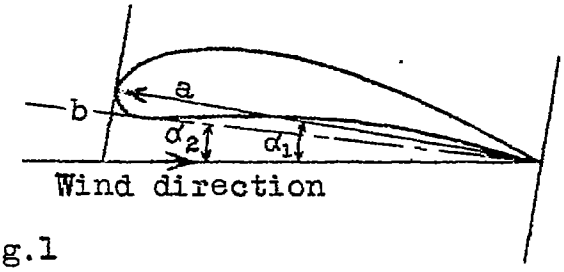

Fig.1

loading it is undetermined to what extent ailerons can be assumed to be part of the carrying surface, or in the case of strong dihedrals whether the surface itself or its horizontal equivalent is to be taken as a basis of calculation. In this case even the meaning of the word "span" becomes subject to misinterpretation. Aspect ratio, which plays such an important part in modern wing-theory, becomes an indeterminate quantity when applied to diminishing chords. To afford a useful basis for description and comparison of aircraft it is imperative that all such elements be defined without possibility of misunderstanding.

A similar divergence in methods applies to the determination of efficiencies. The efficiency of a propeller has been defined by three or four scientifically justifiable expressions, and nevertheless we often read the old $\frac{\text{traction}}{\text{Horsepower}}$ formula, which is in no way characteristic of the efficiency of a screw as it takes neither speed nor dimensions into consideration.

From the above random examples we see that a comparison of opinions and a sifting of various methods now in use would bear good fruit. An <u>immediate</u> understanding on work in course of preparation or contemplated would result in the avoidance of

duplication and would insure that every experiment be undertaken in the laboratory already best equipped to carry on its particular share of the work. The activities of the International Association for Testing Materials, which in pre-war days co-related and assisted in preparing the results obtained in all laboratories, could well serve as an example. If such activities could be extended towards the practical side of aircraft design, as for instance in the comparison and standardization of methods of calculation, determination of factors of safety, etc., a magnificent program could be outlined, the realization of which will be of maximal importance to the further development of the science of flight.

STANDARDIZATION AND AERODYNAMICS.*

By Col. Ing. G. Costanzi, Rome, Italy.

With further reference to the point raised by Wm. Knight in the article on "Standardization and Aerodynamics" published in the Aerial Age of June 20, 1921, and the discussion of that article by Professor Prandtl, of the University of Göttingen (see Aerial Age of October 3, 1921) and by Professor von Karman, of the Technical Institute of Aachen (see Aerial Age of January 2, 1922), the following suggestions are offered by Col. Ing. Giulio Costanzi of the Italian Army, in connection with the matter to be taken up at the international congress of representatives of aeronautical scientific organization as suggested by Wm. Knight.

Colonel Costanzi is well known among aeronautical scientists on account of the important research work done by him at the Royal Aircraft Establishment in Rome, Italy. During the war and after the war he was the representative of the Italian Air Service to the Supreme War Council in Versailles and also technical representative of Italy to the permanent Interallied Aeronautical Commission in Paris.

Colonel Costanzi's Comment.

It was with the greatest interest that I read the article on "Standardization and Aerodynamics" published by Wm. Knight in the Aerial Age a few months ago. The subject was not entirely new to me, having discussed that matter several times with Mr. Knight

* From Aerial Age, February 20, 1922.

who has been striving for the last two years while acting as technical assistant in Europe to the National Advisory Committee for Aeronautics to bring about a much needed international cooperation between aeronautical scientists and technical men, both in Europe and in the United States, for solving our common aeronautical problems in a true spirit of mutual helpfulness.

It is out of question that the standardization of symbols and of graphical methods of representation of experimental results as used in technical and scientific aeronautical works would be of a tremendous help to every user of such works. To curtail the individualistic tendencies of many scientists (especially in Europe) by agreeing to talk, all of us, the same scientific language, will be of the greatest advantage to the progress of aeronautics, and this seems to be the right moment to do it, now that aeronautics is yet a new science without the burden of traditions weighing on older sciences. However, no matter how desirable it might be to agree on the adoption of international symbols meaning the same thing in every country and on the adoption of standard methods of graphical representation of results of research work, I anticipate the greatest difficulty in persuading authors of aeronautical publications to stop the prevailing practice of adopting definitions and graphical methods of their own (which a good many times are misleading the reader in another country who is not familiar with them) in the absence of any international agreement.

The other point raised by Wm. Knight in the Aerial Age about

the necessity of conducting comparative tests on wind tunnels I believe is one of the most vital importance, and undoubtedly something should be done without delay in that direction in order to dispel the doubts and the skepticism which must necessarily prevail at the present time about the results of aeronautical research and investigation work being conducted in the various research laboratories.

Both Professor Prandtl and Professor von Karman in discussing Knight's article have particularly emphasized the necessity of conducting such comparative tests which might lead to a more definite knowledge of the reliability of the results obtained in the various wind tunnels and to a more intelligent and less conflicting interpretation of their comparative value, and I wish to express my entire sympathy with any plan which might bring about the desired results in that direction and to offer at the same time a few suggestions.

During years of experimental work both in the Aerodynamical and Hydrodynamical Laboratories of the Royal Aircraft Establishment in Rome, I was I believe the first one to point out in May, 1911, the existence of a change in the regime of resistance of cylindrical and streamlined struts, wires, spheres and streamlined bodies, and I pointed out at that time the difficulty offered by such changes of regime in the correct interpretation of the experimental results obtained while experimenting on a model of airplane in which wings, struts, wires, radiators, etc., all follow different laws of similitude and all have a different regime of

variation of resistance depending on the dimensions of the model and the velocity of the fluid.

In 1911 I pointed out the influence of the degree of turbulency of the fluid (I was conducting my experiments in water), on the determination of the regime of fluid resistance offered by a body moving in the water at a constant velocity when the degree of turbulency of the water in front of the model was changed.

Also, while experimenting in the wind tunnel, due to the absence of an absolute method for measuring the wind velocity, my own work was handicapped by lack of an exact knowledge of the absolute velocity of my wind stream. Other experimenters were working at that time under the same handicap, and the values assigned by them to the velocity of the air in the wind tunnel was in their cases as well as in my own case a question of more or less accurate measurement of such velocity.

Another stumbling block in wind tunnel work was (and still is) brought about by the interference of the supports holding the model in the tunnel - interference which is sometimes prevailing to such an extent as to completely change the phenomenon taking place in the wind stream. I tried once to reduce to a minimum the influence of the supports holding down a model of a Zeppelin 9 cm diameter x 90 cm long in the wind tunnel. I used two wires of .05 of a millimeter in diameter, and after measuring the air velocity in a plane perpendicular to the axis of the model at the distance of 50 centimeters from the model I could notice that in spite of the very small diameter of those wires their influence was quite distinctly felt.

I believe that in the classical experiments made by Eiffel at the Eiffel Tower which lead to the conclusion that the specific resistance of disks perpendicular to the direction of the wind increases with the increase in dimensions of the model experimented upon, the influence of the supports was such as to entirely upset the experimental results obtained.

In conclusion, I like to suggest that one of the appointed tasks of the international congress of representatives of aeronautical scientific organizations as suggested by Wm. Knight, should be to lay out a program of investigation work in the most important aeronautical laboratories with a view of determining:

1. Why such a lack of agreement exists between the results arrived at in the various laboratories? Is such a lack of agreement due to the lack of a perfect similarity of the models used? Is it due to the scales of the models? Is it due to the fact that the velocity of the fluid used is not exactly the same in two laboratories? Is it due to the nature of the air stream in the wind tunnel which is greatly and differently affected in the various wind tunnels after passing through differently shaped honeycombs? Or is it due to faulty measurements of the wind tunnel balances used?

2. How are the results affected by conducting the experiment either on a moving model in presumably still air or on a stationary model in a wind stream produced by either a sucking or blowing fan?

I would suggest that a series of experiments be made for

determining the resistance of spheres of various dimensions falling a certain height when compared to experiments made on the same spheres under analogous conditions in a wind tunnel.

It would also be interesting to make experiments in a specially designed closed circuit wind tunnel where thin or compressed air, hydrogen or other gases could be used as suggested by Ing. Ottorino Pomilio in Italy and by Mr. W. Margoulis in France.

3. Why the ratio $\frac{Rx}{Rx}$ increases with the velocity in the wind tunnel when experimenting upon some models of airplanes? An aluminum model of airplane which I had recently tested out at the Central Aeronautical Institute in Rome showed an increase of $\frac{Ry}{Rx}$ in the order of 22 per cent when tested at 15 m/sec and 35 m/sec respectively, the angle of incidence being the same in both cases, viz. 3°. I should be glad to place that model at the disposal of other laboratories for further tests.

Before concluding my remarks about the discussion on "Standardization and Aerodynamics" appearing in the Aerial Age, I wish to state that there is one point more on which I entirely agree with Wm. Knight, and that is the necessity of inviting the Germans to participate in any international settlement of the various questions affecting aerodynamical research work.

I should think that if we are going to have a congress of representatives of aeronautical scientific organizations, the first meeting of such congress should be held in Germany, where experiments of the highest order of both scientific and practical importance have been conducted in the last few years with the usual German thoroughness and accuracy.

STANDARDIZATION IN AERODYNAMICS.*

By W. Margoulis,
Former Director of the Eiffel Laboratory, Paris.

With reference to the article on "Standardization and Aerodynamics" published by W. Knight in the Aerial Age of June 20, 1921, I beg to say that in 1919, while acting as Aerodynamical Expert of the Paris Office of the U. S. National Advisory Committee for Aeronautics, in an article published in "France-Aviation," I made suggestions along the same lines.

These suggestions were warmly taken up by Mr. W. Knight, the Technical Assistant in Europe to the U. S. National Advisory Committee for Aeronautics, and he promptly brought the matter to the attention of the various Aerodynamical Laboratories in Europe and the United States.

The suggestions which we made at that time regarding Comparative Tests were taken up by the National Physical Laboratory in England, and in March, 1920, the N.P.L. sent out a suggestion to other laboratories to make a number of comparative tests on similar models.

According to the plan outlined by the N.P.L. and to other suggestions offered to Mr. Knight by the St. Cyr, The Aachen and Göttingen Laboratories, these tests should have been as follows:

1st - Determination of Kx, Ky and of the centers of thrust on a wing.

2nd - Tests of a complete model of airplane comprising the

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* From Aerial Age, March 6, 1922.

complete determination of forces and moments (it should now be added: "and the influence of the slipstream of the propeller"), and also of the more important stability derivatives.

3rd - Tests of a sphere and a cylinder for determining the degree of turbulence of the airstream.

4th - Tests of a streamline body.

5th - Measurement of the uniformity of the airstream in time.

The tests on the wing and the streamline body should have been made on a single standard model to be tested by all the laboratories successively and on individual models made by each laboratory from the same drawing.

The tests of the model airplane should have been made with the same model in all laboratories.

In the summer of 1920 the N.P.L. sent to a number of laboratories a drawing of a streamline body to be used as a first test model, at the same time asking for their ideas on the method of fixing the model to the support.

Since then, however, the project has probably been given up, for nothing more has been heard of the matter, at least by the French laboratories.

We consider, moreover, that if such tests are to give results, they must be both numerous and systematic in order that, as a whole, they shall characterize the airflow in each wind tunnel.

Thus in a paper read October 16th, 1920, at one of the monthly meetings organized in Paris by Mr. Knight and myself for the discussion of Aeronautical problems, I proposed the following tests,

and the following recommendations were made:

Tests A.- <u>Struts</u>: Fineness Ratio 0: rectangular plate
" " 1: cylinder
" " " 1,5; 2; 2,5; 3, 5 and 10: struts proper

Tests B.- <u>Streamline Bodies</u>: Fineness Ratio 0: disk
" " 1: sphere
" " 1,5; 2; 2,5; 3; 4 and 6: revolving bodies.

For each aspect ratio there would be three models of different dimensions and each model should be tested at all available speeds. We may thus draw up two tables for each laboratory, one for streamline bodies (similar to that given by Prof. Prandtl for the old Göttingen Wind Tunnel) and the other for struts (similar to that which I gave for the large tunnel of the Eiffel Laboratory in the previously quoted article in "France-Aviation").

These tables would form, if I may be permitted the expression, the "finger-prints" of the wind tunnel.

The tests on WINGS should be made on three wings of mathematically defined profile, (the Joukowski profiles, for instance), of different thicknesses and camber. Each wing should be tested with several aspect ratios.

At the same time, the St. Cyr Institute would be requested to test the same models in the open air on its truck; these latter tests would be of great importance, for up to now wind tunnel tests have usually been compared with free flight tests of all full sized airplanes, ignoring the intermediate stage, namely, that of free flight tests of models.

This program may seem rather a long one, but in aerodynamics results can only be obtained by means of a great number of tests.

I also submitted these suggestions to the First International Congress of Aerial Navigation which has just been held in Paris. They were adopted by the Congress and introduced into its resolutions. The following is the text of the Resolutions voted by the Congress:

"GENERAL RESOLUTION"

"The First International Congress of Aerial Navigation resolved to form itself into a permanent Congress. It is proposed that the 2nd International Congress of Aerial Navigation be held in London, June, 1923. It is recommended that permanent sections be formed in each of the countries represented at the Congress and that they keep in touch with the English Organization Committee with a view to preparing the questions to be studied at the 2nd Congress.

MOTIONS OF THE TECHNICAL SECTION.

"3rd - Study of the measures which may be adopted immediately in the test methods of aerodynamical laboratories in order to make it possible to compare results; in particular to define the geometrical forms and the material realization of a large number of typical models which, tested systematically in well defined conditions, would serve, in some sort, as a characterization of a wind tunnel; also to bring about an agreement that the same collection of such models be tested successively in the various laboratories.

"4th - Unification of the terms and notations employed in the

aeronautical publications of the different countries."

The future London Congress seems to be perfectly qualified to solve these questions of Standardization. Let us hope, however, that it will be really international and that we shall be able to shake hands there with scientists from the North, the South, the East and the West without any discrimination of nationalities.- Let us also hope that the men attending the London Congress shall keep in mind that in the standardization of terms and symbols used in aerodynamics it is immaterial which system is adopted provided that one is adopted by all.

The U. S. National Advisory Committee for Aeronautics is to be complimented for taking the initiative in adopting for wings the same coefficients used by the Göttingen Laboratory; and French laboratories are going to do the same. I doubt, however, if British Laboratories shall be inclined to accept and to adopt terms and symbols other than their own.

The differences noted between the various laboratories in comparing the experimental results obtained have induced them to come out of their isolation.

In May, 1920, appeared a Memorandum by Miss Lang: "German Aerofoil Tests" (R. and M. No. 695) in which the author compared the results of the N.P.L. closed tunnel with those of the old Göttingen closed Wind Tunnel, obtained on the same wings. The polar curves agree perfectly, with a slight displacement of the lift and resistance curves in function of the incidence.

On the other hand, the Eiffel Laboratory in its researches on

the causes of the disagreement between its own results and those obtained by other laboratories, has just found that this disagreement was due to the method of fixing the wings. The following table summarizes the numerical values of the elements of the resultant of the thick and cumbered wing, E. 321, of the Joukowski type:

Incidence	METHOD OF ATTACHMENT			
	On the upper surface of the Wing		On the under surface of the Wing	
	Kx	Ky	Kx	Ky
-9°	0.00119	0.00254	0.00124	0.00518
-6	0.00155	0.0153	0.00138	0.0172
-3	0.00239	0.0278	0.00194	0.0298
0	0.00351	0.0398	0.00279	0.0424
3	0.00514	0.0519	0.00418	0.0556
6	0.00694	0.0630	0.00566	0.0675
9	0.00867	0.0710	0.00732	0.0770
12	0.0110	0.0763	0.00945	0.0806

Kx and Ky expressed in $Kz/m^2/m:sec$.

We see clearly that the old method of attachment, on the upper surface of the wing, gave much lower polar curves than the new method of attachment on the lower surface of the wing, now exclusively employed in the Eiffel and St. Cyr Laboratories.

Under these conditions the tests of wings in the open tunnel of the Eiffel, St. Cyr and Göttingen (new wind tunnel) laboratories, agree perfectly.

It would thus appear that the results of tests on wings are the same for all laboratories, provided that the type of tunnel is the same, that is, that only tests carried out in open tunnels shall be compared together, or those carried out in closed tunnels. We have thus only to find a means of comparing the two systems. This does not appear to be a very easy matter, for, experiments made at the Institute of St. Cyr, where the experimental chamber can be proposed either open or closed, it is shown that the correction proposed by Professor Prandtl does not always accord with the experimental results, more especially in the case of a rather complicated model. Thus, for a complete model of airplane the polar curves obtained in an open and a closed tunnel scarcely differed while there was a notable difference in those obtained for single wings.

I consider that this question of corrections to be applied to results of wind tunnel tests is one of the most important for the future Congress, for the laboratories are far from agreeing on the subject. (As a correction depending on the internal structure of the airstream, I would point out that of the N.P.L. due to pressure drop in closed tunnels, and for making corrections due to the ratio between the dimensions of the model and those of the airstream, I would point out first, Prandtl's correction for wings, previously mentioned, and then those of Fage-Collins (R. and M. No. 605) and Wood (R. and M. No. 662) for propellers).

Finally, the laboratories will have to make their results agree with those of test of full size airplanes.

We are aware that, as regards this question, there are two opposite camps: that of the optimists and that of the pessimists. The former comprise chiefly those who are working in laboratories and who consider that their tests agree perfectly with those made on full size airplanes; generally speaking they estimate the error involved not to exceed 10%.

The pessimists, on the other hand, are quite ready to assert that "the results obtained in present day laboratories are of no practical use"; they also say that the laboratories work at rates of airflow which are unstable in general, and very different from the conditions obtaining for airplanes in flight, and that, for these two reasons, it is difficult and even useless to attempt to make laboratory results agree.

Finally, we have the aircraft manufacturers who take no interest in such academical discussions and only seek one thing, namely, to be able to forecast the performances of the airplane they have designed as accurately as possible and with as little expense as may be. It is they who should offer a prize for "An International Competition for Obtaining the Best Method for Predicting the Performances of an Airplane," having special reference to predicting the performances of an airplane, the characteristics of which would be published some months before the free flight tests. By "performances" I mean not only the values of the horizontal and vertical speeds at various altitudes and at various throttles, but also the values of the forces acting on the controls at various regimes.

The tests would be carried on by the Technical Section of Aeronautics of the country of the aircraft manufacturers taking the initiative in this matter.

The Competition should be open to every one alike; to pessimists as well as optimists, but the latter should be obliged to use the test results of their laboratories on the model airplane.

The discussion contributed by Prof. Prandtl, Prof. von Karman and Col. Costanzi to W. Knight's article on "Standardization and Aerodynamics" has thrown some additional light on the subject.

Any further discussion on this matter giving the various points of view shall greatly help in formulating plans for organizing the proposed international Congress and with this end in view the present article was written.

STANDARDIZATION AND AERODYNAMICS.*

By Lieut. Col. Ing. R. Verduzio,
Director, Aeronautical Experimental Institute, Rome, Italy.

The article published by Wm. Knight, in the Aerial Age of June 20, on Standardization and Aerodynamics has given rise to a very interesting discussion on the part of European scientists interested in the progress of aerodynamics (see discussion by Prandtl, Aerial Age, January 21, 1922; discussion by Costanzi, Aerial Age, February 20, 1922; and discussion by W. Margoulis, Aerial Age, March 6, 1922); and I think it should be stated here the stand taken by the Italian Aeronautical Experimental Institute, about this matter.

If we consider the progress made by the heavier-than-air and the lighter-than-air aircrafts, we see that although the cycle has not been the same for both, the characteristic phenomena of this progress have been the same for both. In both cases, we have an initial state of uncertainty during which early experiments, not very conclusive, have been followed by a better organic conception of future experiments which have laid out the needed foundation of the technique for attaining the necessary progress.

When the thermodynamics and metallurgy both concurred in giving us a lighter and more powerful power plant, aeronautics entered a new era. The stage of uncertainty ended then and from that point on the progress made in aeronautics was both rapid and important. The airship and the airplane at that time became a practical reality. We had the necessary power for propelling them,

* From Aerial Age, April 3, 1922.

the theory of stability was sufficiently developed and we were able from that time on to design and build aircraft sufficiently strong and aerodynamically sound.

After this period of comparatively rapid progress, further progress has been made at a much slower space.

The problem of improving upon the flying machine as it is at present, is somewhat a harder problem for us today than it was the realization of the flying machine itself. At the present time we find that the fuselage of an airplane is of such a shape as it must be possessed by a body with good aerodynamical characteristics. This is also true of the wings. The aerial engine has also reached a stage of development where we cannot expect any revolutionary change in its design. Therefore, an increase in the efficiency of the flying machine can be obtained in the future only by making a thorough study of the aerodynamical phenomena taking place in flying so as to be able to introduce such slight changes that we might be able to make in the present designs which will allow an increase in efficiency. As far as the engine is concerned we are reduced to the point of needing to improve upon the auxiliary organs more than upon the engine itself in order to increase the efficiency of the power plant. In an airship we might try to improve upon the design of the gas bag, of the control planes, of the cables, and other attachments of the nacelle to the envelope and also improve upon the streamline shape of the nacelle itself. In an airplane we might try to reduce the air resistance of struts, landing gear and wings and investigate the interrelation existing between

changes made on each single part. For instance, in reducing the air resistance of a wing we keep in mind the fact that although a thinner wing offers less air resistance than a thicker wing, due to the fact that the thinner wing needs to be braced with struts and cables, the total aerodynamic efficiency of a thinner wing with its struts and cables is less than the efficiency of a thick wing without reinforcing members. Thus we see that monoplanes with thick wings are often to be preferred to biplanes needing struts and cables in their construction. In designing fuselages we improve the aerodynamical efficiency of them by enclosing in them both pilots and passengers.

In conclusion, the airplane designer at the present time has not a wide field from which to pick up improvements for his design. At the latest international aeronautical exhibition which took place recently in Paris, we have seen that the general lines of airplanes have remained the same as they were a few years ago. No revolutionary changes in design have appeared in the last few years. We therefore arrive at the conclusion that the cycle of evolution in the design of flying machines has reached now a stage when improvements must be looked for, not any more in the conception of the flying machine itself, but rather in the details inherent to the present design.

At the latest aeronautical international congress which took place in Paris, last November, the problem of what should be done in order to further the advance of aeronautics was such a problem that everybody felt rather keenly and when the discussion was open

about what is to be expected from aerodynamics as a science for contributing to the solution of the engineering problems involved in the design of airplanes, all the technical men agreed that the time had arrived for establishing a closer cooperation among themselves and their studies. France, Spain, Belgium and Italy, through their representatives, advised the desirability of arriving at an agreement about the standardization of the nomenclature used in the technical works.

As a representative of the Italian Aeronautical Engineering Association, as the Director of the Aeronautical Experimental Institute of Rome, and as a representative of the Aerodynamical and power plant section of the Polytechnic Institute of Turin, I brought to the attention of the second commission of the International Aeronautical Congress, that due to the initiative of Mr. Wm. Knight, while acting as Technical Assistant in Europe to the United States National Advisory Committee for Aeronautics, an exchange of views about the matter of cooperation among British, American, French, German and Italian laboratories had already been started about two years ago. One and one-half years ago, the British N.P.L. suggested a number of cooperative tests to be conducted on models in the various wind tunnels of those laboratories to which the invitations had been extended to participate in these tests. These tests being made for the purpose of determining how the results obtained in each wind tunnel would compare with results on tests on the same or equal models in other wind tunnels. The Aeronautical Experimental Institute accepted the invitation to participate in these tests

but since that time we have not heard any more from our British friends and the suggestion made by them has not been realized.

Besides, however, the need of obtaining a more intimate knowledge of the comparative value of the testing equipment used by the various aerodynamical laboratpries, we have very keenly felt the handicap as brought about by the lack of agreement between technical men of all countries not employing the same notations and symbols for expressing the results of their investigation in technical works.

The Department of Italian Aeronautics, in order to try to eliminate such a handicap, in a bulletin issued by the Experimental Division, suggested about one year ago, the adoption of a set of symbols and definitions, which since then has been revised and simplified and which, I suggested to the International Aeronautical Congress, could be taken as a basis for discussion in order to arrive at an agreement. In the ensuing discussion, Prof. R. Soreau made the remark that considering the fact that the various Aeronautical Laboratories represented there, were Government Institutions, it was not possible to arrive at any definite conclusion without the official intervention of the various Governments, but he suggested that the various technical men and directors of aeronautical laboratories, taking part in the discussion, should try to exchange their views on this matter and reach some sort of an agreement, and at the end of the Congress, a resolution could be adopted inviting the under-secretary of state of French Aeronautics to take the initiative in inviting representatives of the

departments of aeronautics of other countries to meet together for the purpose of agreeing on the standardization of aeronautical terms and characteristics. This suggestion as made by Prof. Soreau was heartily approved by the technical men and it was hoped by them that some such action as outlined by Prof. Soreau, would be taken before concluding the works of Congress. However, at the joint meeting of the various commissions when the conclusions of the second commission about this matter were presented and discussed upon, the resolution was adopted with a number of changes and modifications and one of the changes made was the suppression of the meeting of the technical representatives of Aeronautical laboratories, which had been recommended.

It is out of the question that the present state of affairs when all sorts of symbols, notations and graphical methods are used in technical publications, makes it very difficult for the designers of airplanes to make use of the experience gained by experimental works conducted in the various laboratories in Europe and the United States and which are expressed by technical men of the various countries in so different and sometimes so contradictory ways.

As we said before, progress in aeronautics at the present stage of development must be looked forward to improvements of details rather than in the change of the general conception of the design of the present flying machine. These improvements can quite noticeably increase the efficiency and the security in flight of the flying machine and this can be obtained by the unit-

ed efforts of all those who are engaged in the study of aeronautical problems; therefore, every effort should be made in making available to designers and other technical men, the results of the research work conducted in aeronautical laboratories without imposing on them the strain of memorizing symbols and definitions adopted by all the countries.

The initiative taken by Wm. Knight and the suggestion made by him of calling a congress of representatives of aeronautical laboratories and other scientific organizations interested in aeronautical problems, both in the United States and Europe for the purpose of agreeing on the standardization of terms, notations and graphical methods of representation which has already been endorsed by Prof. Prandtl and Prof. Karman and others is a very timely suggestion and as far as Italian aeronautics is concerned, we shall be very glad to cooperate in the realization of such plans, which we endorse unreservedly.

STANDARDIZATION AND AERODYNAMICS.*

By Dr. Ing. Richard Katzmayr,
Aerodynamical Laboratory of the Technischen Hochschule
of Wien, Austria.

With reference to the suggestion made by Wm. Knight in the Aerial Age, of June 20, 1921, for calling a congress of representatives of aeronautical laboratories in Europe and in the United States in order to arrive at an international agreement on the subject of wind-tunnel experimental work and standardization of aerodynamical terms and symbols used in aeronautical technical works, I wish to express the point of view of both Prof. Triz. Richard Knoller and myself on this subject.

After the very interesting discussion in the Aerial Age, by Prof. Prandtl (Oct. 3, 1921), by Prof. Karman (Jan. 22, 1922), by Col. Costanzi (Feb. 20, 1922), by Mr. Margoulis (March 6, 1922), and by Col. Verduzio (April 3, 1922), of Mr. Knight's article on "Standardization and Aerodynamics," I think it is well to state the stand taken on this matter by our laboratory.

In the issue of Aerial Age which appeared on October 3, 1921, Prof. L. Prandtl insisted on the absolute necessity of having an airstream of great constancy and freedom from eddies if wind-tunnel experiments are to have any practical value, and showed how such an ideal airstream can be obtained in practice. As a matter of fact, the wind-tunnel of the Aerodynamic Institute, at Göttingen happens to be one of the few that permit such excellent conditions, and it should not be difficult to build all future wind-tunnel installations to give equally good results, if Prof.

* From Aerial Age, May 8, 1922.

Prandtl's carefully-prepared specifications be closely adhered to. In the great majority of existing laboratories the airstreams that can be obtained with present apparatus are all but even, yet it would be uneconomical and too radical to consign them to the scrap-heap forthwith for that reason.

It would be of great value, however, if it were possible to compare without further question results obtained upon similar models in different laboratories, and this is quite within present possibilities. It would only require the testing of a number of standard bodies (such as spheres, fusiforms and one or two air-foils), for their aerodynamic characteristics in all the leading laboratories and to compare results. To insure accuracy and to prevent slight differences in the models that might affect their behavior under test, the same set of models should be used in each experiment, no matter where performed. The several results thus obtained could then be used to establish what we might call a "laboratory factor" or a constant which would express all those elements which are peculiar to the laboratory in question and which cannot be deduced mathematically, as turbulence, proportion of model to area of airstream and especially the influence of the means for fastening the model to the balance. It is not sufficient to test merely a sphere, as was suggested, as such investigations as have been made with wing models have given different results. At the present time a series of comparative tests is being made between the laboratories in Vienna and Göttingen and it is intended to send the models to all the other wind-tunnels in Germany to

obtain a better basis for comparison. It would be advisable to have this matter taken up by an international committee so as to include all the leading European and American institutions.

Attention should be called to the fact that for practical purposes it is not always advisable to employ a current that is totally free from eddies, such a condition is never prevailing in free flight. The degree of turbulence in the Vienna wind-tunnel happens to be such that the results therein obtained can be adopted without further correction, and several comparisons of full-sized aircraft with their models (usually in 1 : 15 ratio) have shown a remarkable correlation of the actual flight performance with the results calculated from wind-tunnel tests. It was noticed that an increase in turbulence has the same effect as the increasing of $\frac{v^1}{v}$, which fact is of importance to laboratories of small dimensions and comparatively slow airspeeds, which are thus enabled to give satisfactory results with lower cost of construction and maintenance. For purely theoretical measurements, however, an airstream without turbulence is essential.

Regarding the size of the models and the best airspeed to be used, it may be observed that the results obtained during the past ten years in the Vienna laboratory with a standard airfoil of 300 x 150 mm and in an airstream of 18 meters per sec have proven very satisfactory.

Of great importance is the correct fastening of the models in the airstream. They should be so secured that the flow around the model is not disturbed, and yet a very stiff and inflexible mounting

is essential. At Vienna this is obtained by means of four wires and a streamlined supporting rod 2.5 millimeters thick.

In Aerial Age of October 3d, Prof. Prandtl commented upon the advantages of reducing the airspeed to the equivalent expression for height $\frac{V^2 g}{2}$ as first proposed in 1914 by Prof. Knoller and adopted by all German laboratories since 1917. He also advocated the general introduction of absolute coefficients.

One of the most necessary tasks of such an international committee is the standardization of aerodynamic definitions and units. Without prejudice toward the labor of the future committee the most widely used expressions and their generally accepted meaning may be summarized here.

In Austria the following symbols have been decided upon:

$p = \frac{V^2}{2} g$ = Velocity pressure, dynamic air pressure, head.

v = resultant velocity, flight speed in meters per second or feet per second.

V = the same in KM per hour or M. per hour.

F = Wing surface or wing area.

R = Resistance.

A = Lift.

W = Drift.

N = Normal force.

T = Tangent force.

c_R, c_A, c_W = Unit air resistance, unit lift, unit drift, or absolute coefficient of res., lift or drift.

e = Center of pressure.

M = Ne = Torque.

E = Ratio $\frac{W}{A}$.

X = Angle of incidence.

The following is an exposition of the choice of the above symbols:

p stands for "velocity pressure," and is well nigh international (pressure in English, pression in French, pressung in German) being derived from the common Latin root premo (to push).

v and V for "velocity," derived from the Latin "velocitas."

F for surface, with reference to the English and French (sur)face and the German fläche, all of which are derived from "facies."

R was chosen for "resistance," a word identical in most languages; also stands for the German "resultierende" (resultant).

Hitherto R was resolved into its components L (Lift) and D (drift), corresponding to the French R_y and R_x and the German A and W, the assumption being that L is perpendicular and D parallel to the line of flight. To speak about "lift" in this sense, however, is not strictly correct, inasmuch as a strict interpretation of that word assumes a force that is vertical with respect to the horizon and is equal and opposite to gravity, which condition in actual flight is but seldom true. It would therefore be advisable to use another symbol in every language. Prof. Knoller proposes to replace "lift" by "shear" - as expressing more correctly the action of a force which is perpendicular to another force independently of the latter's direction in space. The word "shear" be-

ing an engineering term meaning a force acting perpendicularly to the grain of a given material (German for shear = "schubkraft"). S would be a better symbol in spite of the fact that the corresponding French word is "cisaillement."

The present symbol for drift or drag could be retained, and the present German expression (rucktrieb) could be replaced by "druck," meaning to pull, or pressure, and a mathematically more correct expression. D therefore fits all languages and should be retained. Another proposal made by the present writer would substitute Z and X for L and D. The advantage thereof lies in the internationally understood application and the fact that the resistance R is actually resolved into two components which are vertical only to each other and belong to a system of coordinates of which the X axis is parallel to the line of flight. The aerodynamic expert is already familiar with the practice of referring moments of stability to this system, the axes being assumed to be identical with the theoretical axes of the machine itself.

The symbols N for normal force and T for tangent force are internationally self evident and require no explanation.

As Mr. Knight has observed, the greatest difficulty is encountered with the expressions $^{c}R, ^{c}A, ^{c}W$. In Germany and Austria they stand for dimensionless or "absolute" coefficients, which are obtained by dividing the forces R, A, W by the area F and the pressure p, as given by the equations $R = {}^{c}R\ F\ p$, $A = {}^{c}A\ F\ p$, and $W = {}^{c}W\ F\ p$. To express these quantities as "unit forces" is better, it being generally easier to understand a mathematical formula when every factor

stands for a definite and concrete entity rather than a purely philosophic concept. After all ^{c}R, ^{c}A, ^{c}W are "forces" in the accepted sense, for they express a weight in kilograms which would act on a one square meter of surface under a dynamic pressure of 1 millimeter hydrostatic pressure. To write with a small $(^{c})$ immediately conveys the impression that a coefficient is expressed, and writing it <u>before</u> the symbol prevents misunderstanding with exponents. This method of writing instantly indicates what force the coefficient refers to and is therefore easier to read than either the English (k_L, k_D) the French (k_x, k_y) or the German (C_a, C_w) in all of which the stress is laid on the quantity as a "coefficient" and the force that it refers to is merely indicated by a small letter below. To avoid every mistake it should be noted that

$$^{c}A = 200\ k_L = 1600\ k_y = C_a$$

In addition in Austria the following symbols have been accepted: ^{s}A for "specific lift" as per the expression $A = {}^{s}Ap$ and ^{r}A for "reduced lift" as per the formula $A = {}^{r}A\ F$. These expressions have been found very useful. Of course the prefixes s and r have international significance in this respect.

The symbol e to indicate the distance of the center of pressure from the upper airfoil surface has been in use in Germany and Austria for over ten years with good results. In other countries this quantity is seldom made use of. Whether e is the best symbol for this expression is a matter that should be decided by the committee.

M as an expression for torque is a well known symbol in mechanics, and it is advisable to retain it for that reason. Mathematically $M = N \times e$ and since N is nearly equal to A the expression $M = A \times e$ can be safely used for approximations. In Austria the special symbol ${}^{a}M = A \times e$ has been adopted.

Just as we have units of force we can have a "unit of torque" - also an abstract coefficient. For its expression ${}^{c}M$ has been devised with its corollary ${}^{ca}M$. We can, therefore, write

$$M = {}^{c}M \times F \times p \times t \text{ and } {}^{a}M = {}^{ca}M \times F \times p \times t$$

in which "t" is the chord.

Σ expresses in Germany the ratio $\frac{W}{A}$ and α the angle of incidence. Whether these symbols should be internationalized is fit subject for discussion.

Regarding the graphic representation of test results it may be observed that the Vienna laboratory conforms itself to the standards prevalent throughout Germany.

It would be very desirable to come to some international agreement regarding the unification and standardization of aerodynamical expressions, and we hope that Mr. Knight will succeed in eliminating such objections as still, perhaps, exist, toward the satisfactory solution of this important matter.

STANDARDIZATION AND AERODYNAMICS.*

By E. B. Wolff,
Director, Rijks-Studienst voor de Luchtvaart, Amsterdam, Nederland.

The discussion brought up by William Knight in the Aerial Age of June 20, 1921, on "Standardization and Aerodynamics" has given rise to a very interesting expression of the views on this subject of the most important aerodynamical laboratories in Europe (see previous issues of Aerial Age, article by Prof. Prandtl, October 3, 1921; article by Prof. von Karman, January 2, 1922; article by Colf Costanzi, February 20, 1922; article by W. Margoulis, March 6, 1922; article by Col. Verduzio, April 3, 1922; and article by Dr. Katzmayr, May 8, 1922). I think I should state what is the stand taken by the Rijks-Studiedienst voor de Luchtvaart on the matter of Standardization of graphical methods of representation of results of tests made in aerodynamical laboratories, standardization of symbols and coefficients used in technical aeronautical publications in various countries, etc.

The desirability of reaching an international agreement on this very important matter, as suggested by Wm. Knight, has already been voiced in the Aerial Age by eminent scientists and aeronautical experts and, in my estimation, as well as in the estimation of Dr. C. Koning and Dr. A. G. Baumbauer of the Section for Aerodynamical Tests of our Institute, we must express our solidarity with the idea of international scientific cooperation in aeronautics which has been championed by Wm. Knight, with whom we

From Aerial Age, June 19, 1922.

have already discussed several times this matter during the last few years while he was the Technical Assistant in Europe to the U. S. National Advisory Committee for Aeronautics.

It seems to us that it should not be difficult to come to an agreement on this point, as the importance of standardization in aerodynamics will be granted by all aerodynamical experts and the change from the system originally used by a laboratory to the one that will be adopted as the international standard system will not offer serious difficulties. Moreover, a discussion on these questions may be a welcome introduction to further international cooperation and understanding. An aerodynamical coefficient which stands at the present time in great need of standardization is the coefficient vl (Reynolds number) for model tests. Considering the diameter and the maximum velocity of the existing wind tunnels, it would perhaps be possible to divide them in groups, each group making routine-tests at the same value of vl (such as tests on wing sections and airplane-models) in order to make the results of these tests comparable with each other, without any corrections for scale-effect.

Table 1.

Wind Tunnel	V in M/sec	D in M	VD in M2/sec
N.P.L. 4 ft.	15	1.22	18.3
N.P.L. 3 ft.	21	0.91	19.1
Massachusetts Institute of Technology	29	1.22	35.4
N.P.L. 7 ft. Nr.1	20	2.13	42.6
N.P.L. 7 ft. Nr.2	26	2.13	55.4
Rijks-Studiedienst voor de Luchtvaart (Holland)	35	1.60	56.0
Eiffel (Auteuil)	30	2.00	60.0

Table 1 (Cont.)

Wind Tunnel	V in M/sec	D in M	VD in M2/sec
Tokio (Marine)	30	2.00	60.0
Saint Cyr	40	2.00	80.0
McCook Field	235	0.36	84.6
Istituto Sperimentale de Aeronautica (Rome)	50	2.00	100.0
Göttingen	50	2.24	112.0
Luftschiffbau Zeppelin	50	3.00	150.0
Dayton	67	2.50	167.5

In Table 1 the values of V (maximum velocity) in meters per second, those of D (diameter or side of the square of the working portion) in meters, and the product VD are tabulated for some of the existing wind tunnels. The product VD is the deciding factor of the maximum value of $v\,l$ at which tests can be made. This table shows that there are a number of wind tunnels for which the values of VD show only small differences.

Comparative tests in the different wind tunnels is another important aspect of the proposed international cooperation.

Although we have at the time joined Wm. Knight in his effort to bring about a comparison of results of model tests on standard-models in different laboratories, we should like to point out some difficulties which will perhaps make it desirable to introduce some slight changes in the comparative tests program now under consideration when one or two models are successively tested in the wind tunnels of different laboratories, as has been proposed values found for the lift, drag, etc., will not be the same. The question will then arise, What is the reason for the differences and which value must be considered as the true one?

The differences found may be caused by the following factors, which can be arranged under threemain headings:

First, there are errors caused by the method of measurement of the forces. Here we must mention the interference of suspension members with the flow past the model, and the correction needed for the forces acting on the parts of the weighing apparatus projecting into the wind stream, and also errors of the weighing apparatus itself and errors due to the instruments used for measuring the air velocity.

Second, the influence of the boundaries of the airstream upon the results.

Third, the differences which are due to the nature of the airstream itself - irregularities of the velocity of the airstream in different parts of the cross-section and in regard to time, turbulence of every kind and variations of static pressure. It seems to us that it would be greatly desirable to separate errors caused by these three groups of causes in order to reach a sound comparison of wind tunnel characteristics, and this can be done by pursuing the following experimental program:

1. Experiments on the different methods of suspension of models and a critical study of the different kinds of weighing mechanisms and velocity measuring devices used by the various laboratories.

2. Experiments and theoretical investigation of the influence of the finite dimensions of the airstream.

3. Experiments on the influence of irregularities of the flow and of turbulence around different kinds of models.

4. A thorough exploration of the airstream of the wind tunnels as to turbulence, regularity of the velocity and variation in static pressure.

The experiments listed under 1, 2 and 3 need not be carried through in every wind tunnel. This part of the work can be done by laboratories, which are best fitted for this work and dispose of differentewind tunnels so that their ordinary work is not too much retarded by these long systematic tests. Some of this work has already been done.* Only the experiments mentioned under 4 need to be done in every existing wind tunnel.

The results of a comparison of this kind will be that an intimate knowledge will become available of the inherent quality of the airstream of each laboratory. When, from the tests grouped above under 1, 2 and 3, we shall have learned the influence of the different factors upon the results of the tests, it will be possible to draw conclusions about the exact meaning of such tests.

A program, as set forth above, will necessarily take a great deal of time; but it seems to us that such a program would not be too much of a burden on the laboratories and would lead to a knowledge of the actual conditions under which research work is carried which will be of great help to the progress of the scientific end of aeronautics.

However, it is desirable to have without further delay some preliminary base of comparison, and for this reason the adoption of a preliminary limited program of investigation as suggested by Wm. Knight would be acceptable to us.

The superintendent of the aerodynamical section of the National Physical Laboratory in Teddington informed us that he is actually experimenting on some models prior to the circulating of them through the different laboratories which are willing to make the necessary experiments, and we are awaiting with interest the materialization of this preliminary form of international cooperation in scientific work, which we hope will become more intimate and effective as time goes on.

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* See articles:

On the influence of the suspension parts:

Robert - Utilisation des resultats des essais. Rapports du Premier Congres International de la Navigation Aerienne. Vol. I, p. 1.

Preliminary experiments of the effect on the experimental results of the method of suspending the model in aerodynamic measurements. Verslagen en Verhandelingen van den Ryks-Studiedienst voor de Luchtvaart, Amsterdam. Vol. I, p. 54.

Irving, H.B., and Jones, C. N. - Note on the form and resistance of the spindle used by the N.P.L. for standard tests of 18" x 3" airfoils. R&M 418. Advisory Committee for Aeronautics.

On weighing mechanisms:

Warner, E. P., and Norton, F. H. - Wind tunnel balances. Report No. 72. National Advisory Committee for Aeronautics.

On the influence of the boundaries of the airstream:

Prandtl, L. - Tragflügeltheorie II. Nachr. von der Kön. Ges. d. Wissensch. zu Göttingen, p. 123.

Prandtl, L. - Applications of modern hydrodynamics to aeronautics. Report 116. National Advisory Committee for Aeronautics, p. 51.

On the influence of turbulence:

Wieselberger, C. - Der Luftwiderstand von Kugelen. Zeitschrift Flugt. u. Motorluftsch. f. 1914, p. 140.

Relf, E. F., and Lavender, T. - The effect of upwind disturbances in the air current of the channel upon the forces on models, with special reference to the effect on the drag of an airship model. R&M 597. Advisory Committee for Aeronautics.

On the influence of the fall of static pressure:

Horizontal buoyancy in wind tunnels. Technical Note No. 23. National Advisory Committee for Aeronautics.

** Part of this work has been done, too, we have published our results regarding velocity distribution in the wind tunnel of the Ryks-Studiedienst voor de Luchtvaart: "Verslagen en Verhandelingen van den Ryks-Studiedienst voor de Luchtvaart," Vol. I, 1921, p. 11. We presume that a great deal of unpublished results obtained in other tunnels could be collected.

STANDARDIZATION AND AERODYNAMICS.

By Dr. A. F. Zahm,
In Charge of Aerodynamical Laboratory,
Bureau of Construction and Repair, U. S. N.

With further reference to the article on "Standardization and Aerodynamics," published by William Knight in the Aerial Age of June,20;31921, and the subsequent discussion in the Aerial Age of the suggestions therein contained, as contributed by Prof. Prandtl (October 3, 1921), Prof. von Karman (January 2, 1922), Col. Costanzi (February 20, 1922), W. Margoulis (March 6, 1922), Col. Verduzio (April 3, 1922), Dr. Katzmayr (May 8, 1922), Dr. Wolff (June 19, 1922), regarding the comparison of methods of aerodynamic measurement and expression, I should say that it would now be opportune to have a representative committee appointed to formulate a program for such work.

The inclusion of a very great number of laboratories in the comparative tests does not seem advisable at the beginning. If a few of the foremost ones, testing not too difficult models, can obtain identical results, a good start will have been made. Such tests already are in progress in this country and elsewhere, but without a common plan of attack, and without a common formulated theory to furnish guidance and precaution.

The experimental program should be at least as comprehensive as the one proposed by Dr. E. B. Wolff, in the Aerial Age Weekly for June,19;31922. An accurate exploration of the air stream, before the insertion of the model and during the test, should es-

* From Aerial Age, September, 1922.

pecially not be overlooked by the experimentalists. In two papers published by the National Advisory Committee for Aeronautics*, I emphasized this feature when the Committee was working on its program for comparative wind tunnel tests.

The most direct way to study accurately and convincingly the correction to be made for Reynolds number vl/D, in applying model data to aircraft, would be to insert the full-scale craft in a wind tunnel of suitable size. A fully equipped airplane, for example, could easily be supported on a wire balance in such a tunnel, and given a comprehensive test when in natural working condition, including its power plant and observers.

Such a tunnel should have a throat measuring in cross-section rather more than 10 x 20 meters, and maintain a uniform air stream at 10 to 30 or more meters per second. The propulsive system required to maintain such a stream, at 100% efficiency, would be of slightly less than 170 metric horsepower for 10 meters a second, and roughly 4500 horsepower for 30 meters per second. A tunnel of 5000 or more horsepower might well be recommended.

The first cost of such a tunnel would be of the same order as that of the largest airship shed or astronomical observatory. The cost of operating with very high speeds could be limited by choosing a site near the cheapest source of power. The cost does not seem to be prohibitive either to a nation or to a wealthy patron of science.

The question now raised is as to the value to aeronautics of

* Report No. 139 - Influence of Model Surface and Airflow Texture on Resistance of Aerodynamic Bodies.
Note No. 23 - Horizontal Buoyancy in Wind Tunnels.

a full-scale wind tunnel for both absolute and comparative tests. If it be considered very desirable, the representatives of aerodynamics might do well to indicate its advantages. For if the tunnel should appear to be of sufficient importance, the planning and paying for it would perhaps not offer very formidable difficulties. One on a continent would suffice for the present. Various engineers with whom I have discussed the need for a full-scale tunnel are of the opinion that it would be more useful to mankind than another great astronomical observatory, or mammoth airship shed. In fact a large airship shed might be used as the housing for such a tunnel till its permanent value could be ascertained.

A full-scale tunnel would have some obvious advantages. It would furnish a uniform wind throughout the year, irrespective of weather or season. Models and full-scale craft or parts thereof, whether inherently stable or unstable, could be held steady at any attitude to the wind undisturbed by gravity or gusts. The measurements of forces, moments, pressure distributions, flow distributions, could be made under constant conditions and with stationary instruments. Similar models varying greatly in size could be used, thus enlarging the range of vl/D. The effect of varying the surface texture, or structural details of full-scale craft, and the effect of ageing and distortion, could be studied. Laws of comparison between models and full-scale craft could be more exactly established when needed, and in some cases dispensed with by putting the actual ships to direct test.

If an international committee is to consider methods of ex-

perimentation, laws of comparison, and forms of expression, it might well include within its scope not only the work of ordinary wind tunnels but also that of a compressed air tunnel, a full-scale tunnel if possible, and actual flight tests.

STANDARDIZATION AND AERODYNAMICS.*

By William Knight, M.E.

On June 20, 1921, I published an article in the Aerial Age under the title "Standardization and Aerodynamics" in which the suggestion was made of the desirability of calling a congress of representatives of leading aerodynamic laboratories, without any discrimination between former allies and former enemies, for the purpose of arriving at an understanding as to the coordination of laboratory work in aerodynamics leading to a better utilization of scientific research knowledge in aeronautics in the interest of all concerned in this matter.

In that article I presented a number of suggestions contained in a report of mine to the National Advisory Committee for Aeronautics which I had submitted to that organization in 1919 while I was representing that Committee in Europe.

The suggestions contained in that report can be summarized as follows:-

The appointed task of the proposed Congress of representatives of aeronautical laboratories and other aeronautical technical and scientific organizations should be:-

1st - To agree on a number of tests to be made in existing wind tunnels both in this country and in Europe on some standard model, or models, with a view of determining the influence of local conditions prevailing in each wind tunnel (method of attachment of the model to the forces measuring device, dimensions of model as compar-

* From Aerial Age, December, 1922.

ed to the dimensions of the wind channel, state of turbulence of the airflow, etc.) and the necessary corrections to introduce into the calculations of the results obtained in each wind tunnel on the same model in order to bring such results in line with those obtained in other wind tunnels.

At present such a divergency exists between experimental results obtained in various wind tunnels, when no such divergency should exist, that the confidence of aircraft manufacturers and designers in the usefulness of wind tunnel research work is badly shaken. Such a dangerous situation could be corrected with the organized cooperation of scientists and technical men engaged in research work in aeronautics who know better than anybody else where the trouble is to be found and who, furthermore, are eager to cooperate with each other, if the initiative is taken by some responsible party in calling a truly international congress of representatives of aeronautical scientific organizations for the purpose of investigating the causes of the trouble and finding the remedy.

2nd - The proposed Congress of Aeronautical Experts should take up the matter of definitions, symbols and graphical methods used in aeronautical reports, books and other publications which at the present time, in the absence of any uniform standard accepted and adopted by leading scientists and aeronautical organizations, same as are adopted in statics, dynamics and in the art of applied engineering, (as for instance in the testing of materials) follow the line of thought of some particular group of technical men with-

out any reference to the symbols, the terminology and the graphical methods of representation used by other groups of technical men in other countries. Here again we are confronted with the fact that scientific and technical aeronautical reports and publications have no other excuse for being edited than their usefulness in facilitating the task of aircraft designers and manufacturers in designing and manufacturing better aircraft.

It is already bad enough that the people of the world do not talk the same language, if we add to this the self-imposed handicap of a different scientific language spoken in each country in aeronautical publications, I do not see how we are going to be fully benefitted by the efforts made by scientists and technical men all over the world who are trying to perfect for us a new means of transportation which will have a tremendous influence on the progress of this civilization of ours.

We cannot too strongly insist on the fact that when in reading a report we are stopped either by the meaning of a symbol or by the value of a coefficient it is impossible to follow the sequence of ideas and the report is usually thrown aside.

The proposed congress can remedy such a state of things if the matter is approached in a true spirit of international cooperation in the scientific and technical progress of aeronautics, by adopting some fundamental standards which, without any doubt, would be accepted by technical writers all over the world.

How the Discussion on Standardization Started.

The suggestion contained in my article of June 20, 1919, in the Aerial Age, gave rise to a very interesting discussion in that review which was contributed by leading aeronautical authorities and, furthermore, it found an echo in the First International Congress of Aerial Navigation and in an informal congress of leading scientists and technical men which was recently held at Innsbruck (Tyrol).

Considering the great importance of the subject and the urgent need of arriving at a practical conclusion of the very regrettable state of affairs prevailing at present in the technical and scientific field of aeronautical work, due to the delay in calling the proposed congress of representatives of leading aeronautical laboratories, scientists and technical men engaged in aeronautical research work in every country, a little history of the case and a resume of the opinions expressed by leading aeronautical authorities on this matter shall be probably helpful.

In May, 1919, I was appointed Technical Assistant in Europe to the National Advisory Committee for Aeronautics for the purpose of establishing the promotion of a prompt and cordial exchange of scientific and technical data and information on research and experimental work in aeronautics and sciences thereto allied between the United States on the one hand and the Governments, private institutions and individuals in Europe on the other hand.

In October, 1919, in a report to the National Advisory Committee for Aeronautics prepared by W. Margoulis, former director of the

Eiffel Aeronautical Laboratory, and at that time my assistant in Paris and Aerodynamical expert of the Paris office of the Committee, the need for the inauguration of a cordial spirit of cooperation between the various leading scientists and organizations doing research work in aeronautics both in Europe and in the United States was pointed out, and the suggestion was made that the Committee should take the initiative in organizing a congress of representatives of aeronautical laboratories to be held in Paris for the purpose of arriving at a mutually satisfactory agreement on the means to be devised for obtaining:-

1st - More reliable results in wind tunnel experimental work, based on a better knowledge of existing conditions in each wind tunnel,

2nd - the adoption of uniform fundamental symbols and definitions in aeronautical reports and publications,

3rd - the adoption of standard graphical methods of representation of ordinary test results so as to facilitate the comparison of results obtained in various countries,

4th - the adoption of a standard method of classification and indexing of aeronautical publications so as to facilitate research work.

The National Advisory Committee for Aeronautics approved all of the above suggestions with the exception, however, that, considering the fact that the British Advisory Committee for Aeronautics had contributed during the war a good deal more than the corresponding American Committee to the advancement of aeronautics, it was deemed

desirable that the initiative in originating a move such as I had suggested would be taken by the British rather than by ourselves.

Accordingly I took up the matter with the British Advisory Committee for Aeronautics and communicated to them the views of the N.A.C.A. on this matter.

In 1920, an invitation was issued by the British Advisory Committee for Aeronautics to our own Committee and to the leading aeronautical laboratories in France, Holland and Italy to conduct a number of comparative tests in their various wind tunnels on the same model - No invitation was issued to German and Austrian laboratories to participate in these tests, and no provision was made for agreeing on the unification of symbols, definitions, graphical methods, etc.

In June, 1921, I resigned my position as Technical Assistant in Europe to the National Advisory Committee for Aeronautics, and I published in the Aerial Age under the title "Standardization and Aerodynamics" the suggestions contained in my earlier report to that Committee regarding the organization of a Congress of representatives of aeronautical laboratories both in Europe and in the United States. Since that time the following comments have been expressed in the technical press and elsewhere on this subject:-

German Comments.

Prof. L. Prandtl, Director of the Aerodynamical Laboratory of the University of Göttingen, Germany, and one of the foremost German scientists who has greatly contributed to the present stage of development of Aerodynamics, approves of the idea of calling the pro-

posed congress, which, however, he suggests should be preceded by an exchange of views by correspondence between those participating in the congress, so as to prepare the ground for a quick settlement of the various points involved. He offers a number of valuable suggestions as to the way comparative tests should be made in the various wind tunnels in order to bring about a better agreement between testing results obtained in various countries.

Dr. Ing. W. Hoff, Director of the Deutsche Versuchsanstalt für Luftfahrt at Adlershof, Germany, in a letter addressed to me, endorsed Prof. Prandtl's comments and suggestions.

Prof. von Karman, Director of the Aerodynamical Laboratory of Aachen, Germany, points out the important need of reaching an agreement on the matter of standardization of symbols, coefficients and methods of measurement of airspeed in wind tunnels. He points out the many objectionable features of the present state of things which is fraught with danger to the science of Aerodynamics - he thinks that an international aeronautical association organized along the same lines as the International Society for Testing Materials would provide a very good permanent medium of exchange of views between scientists of all nations in the interest of Standardization - he approves of the idea of calling a congress of representatives of aeronautical laboratories which he suggests should be instrumental in laying the foundation of a permanent International Scientific Aeronautical Association. (Aerial Age, January 2, 1922).

Italian Comments.

Col. Ing. G. Costanzi, former Director of the Royal Aircraft Establishment in Rome, Italy, who during and after the war was the representative of the Italian Air Service to the Supreme War Council in Versailles, and the technical representative of Italy to the permanent Interallied Aeronautical Commission in Paris, approves unreservedly the calling of the Congress and the suggested matter to lay before the Congress for discussion. He emphasizes the necessity of putting a stop to the prevailing lack of agreement between experimental results obtained in various laboratories. He also states that it would be unconceivable to reach any agreement in this matter without inviting the representatives of German Aeronautical Laboratories to the proposed Congress which, in his estimation, should be held in Germany, where aeronautical works of the highest order of both scientific and practical importance have been originated in the last few years (Aerial Age, February 20, 1922).

Lieut. Col. Ing. R. Verduzio, Director of the Aeronautical Experimental Institute in Rome, Italy, considers the suggestion as a timely one, approves the program laid out for the Congress and states that Italian Aeronautical Services shall be very glad to cooperate to its realization (Aerial Age, April 3, 1922).

Lieut. Col. A. Guidoni, Aeronautical Attaché to the Italian Embassy in Washington, and a well known authority in aeronautics, suggests in a letter to the writer that the matter of the adoption of the metric system in aeronautical measurements should be taken up by the Congress in connection with the matter of Standardization of

of Symbols. He points out that the Interallied Aeronautical Committee had already started a very important work of Standardization which could be taken as a basis for further expansion by the proposed Congress.

French Comments.

W. Margoulis, former Director of Eiffel Laboratory, Paris, France, discussing the tests suggested by the British Advisory Committee for Aeronautics, points out that comparative tests in wind tunnels, in order to serve the purpose for which he originally suggested them, must be both numerous and systematic in order that, as a whole, they may characterize the airflow in each wind tunnel. The tests suggested by the British Advisory Committee for Aeronautics are to be made on a model of streamline body supplied by the National Physical Laboratory and successively tested in the various laboratories in England, France, Holland, Italy, and the United States. Mr. Margoulis points out that in October, 1920, in a paper read by him at one of the monthly meetings organized in Paris by himself and the writer for the discussion of Aeronautical problems (and which was published in the "Technical Review of Aeronautical Works" issued by the Paris office of the National Advisory Committee for Aeronautics) he suggested that comparative tests in wind tunnels, in order to be effective, must include tests on spheres, cylinders and streamline bodies of different dimensions and aspect ratio, tested at all available speeds in each wind tunnel and also in the open air on the aerodynamical truck of the St. Cyr Institute, so as to supply a much needed knowledge of free

flight tests of models as compared to wind tunnel tests of the same models. (Aerial Age, March 6, 1922).

Austrian Comments.

Dr. Ing. Richard Katzmayr, and Prof. Ing. Richard Knoller, of the Aerodynamical Laboratory of the Technischen Hochschule of Wien, Austria, both agree on the urgent need of calling an International Congress of representatives of Aeronautical Laboratories and suggest preliminary comparative tests in wind tunnels of various countries on standard bodies such as spheres, streamline bodies and one or two airfoils, the same models to be successively tested in the various wind tunnels. These preliminary tests to be made for the purpose of determining what the writers call a "laboratory factor" or a constant expressing all those elements which are peculiar to each wind tunnel and which cannot be deduced mathematically, such as: turbulence of the airstream, ratio between dimensions of model and dimensions of working section of wind tunnel and, especially, the influence of the method of fastening the model to the balance.

Prof. Knoller and Dr. Katzmayr also state that one of the most important tasks of the proposed congress should be the standardization of symbols and definitions used in aerodynamics and make suggestions along this line. Prof. Knoller as early as the year 1914 suggested the adoption of absolute units in fundamental formulas used in aerodynamics - as to the unification of methods of graphical representation it is pointed out that both in Germany and Austria the same methods are used. (Aerial Age, May 8, 1922).

Dutch Comments.

Dr. E. B. Wolff, Director, Dr. C. Koning and Dr. A. G. Baumbauer in charge of the aerodynamical tests at the Aerodynamical Institute of Amsterdam (Rijks-Studiedienst voor de Luchtvaart), entirely agree on the necessity of calling the proposed congress and unreservedly approve of the suggested program of activities of such congress. On the matter of comparative wind tunnel tests, they agree on the preliminary limited program suggested by myself but they suggest an additional number of systematic tests to be undertaken by only a few of the most up-to-date laboratories in order to separate the causes of errors in wind tunnel experimental work as due to: the method of measuring forces, the influence of the boundaries of the air stream and the nature of the air stream itself. This last cause of error, which includes: irregularities of the air velocity at different points of the cross section of the wind tunnel in regard to time, turbulence of every kind and variation of static pressure, however, should be investigated quite thoroughly in every wind tunnel (Aerial Age, June, 1922).

American Comments.

Dr. A. F. Zahm of the Aerodynamical Laboratory, Bureau of Construction and Repair, U. S. Navy, believes that the inclusion of a very great number of laboratories in the comparative tests is not advisable at the beginning, but he is certainly in favor of making these tests in the most important aerodynamical laboratories and he points out that in order to bring about the desired results,

the experimental program adopted should be at least as comprehensive as the one suggested by Dr. E. B. Wolff in the Aerial Age of June 19, 1922, and should be followed up in accordance with a common plan of attack and with a common formulated theory to furnish guidance and precaution. In two papers published by the National Advisory Committee for Aeronautics (Note No. 23 and Report No. 139) Dr. Zahm had emphasized this feature when the committee was working on its program of comparative wind tunnel tests which we will mention later on. He also believes that the most direct way to study accurately and convincingly the correction to be made for Reynolds numbers in applying model data to aircraft, would be to insert the full scale craft in a wind tunnel of suitable size and he suggests the building of a wind tunnel 10 meters in diameter by 20 meters long at the throat providing a wind stream of 10 to 30 meters per second and requiring about 5000 horsepower. In his opinion, such a wind tunnel would be more useful to aeronautics than anything else at the present time. (Aerial Age, September, 1922).

In connection with Dr. Zahm's remarks on the usefulness of a large wind tunnel allowing aerodynamical tests on full size aircraft I might mention here that a complete project of a wind tunnel of the same dimensions and requiring the same power as the one mentioned by Dr. Zahm was prepared by Mr. W. Margoulis for the Belgian Government and was transmitted by myself to the National Advisory Committee for Aeronautics in 1920, strongly recommending that it should be taken under consideration. Also, in 1920, a project of a compression wind tunnel (this project also by Mr. Margoulis) was

submitted to the Committee by my office in Paris and eventually the tunnel has now been built at Langley Field and shall probably prove to be a very useful testing device, without however detracting any from the very practical (although rather costly) usefulness of a large wind tunnel allowing making tests on full scale aircraft.

The National Advisory Committee for Aeronautics, replying to a letter of mine of last May requesting a statement of the present views of the Committee on the matter of the Congress of representatives of Aeronautical Laboratories which I suggested to them in 1919, makes the following statements:-

(1) "The standard tests mentioned by the British Aeronautical Research Committee are entirely separate from the tests that we have outlined for the wind tunnels of this country. There is, however, a connection between the work of our Committee and the Canadian Air Board and it is contemplated that the models for test in wind tunnels prepared by the Aeronautical Research Committee will be forwarded to our Committee by the Canadian Air Board, after they have been tested in the wind tunnels in Canada. By the same arrangement we will forward the models prepared by this Committee to the Canadian Air Board, and it is contemplated that when the tests of models are made in all the wind tunnels in this country, the models will be sent to Europe after tests have been conducted in Canada.

(2) The aerodynamic laboratories of Germany and Austria were not excluded from the general list where it is proposed to have the models tested outside of the United States.

(3) The Committee is very sympathetic in regard to reaching an

understanding with all countries for the standardization of symbols and methods of graphical representation used in aerodynamics.

(4) The Committee is not willing to take the initiative in the forming of an International Congress for the Standardization of aerodynamics. Such a congress must of necessity be international in scope and it would be impossible for the Committee to have an official representative there, as the United States Congress does not look with favor upon the United States being officially represented at any international conference. We would, however, have a representative present who will probably join in the discussion but would not have the official standing necessary to vote."

British Comments.

The British Aeronautical Research Committee answering a letter of mine requesting a statement of their point of view in the matter of the proposed Congress, writes to me:-

"Your letter of March 28th was brought to the attention of the Research Committee at their meeting of April 11, 1922. They were interested to learn of the steps that had been taken to provide a preliminary exchange of views between a number of experts who had communicated articles in the Aerial Age but they do not consider that the time is yet come for the proposed congress of representatives of aeronautical research laboratories. Perhaps the best step that could be taken to coordinate the work of these different laboratories has already been projected, since the international trials on certain models have commenced and the models are en route to the

various laboratories approached by the British Aeronautical Research Committee. It seems doubtful whether any additional advantage can be obtained in calling together, at a great expense, a congress of the proposed nature, since at present there is only a relatively small quantity of research work on aerodynamics being carried out throughout the world, and the best means of coordinating work already published arises with the collection of results of tests by the various laboratories on the same models, and this is in hand.

We are not at present aware of what steps have been taken to coordinate the standardization of aeronautical terms and symbols. Some years ago, the Royal Aeronautical Society prepared a glossary of aeronautical terms, and later the American authorities prepared a similar glossary. These agree in most respects. Since that date, the French authorities have translated the English glossary and are, we understand, in touch with the British Engineering Standards Association with reference to the new revision of the old glossary, which is being prepared by this Association in cooperation with the Royal Aeronautical Society, the Air Ministry, the Aeronautical Research Committee and other technical aeronautical bodies in this country."

Comments Made at the First International Congress of Aerial Navigation.

At the First International Congress of Aerial Navigation held in Paris in November, 1921, the matter of international cooperation in systematizing wind tunnel work leading to the adoption of uniform fundamental symbols and definitions was the object of a lively discussion contributed by representatives of French, Italian, Dutch,

Spanish, and other European aeronautical laboratories. American and British laboratories were conspicuously absent at this First International Congress of Aerial Navigation and German Laboratories were not allowed to join.

Mr. Herrera, Director of the Aerodynamic Laboratory of Madrid, Spain, at one of the meetings of the Technical Committee of the First International Congress of Aerial Navigation suggested the organization of an "International Union of Aerodynamic Laboratories" headed by one laboratory (he suggested the Eiffel Laboratory) which should formulate a program of comparative tests on a number of models. According to Mr. Herrera, the same set of models should be successively tested in the various laboratories, following the particular method of experimentation of the laboratory making the tests. After the tests have been completed in all laboratories, the results should be compared and, from the results of such a comparison, enough data should be available as to allow of the adoption of uniform coefficient and the standardization of methods of future experimental work in wind tunnels. (Frankly, we fail to see that the matter is so simple as Mr. Herrera seems to think). Mr. Herrera also suggested that this work should be planned for by the one laboratory representing the proposed International Union of Aerodynamic Laboratories and be carried through by the various laboratories under the supervision of this super-directing laboratory (the Eiffel laboratory).

Prof. Soreau, Vice President of the Aero Club of France, and Chairman of the Technical Committee of the First International Con-

gress of Aerial Navigation, objects to Mr. Herrera's suggestions for two reasons: 1st - because he does not see that it is possible to establish a supergovernment of aerodynamical laboratories as suggested by Mr. Herrera and, 2nd - because in order to compare the the results obtained in two laboratories it is essential that the conditions under which experiments are made be the same, therefore, it seemed to him that the proper thing to do would be to adopt first uniform methods of experimentation (as for instance the same method of attaching the model to the balance) and then make the tests, rather than doing the reverse as Mr. Herrera suggested.

Dr. E. B. Wolff, Director of the Aerodynamical Laboratory of Amsterdam, Holland, referring to his correspondence with the National Advisory Committee for Aeronautics and the British Aeronautical Research Committee regarding the proposed comparative wind tunnel tests, states that after receiving the invitation to participate in the tests suggested by the British Aeronautical Research Committee he has not heard any more about this matter. He suggests that something should be done, without any further delay in order to start the proposed comparative tests on the same models in the various tunnels.

Mr. Louis Breguet, French Aircraft Designer and Manufacturer, endorses the suggestion made by Mr. Herrera and by Dr. Wolff and suggests the appointment of a committee charged to make definite suggestions leading to the standardization of methods of experimentation in wind tunnels and to the standardization symbols used in aeronautical works.

Mr. W. Margoulis reports to the congress the initiative taken by himself and by myself in 1919 in order to bring about the proposed comparative tests. He deplores that the British Aeronautical Research Committee has not gone any further in the realization of its test program than issuing an invitation to participate in some comparative tests on a model prepared by that committee, which, however, has never been sent to the various laboratories to which the invitation was issued.

Prof. Soreau, chairman, answering Mr. Margoulis's remarks regarding our unsuccessful efforts in 1919 to try to induce the National Advisory Committee for Aeronautics to take the initiative in bringing about a much desirable cooperation between aerodynamical laboratories, states that he knows the reasons why both Mr. Margoulis and myself failed three years ago. He could not reveal what the reasons were but he could state nevertheless that the stumbling block was represented by some governments (meaning the United States, quite evidently) who are not inclined to take part in international conferences. Such being the case, he said, it would seem that the appointment by the First International Congress of Aerial Navigation of a committee such as it had been suggested by Mr. Breguet would not constitute the most advisable step to take at the present time, especially considering the fact that most of the aerodynamic laboratories in every country are under government control. In his opinion, the best thing to do would be to adopt a number of resolutions and submit them to the French Under-Secretary of State for Aeronautics which would take up the matter of Standard-

ization of symbols, notation, and methods of experimentation with foreign governments.

Mr. Breguet and Mr. Prix of the St. Cyr Aerodynamic Institute insist on the appointment of a committee.

Col. Verduzio, Director of the Aerodynamical Laboratory of Rome, Italy, points out the great disadvantage under which the work in aerodynamics is proceeding at present in the absence of an understanding between aerodynamic laboratories on the matter of experimental methods adopted and in the absence of uniform symbols and notations having the same meaning in every country. The latter, according to Col. Verduzio is of the greatest importance and he submits to the congress a list of symbols and notations prepared by the Italian Aeronautical Technical Services which, he suggests, could be taken as a basis in the discussion for the adoption of international standards. Col. Verduzio refers to the failure of the British Aeronautical Research Committee to carry through the proposed program of international wind tunnel tests on a model supplied by them and, in order to get started, he suggests that each laboratory should make its own model from the same drawing and start the tests.

Col. Fortant, Director of the French Technical Section of Aviation, suggests that, independently of any governmental action by the Under-Secretary of State for Aeronautics in dealings with foreign governments in the matter under discussion, as suggested by Prof. Soreau, the suggestion made by Mr. Breguet and others regarding the appointment of a committee, be at least unofficially

adopted and that the representative of aerodynamic laboratories attending the congress meet together and exchange their views on the matter of symbols and comparative tests which, in their opinion, should be the object of an international agreement.

Resolutions Adopted by the International Congress of Aerial Navigation.

At the close of the First International Congress of Aerial Navigation the following resolutions were adopted expressing the views of the Technical Committee which were offered by the Congress with the suggestion that they should be adopted by governmental and civilian aeronautical organizations:

"Resolution No. 3 - To make a study of the measures which may be immediately adopted in the test methods of aerodynamical laboratories in order to make it possible to compare results; in particular to define the geometrical forms and the material realization of a large number of typical models, which tested systematically in well-defined conditions, would serve in some sort as a characterization of a wind tunnel; also to bring about an agreement that the same collection of such models be tested successively in the various laboratories.

"Resolution No. 4 - Unification of terms and notations employed in the aeronautical publications of the different countries."

The appointment of a committee charged with the actual carrying through of the work outlined in resolutions No. 3 and No. 4 which had been advocated by Mr. Breguet and others did not take place and, besides expressing a more or less sentimental wish that

somebody, somewhere, would do something in the direction pointed out in the two resolutions quoted above, the First International Congress of Aerial Navigation did not do a thing for bringing about the much-desired international wind tunnel tests and the standardization of symbols, terms and graphical methods employed in aeronautical publications of the different countries represented at the congress, in spite of the fact that urgency of such a measure had been pleaded for by the representative of every aeronautical laboratory attending the congress.

It is no wonder, however, that the First International Congress of Aerial Navigation could not accomplish anything in a matter such as this which required the cordial cooperation of scientists of every nation, when we stop to consider that American and British scientists were conspicuously absent and German, Austrian and other scientists of former enemy nations were not allowed to join this congress which was held under the auspices of the French Government.

The Moral of a Sad Story.

From the above history of the fruitless efforts which have been made during the last three years by scientists and technical men of all countries interested in aeronautics in order to bring about a much-needed international cooperation in aeronautical research work in the interest of aeronautics as a science and as a new and tremendously important branch of engineering, we can draw the following conclusions:

(1st) It is well recognized by all leading authorities in

aeronautical research work that the lack of cooperation between the various aerodynamic laboratories in adopting a common standard whereby the results of wind tunnel tests can be intelligently interpreted and compared with each other (wherever it stands to reason that such a comparison should be possible) is fraught with danger and tends to destroy the confidence of aircraft designers and manufacturers in wind tunnel tests which are now the only scientific guidance that aerodynamics can give to the aircraft designing engineer in order to allow better and safer design of aircraft.

(2nd) The present chaotic condition existing in the matter of symbols, definitions and methods of graphical representations used in aeronautical technical reports and publications edited in various countries, makes it almost impossible for anybody who is not familiar with the technical aeronautical terminology adopted by each country to derive any benefit from publications and reports edited in any other country than his own.

(3rd) The present lack of cooperation between aerodynamic laboratories and the handicap brought about by the absence of a uniform scientific aeronautical language having the same meaning in every country, is not due to a lack of appreciation by scientists and technical men engaged in aeronautical research work, of the very undesirability of the prevailing situation. On the contrary, almost all of them are ready to enter into and to abide by any sort of international agreement which will correct the present state of affairs.

(4th) Due to the fact that all leading aeronautical laboratories and other aeronautical scientific organizations in the world are under government control, any initiative in the desired direction can only be taken at the present time by one or more governmental aeronautical institutions with the approval and the active support of the government machinery back of it.

(5th) Any move of this sort originated by the aeronautical services of any of the big nations in Europe, is bound to be influenced by political considerations, by limitations imposed by the treaty of Versailles, and by resolutions officially adopted during the war at interallied meetings of prominent scientists and representatives of academic bodies on the matter of post-war cooperation with scientists of, at that time, enemy countries.

(6th) Quite evidently under these conditions it is impossible to reach a truly international agreement, such as is desired as long as German aeronautical progress and German scientists are either ignored or snubbed.

The failure of the First International Congress of Aerial Navigation to work out any plan for meeting the situation, which had been brought to their attention by those most interested in and most concerned with the desirability of reaching an agreement on the matter of international cooperation in aeronautical research work and on the matter of standardization of aeronautical technical terminology, provides the best illustration of the futility of placing any hopes in the outcome of the vague recommendations presented by its technical committee to the French Under-Secretary of State for Aeronautics.

(7th) The program of wind tunnel tests on a single model successively tested in various wind tunnels in Europe and in America, which was outlined by the British Aeronautical Research Council almost three years ago (and which, as far as I know, has not materialized as yet) did not include and does not include at the present time, for all I know, the cooperation of German Aeronautical laboratories. Furthermore, that program was not prepared with the collaboration of any of the laboratories invited to join in the proposed tests; it was simply a British ready-made program of wind tunnel investigation work which discussion in the Aerial Age of this subject has failed to prove that it was the most acceptable one to all concerned. On the contrary, that discussion has led to the contribution of a good many suggestions by prominent aeronautical authorities which most certainly should be taken into consideration before formulating a program of international cooperation in a work which is to be purposely undertaken in the interest of the scientific and technical progress of aeronautics in all countries.

Our National Advisory Committee for Aeronautics an Important Factor in International Aeronautics.

When, three years ago, I suggested to and strongly urged upon our National Advisory Committee for Aeronautics to take the initiative in calling a meeting in Paris of the representatives of leading aeronautical laboratories in the United States and in Europe for the purpose of outlining a program of international wind tunnel tests which would have eliminated the present objections to wind tunnel experimental work, and which would have laid out the basis

for the adoption of a much needed consistent uniformity in aeronautical technical terminology, I was prompted by the fact that I knew that our National Advisory Committee for Aeronautics was the only aeronautic scientific organization in the world which could have undertaken this task and carried it through to a successful conclusion.

In fact, this Committee had the assurance of the most effective cooperation of scientists of all nations (former allied and former enemy nations) who, in spite of the official taboo which separated and still separates in most European countries scientists in two groups: friendly and enemy, would have welcomed any attempt on our part to bridge the gap, in so far at least as aeronautics are concerned.

Furthermore, our National Advisory Committee for Aeronautics being as it is directly responsible to the President of the United States and to Congress only, is the only aeronautical scientific organization in the world under Government control which is independent of all governmental departments while at the same time it cooperates with all of them as well as with our national aircraft manufacturing industry, with engineering societies, universities, and other educational and academic bodies engaged in aeronautical research work in this country.

The contribution made by this Committee to the advance of research work in aeronautics during the last five years, with the insufficient funds placed at its disposal by Congress, places our National Advisory Committee for Aeronautics in a position of natur-

al leadership in the scientific field of aeronautics, and furthermore, the disinclination on the part of the American people to discriminate between scientists of former enemy and former friendly and neutral nations would have created an atmosphere of confidence and a spirit of effective cooperation in a meeting of representatives of aeronautical research laboratories organized by this Committee. This, however, could not be accomplished due to the fact that the National Advisory Committee for Aeronautics must look upon Congress for guidance on all matters more or less directly related to our dealings with foreign nations. As stated before, the Committee (1) is very sympathetic in regard to reaching an understanding with all countries for the Standardization of symbols and methods of graphical representation used in aerodynamics (2) it is more than sympathetic in regard to wind tunnel tests leading to a definite and practical utilization in the future of wind tunnel work and (3) it is not disposed to ignore the existence of German and Austrian Aeronautic laboratories and scientists. On the contrary, this Committee has been the first one which has adopted for wings the same coefficients used by the Göttingen Laboratory simply because they were the most logical coefficients to adopt. (This example, I understand, is going to be followed by French laboratories. As far as British laboratories are concerned, it is very doubtful indeed if they will ever adopt symbols, coefficients and graphical methods of representation other than their own).

The Views of Congress on International Cooperation.

The stumbling block on the road of progress and international cooperation (at least in the scientific field of aeronautics) which could have been brought about by the only governmental aeronautical research organization in the world capable of obtaining the desired results, is represented by the unfavorable standpoint from which our present Congress is inclined to look upon any international conferences between ourselves and European powers. Under the circumstances, it is quite natural that the National Advisory Committee for Aeronautics should not be willing to take the initiative in the organization of an International Congress for the Standardization of Aerodynamics. As a matter of fact, should such a congress be organized by another nation, our National Advisory Committee for Aeronautics could not even be officially represented there, same as it has not been represented at the First International Congress of Aerial Navigation or at any other of the international aeronautical conventions which have taken place in Europe during the last three years, where most important decisions affecting international aerial navigation have been taken in our absence, without any reference whatsoever to our present or future interests in that direction.

This is not the proper place for discussing either the wisdom or the narrow-mindedness of our policy of isolation (neither splendid nor always consistent with our national interests) which we are pursuing under the present Congress in every event takeing place, sometimes three and sometimes twelve miles off our shores,

but this is certainly the place where we can say that the unwillingness of Congress, either expressed or assumed by the National Advisory Committee for Aeronautics, to allow that body which has done and is doing some splendid work, to establish closer ties between American and European aeronautical scientific research institutions, is neither consistent with the progress of aeronautics nor with the dignity of an organization which should be left free to work in the interest of science unhampered by political considerations.

When, three and a half years ago, I suggested the establishment of an office in Europe of the National Advisory Committee for Aeronautics for the purpose of establishing and maintaining a cordial exchange of thoughts between American and European scientists working on aeronautics and sciences allied thereto, and when my suggestions were approved by that Committee and I was appointed its representative in Europe for the purpose of carrying through that program, the keynote of our national policy was: cooperation with Europe. We went too far, however, or probably our motives and our lofty ideals which prompted our desire to cooperate with Europe in the reestablishment of order and peace in the world, were not met with the same spirit which actuated them. At any rate, with the advent of the new administration a complete reversal of out foreign policy took place and, helas, I soon discovered that the fine spirit of international scientific cooperation in aeronautics which had provided the only reason for establishing a foreign office in Europe of the National Advisory Committee for Aeronautics,

had been damped to such an extent that my activities in promoting cooperation were actually embarrasing the Committee. After two years of persistent efforts I had to withdraw from a work which, however, I feel has sown good seed which shall bear fruits later on when it will be more fully realized, both in this country and in Europe, that the root of all our evils in the difficult period of evolution of the human race that we are going through is the lack of cooperation between the intellectuals of all nations.

The Discussion has Served its Purpose.

The efforts made by Mr. Margoulis and myself during the last three years for promoting a congress of representatives of aeronautical research laboratories, and other scientists working in aeronautics in the interest of the scientific progress of Aeronautics have not been lost, and the discussion in the Aerial Age of the subject "Standardization and Aerodynamics," I feel has served its purpose, which was to show that intellectual cooperation in aeronautics can be achieved and must be achieved by taking into consideration the views of all before trying to place our own interpretation on what should be done in the pursuance of a plan calling for the cooperation of others.

The suggestions that we made three years ago on the subject of wind tunnel tests have been adopted in principle by all aerodynamic laboratories, however, both the British Aeronautical Research Council and our National Advisory Committee for Aeronautics have each formulated a test program of their own without taking under consideration the views of other laboratories, and each pro-

poses to go ahead with its own program and make its own models, test them according to its own ideas and then ask other laboratories to duplicate the same tests on the same models.

Other laboratories, I understand, are planning to do the same thing and the consequence of this lack of cooperation between the various laboratories in formulating a unique program of experimentation agreeable to all shall bring about a useless loss of time and energies. Since the necessity of making these comparative tests has been recognized by all concerned, why not try to make them as complete as possible in a true spirit of international scientific cooperation?

The discussion of this subject, both in the Aerial Age and at the First International Congress of Aerial Navigation, has supplied enough elements to approach the problem of Standardization and Aerodynamics on some sort of well-defined basis. It should not be difficult to coordinate the various suggestions made by the directors of the various laboratories and to find a common ground on which an agreement might be reached. This can be accomplished mostly by correspondence. After an agreement has thus been reached on general lines, a meeting of American and European representatives of aerodynamic laboratories and leading scientists engaged in Aeronautical research work could be easily arranged for. A meeting of this sort, bringing together scientists of all nations, which on account of the war find themselves separated by nationalistic barriers, would make it possible to work out the details for carrying through a program of immediate and future actions and, furthermore, would supply the human factor as represented by

the personal contact of men having the same object in mind: the progress of science.

Let Us Have Peace.

In spite of the war, in spite of the tremendous turmoil of hate, lust and avarice, in spite of the reawakening of all the baser instincts of the human race which the war has unchained, we can see the signs of a new era dawning upon us. Social reforms based on the old standards of personal and nationalistic advantages shall never restore peace and order, unless we realize first the true meaning of the law of brotherhood and stand ready to compromise on the matter of personal rights, privileges and advantages in the interests of all.

The intellectuals of the world, scientists and technical men engaged in the work of developing and perfecting new inventions, are the pioneers of this new era. It is up to them to realize the meaning of the divine love, of which science is the noblest expression, and it is up to them to give the example and to teach the objective lesson that the world needs: the unselfish cooperation of all in the realization of a common good.

Aeronautics and the enormous possibilities offered by aeronautics, which represent the outstanding engineering progress born out of the war, points out the way to us where international cooperation of scientists and technical men starts.

We have in aeronautics a new science, a new branch of engineering, a new and fundamentally international means of communication. The men who are working in aeronautics are new men, they

understand the need of cooperation, they are ready to cooperate with each other, they invite the leadership of a group of progressive scientists of a progressive nation to bring about the formation of a nucleus of the great brotherhood of the intellectuals of the world.

Can I be blamed for continuing, after three years of efforts (not fruitless, by any means) to look upon our National Advisory Committee for Aeronautics as the best adapted Aeronautical organization in the world for bringing about the desired results? Especially so when we consider that the Committee is in sympathy with the idea of an international congress of scientists working in aeronautics and would be ready to join in a discussion leading to a better understanding of wind tunnel work and to the Standardization of Symbols, notations and methods of graphical representation used in technical aeronautical works, if it was not prevented from doing so by the stand taken by Congress on the matter of American participation in international conferences.

Only last September a pathetic appeal was sent by German and Italian scientists working in aeronautics, to scientists of other nations to take part in a meeting held at Innsbruck (Tyrol). The invitation read: "The research work of the last years has brought about in all countries considerable progress in the development of the classical theories as well as of the fundamental problems of practical hydraulics and aerodynamics. On account of political events the interchange of ideas and personal intercourse among scientists has been impaired. By the said meeting we intend

to avoid whatever hinders at the present time the success of official international congresses. We simply want to rally without any formalities the scientists interested in these special problems."

American, British and French scientists did not answer the call of their German and Italian brethren, not because they did not want to, but because they could not on account of the unfortunate preponderance of political consideration over other considerations of higher nature. This seems to be the price that scientific research work in aeronautics must pay nowadays in order to obtain the scanty credits granted by the various governments for that purpose.

It is rather amusing to see that, of all governments subsiding scientific research work in aeronautics, the German government should be the first one who has not opposed its veto to the action taken by Prof. Prandtl and by Prof. Karman in calling this first international congress of scientists working in aeronautics.

An Appeal to the National Advisory Committee for Aeronautics.

I wish to close the present discussion of the subject "Standardization and Aerodynamics" by appealing once more to the members of our National Advisory Committee for Aeronautics, urging them to use their personal influence and the enormous prestige of the finest aeronautical scientific organization in the world for obtaining from Congress the recognition of the fact that a wider range of independence from political considerations by that Committee in the field of international cooperation in the interest of the scientif-

ic progress of aeronautics is worthy of the high standards of that institution and is consistent with our national interests.

The first step along the road of collaboration with Europe in the work of reconstruction (which, no matter if we like it or not, we shall have to travel sooner or later) it is just and right should be made by American scientists. Such a step would be entirely consistent with the desire repeatedly expressed by the nation, the President, and by members of his Cabinet, to cooperate with European nations in any constructive plan leading to the reestablishment of peace in the world.

Who can suggest any better plan leading to the reestablishment of peace in the world than the one brought about by promoting an increased collaboration between scientists and technical men all over the world? And if the initial move in that direction can be made by promoting peace and collaboration between scientists working in aeronautics - who are ready and eager to fulfill the law of international brotherhood - why not let aeronautics lead the world along the path of intellectual evolution on which, in spite of all adverse forces, we are steadily progressing?

Why should short-sighted and short-lived political considerations deprive this nation and our National Advisory Committee for Aeronautics of the great privilege of being able to make the first move?

Quoting President Harding's Words.

The words spoken by the President at the commemoration of the fourth anniversary of the armistice truly represent the sentiment of

the great majority of the American people on the matter of cooperation with Europe:-

"I think we have come to realize, as a nation, that we cannot hope to avoid obligations and responsibilities, often arduous and burdensome, as part of the price we must pay for our fortunate relationship to the confraternity of the nations. It will be greatly to the national benefit, I am sure, if those who most intimately participated in the events of the great world war, and among them I of course include particularly the men of the overseas forces, shall always keep in mind the fact that their noble service to their country and civilization has imposed upon us a duty to recognize that henceforward we must maintain a helpful and sustaining attitude in all the broader relationships that involve the nations. Our first duty will, indeed, be to our own, but that duty cannot be adequately discharged in narrowness and selfishness.

"That we may be guided to a just judgment of the time and occasion for further proof of our interest in the common cause of humanity, and in choosing the methods whereby to discharge the obligation thus created, will be, I am sure, a fitting prayer for this armistice anniversary."

Let us keep in mind that we can help making this world safe for democracy in one way only: by taking our share of obligations and responsibilities in building up a new International: THE INTERNATIONAL OF BRAINS AND HEARTS.