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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

Technical Memorandum No. 30.

A B A C U S

for the Reduction of

ENGLISH MEASURES TO THE METRIC SYSTEM

and Vice Versa.

9.2.1

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July, 1921.

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ABACUS FOR THE REDUCTION OF ENGLISH MEASURES TO THE METRIC SYSTEM AND VICE VERSA.*

1. Through the constant use of English measures in periodicals and in articles, a considerable number of which have recently been issued in the various languages of numerous countries interested in aeronautics, the reader accustomed to the metric system is often obliged to make laborious calculations in reducing the tables he consults, and which are frequently insufficiently clear. On account of the dimensional equations of certain quantities constantly used in aeronautics (such as density, moment, pressure, linear tension, the resistance (K) offered to the motion in the air on a unit surface, Young's modulus and sometimes the calculation of powers) such reduction also frequently becomes most embarrassing to the reader.

2. The annexed diagram (see figure) represents an abacus of reduction which comprises all the tables necessary, in a single page, and any others which, as we shall see, might occur. This abacus renders it possible for the required reduction to be rapidly made in the course of reading.

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* Extracts from the Abstracts of the Italian Aeronautical Institute, Year VIII, Series 2a, No.2, September, 1920.

In the 3rd Annual Report of the National Advisory Committee for Aeronautics, Washington, 1918, Dr. J. S. Ames points out the importance, in Report No.20, of practically facilitating such reduction and gives a table (pp.393-401) for the reduction of measures from one system to another. The abacus drawn by Dr. Tenani will be of more practical use than the above named table, since it does away with the need for calculation and will therefore be welcomed by many people accustomed to one of the systems, who will be able to read the other system with ease.

DESCRIPTION. - The abacus in question comprises three scales: the left-hand scale for English measures, the central one for metric measures, and the right-hand scale, on which the "points of reduction" are marked. The following example will give a direct explanation of the use of the diagram.

USE OF THE ABACUS. - Example: It is required that a pressure of 2.5 lbs. per square foot be reduced to the metric unit.

We commence by consulting the annexed table. The table headed "Pressure" shows that we must refer to point VII, and that the result of that reduction will be expressed in kg. per m^2.

A straight edge is then applied connecting point VII on the right-hand side with the number 2.5 read on the left-hand scale giving the English measures; the straight line cuts the central scale of metric measures at point 12.2.

This signifies that 2.5 lbs. per square foot = 12.2 kg/m^2.

The same straight line also serves for the inverse reduction.

If the case were that of reducing a pressure of 250 lbs. per square foot instead of 2.5 lbs. per square foot, the same straight line would be applied on condition that if one of the two measures to be reduced, read on the corresponding scale, were multiplied or divided by a power of 10, the result of such reduction would always have to be multiplied or divided by that same power of 10.

The diagram is particularly convenient if a transparent celluloid ruler is used, which leaves the lines of the scale exposed and avoids the necessity for tracing any sign whatever on the diagram.

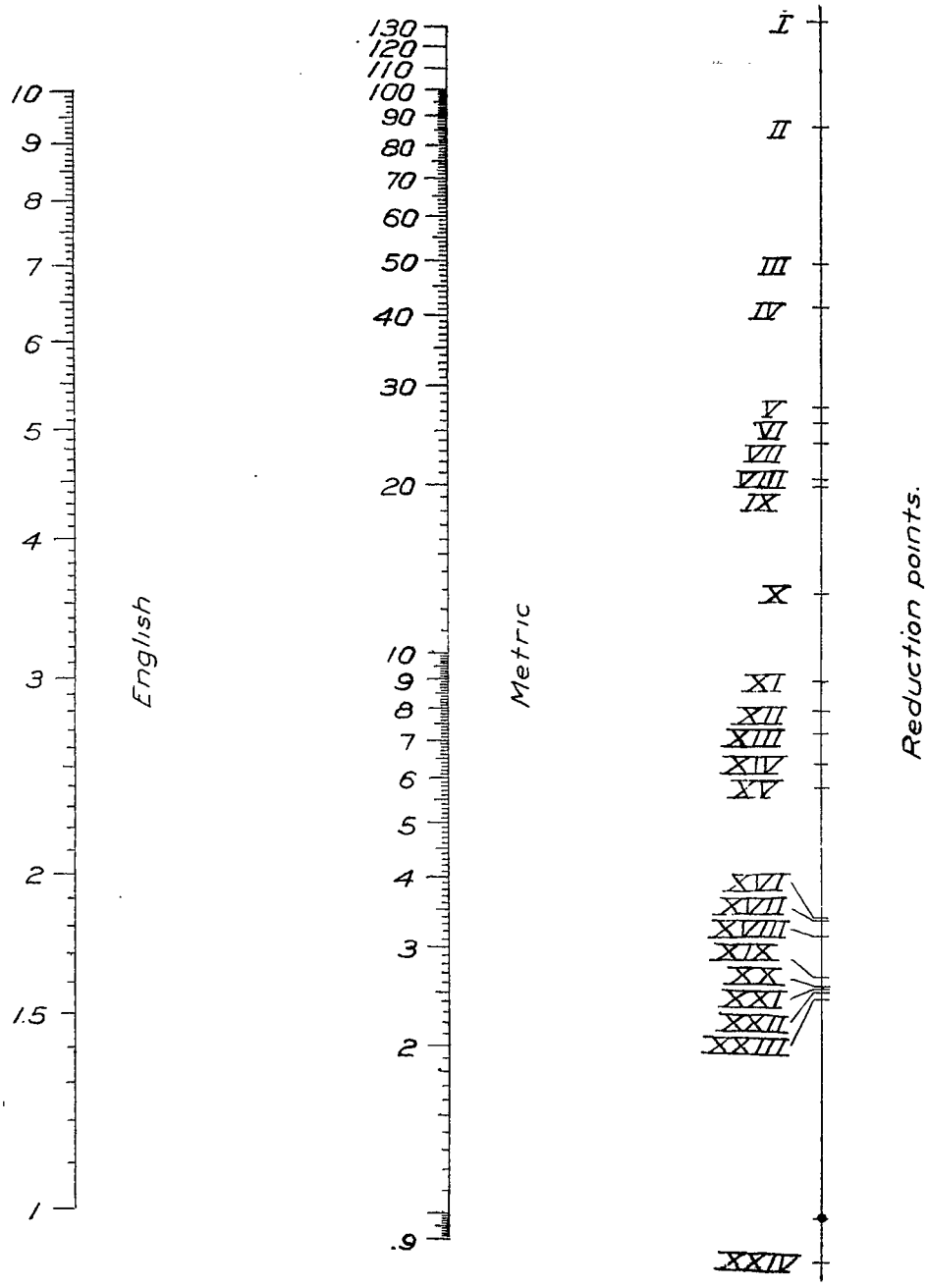
TABLE OF REDUCTION FACTORS.

	Reduction Factors	Corresponding Point		Reduction Factors	Corresponding Point
LENGTH			**WEIGHT**		
Feet into dm.	3.048	XI	lbs. into kg.	4.536	VIII
Inches " cm.	2.540	XIV	oz. " dg.	2.835	XII
Miles " km.	1.609	XX	cwt. " 10 kg. .. (myriag.)	5.080	VI
Yards " m.	0.914	XXIV			
1/16 in. into mm.	1.587	XXII			
SURFACE			**VELOCITY**		
Ft.^{2} into dm^2	9.296	II	m/sec. into km/h.*	3.600	X
In.^{2} " cm^2	6.453	IV	mi/h. " km/h.	1.609	XX
			mi/h. " dm/sec.	4.470	IX
			knots " km/h.	1.853	XVI
VOLUME			**POWER**		
Ft.^{3} into decal. (0.01 m^3)	2.832	XII			
In.^{3} " centil. (0.01 dm^3)	1.638	XIX	lbs. x mi/h. into 0.001 HP	2.70	XIII
Gal. " liters ...	4.546	VIII	lbs. x ft/sec. into 0.001 HP	1.84	XVII

* In this reduction, which is frequently used and which does not apply to the English unit, the meter/sec. should be calculated on the left-hand scale, the km/h. on the central scale.

TABLE OF REDUCTION FACTORS (Contd.)

	Reduction Factors	Corresponding Point.
DENSITY		
lbs/ft.^{3} into myriag./m^3	1.602	XXI
PRESSURE		
lbs/ft.^{2} into kg/m.^{2}	4.882	VII
lbs/in.^{2} " dg./cm^2	7.030	III
tons/in.^{2} " 100 kg/cm.^{2}	1.575	XXIII
MOMENT		
lbs. x in. into kg. x cm.	11.51	I
LINEAR TENSION		
lbs/in. into kg/cm.	1.780	XVIII
RESISTANCE (K)		
$\frac{\text{lbs.}}{\text{ft.}^2}$ per mi/h. into $\frac{\text{myriag.}}{\text{m.}^2}$ m/sec.	2.432	XV
$\frac{\text{lbs.}}{\text{ft.}^2}$ per foot/sec. into $\frac{\text{myriag.}}{\text{m.}^2}$ per m/sec.	5.253	V


10
9
8
7
6
5
4
3
2
1.5
1
English
130
120
110
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
.9
Metric
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
XVI
XVII
XVIII
XIX
XX
XXI
XXII
XXIII
XXIV
Reduction points.

3. The reduction mentioned in the preceding example may be applied by multiplying the English measures (2.5 lbs. per sq.ft.) by the factor corresponding to that reduction, according to the preceding table (4.88).

From this table, we see that (on account of the necessity for comprising the entire reduction in a single diagram) we shall sometimes have to consider a metric system differing from that commonly adopted, as, for instance, in the case of density generally expressed in kg/m.^{3}, which can be reduced, by means of the diagram, to 10 (kg/m.^{3}). There is, however, no inconvenience about this, as all that is needed in the decimal system of metric measurements is to transpose the decimal point of the measures in question.

4. The table may easily be completed by other reductions, if the reduction factor be calculated once for all: the ABACUS CAN ALSO BE EASILY COMPLETED for such reductions by simply measuring, on the scale of points for such reductions, starting from the point marked with a small circle, a segment equal to that which represents the reduction factor on the left-hand scale (starting from 1).

If, for instance, such a reduction factor is 3.6, all we need to do is to mark on the scale of points of reduction, in the same way as before outlined, a segment equal to that comprised between 1 and 3.6 on the left-hand scale (by doing this, we should obtain a point x).

5. CONSTRUCTION OF THE ABACUS. - The abacus is very simply made: a logarithmic scale, marked on the left-hand scale, can be copied directly by means of a slide-rule. Another logarithmic scale, half the length of the one above-mentioned, is marked on the central scale and can also be copied by means of the slide-rule.

Segments representing the logarithm of the reduction factors are marked, as we said before, on the right-hand straight line (starting from the point of intersection of the straight line and the line joining the extreme lower ends of the two scales mentioned above) using the same units, or those used for drawing the left-hand scale.

The scales are parallel, and at equal distances from the central scale. If we draw a transversal line passing through point X, this line, together with the two lateral scales and the line joining the extreme lower ends of those scales, forms a trapezoid, the central scale of which is the central line. The latter therefore determines, on the central scale, a segment equal to one-half the sum of the segments respectively representing the logarithm of the product above mentioned, and this renders it an easy matter to read the product.

A number of commonly used diagrams are based on this principle and are specially utilized in aeronautical calculations, which are generally explained in a more complicated manner by deduction from general nomographic principles.*

* See, for instance, the abacus shown on pp. 80-94 of these transactions, Vol. 2, 1913.