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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Slide Rule

We, RHONE-POULENC S.A., a French Body Corporate, of 22, Avenue Montaigne, Paris, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to slide rules. The slide rule of the invention is to be used to facilitate the calculation of rates of corrosion and electrodeposition.

The annual losses due to corrosion involve very considerable cost, so that increasing attention is being devoted to corrosion problems, and various calculations have to be made in connection with these problems. Similarly, a number of calculations have to be made in problems relating to the protection of metals with thin layers of various metals by electrodeposition.

Depending upon the objects aimed at and the means of investigation employed, the rates of loss or gain of metal are expressed in the most varied "units" which are usually:—

(a) weight per unit surface and time: for semi-industrial laboratories,
(b) thickness per unit time: for industry,
(c) corrosion current per unit surface: for basic research laboratories,
(d) deposition current per unit surface or thickness deposited per unit time: for industrial electrodeposition.

The "units" particularly used are:—

For corrosion

(i) Weight per unit surface and time: $g/m^2/day$—$mg/dm^2/day$ generally denoted in English literature by (m.d.d)
(ii) Thickness per unit time: mm/year, and in the English units: inch per year (ipy) or mils per year (mil)
(iii) Corrosion current per unit surface: $\mu A/cm^2$—mA/dm^2

In electrodeposition

(iv) Current density: A/dm^2
(v) Thickness deposited: micron/sec (μ/sec)—micron/hour (u/h) and in the English units: mil/sec—mil/h.

The equivalents are rarely based on the decimal system because of many factors including:—

(a) the alternative use of metric or English units
(b) non-decimal time division
(c) value of the specific gravity of the material under consideration
(d) value of the gram equivalent of the corrosion current, or deposition current, of the metal under consideration.

This obliges each user to carry out conversion calculations in accordance with the documents which he has been able to procure and the particulars which he desires to obtain.

The literature supplies numerous tables of conversion factors: for example, there may be mentioned that referred to in Uhlig's classic work "Corrosion Handbook" (John Wiley and Sons, London), P.1160, 1948 edition, and those published in the technical books such as "A Guide To Corrosion Resistance" or "Climax Molybdenum".

Some authors have given, for a particular metal, tables of correspondence in columns. For example, there may be mentioned table No. 1 containing logarithmic scales in the article by H. Zitter, F. Matzer and G. Kraxner, published on page 743 of the review Werkstoffe Und Corrosion, September, 1965.

According to the present invention we provide a slide rule for calculating by direct reading the rates of corrosion or of electrodeposition of a metal, such rule comprising a body and a slide movable with respect to said body, said slide or said body carrying two or more logarithmic scales indicating specific gravity, weight of metal corroded or deposited per unit surface in a given time, or current density and either the body or the slide carrying two or more logarithmic scales indicating thickness of metal corroded or deposited per unit time, weight of metal corroded or deposited per unit surface in a given time or electrochemical equivalents.

With such a rule the various equivalents can be immediately read off, when one of the previously indicated units is known for any material.

In order that the invention may more readily be understood the following description will be given merely by way of example, reference being made to the accompanying drawings, wherein:—

Figure 1 illustrates schematically a portion of a first embodiment of rule according to the invention;

Figure 2 is a similar view of a second embodiment; and

Figure 3 is a similar view of a third embodiment.

The rule illustrated in Figure 1 includes a fixed body portion formed of two parts F1 and F2, between which may slide a movable portion on slide M. In the upper part F1 a mark called "reference A" is positioned to correspond with the value 0.36 of the scale 4 described later. In the lower part F2 is a logarithmic scale 4 graduated in thickness of metal lost, or gained, by uniform corrosion or deposition, expressed in millimetres per year. In accordance with the commonly accepted usage, there have been indicated zones of use of the material on the assumption that for thickness of less than 0.1 mm/year the material is very good, and that for thicknesses between 0.1 and 1 mm/year the material is regarded as being suitable for general use, whereas, for most purposes, thicknesses greater than 1 mm/year are unsuitable. The lower part F2 also includes logarithmic scales 5 and 6, appropriately aligned with the scale 4 and graduated in inches per year (ipy) and in mils per year respectively (a mil being one thousandth of an inch). Any other scale giving a thickness of metal corroded or deposited for any units of time may be located in this position.

The slide M includes various logarithmic scales all oriented in the same sense as the scales of the fixed part F. Immediately under the reference A is a scale 1 graduated in values of the specific gravity of the material under consideration. Advantageously, the specific gravity of the commonest materials may be marked on this scale by reference to their chemical symbol.

Scales 2 and 3 graduated in $g/m^2 \times h$ and in $g/m^2 \times 24$ h (or $g/m^2 \times day$), indicate weight of metal deposited or corroded per unit area in a given time and have exactly corresponding zero readings. Any other scale giving a weight of metal deposited or corroded per unit area in a given time, but calibrated in different units, could be located in this position.

At each position at which a value of the scale 1 corresponds with the reference A, there exists an accurate reading of the indicated specific gravity on scale 2 or 3, for the corresponding aligned value given on the scale 4, 5 or 6.

Referring now to Figure 2 the rule illustrated includes a fixed portion formed of two fixed parts F1 and F2, between which may move a slide M.

In the upper part F1, a logarithmic scale 7 gratulated in electrochemical equivalents in g/coulombs (multiplied by 104) of the metals which are lost for an anodic surface or deposited on a cathodic surface. The common metals are directly indicated by their chemical symbols and in accordance with their usual different valencies. Also in the lower part is a logarithmic scale 10 graduated in $g/m^2 \times 24$ h of metal deposited or dissolved. Any other scale giving a weight of metal deposited or corroded for any surface or time units could be located in this position.

The slide M has an arrow indicating a point called "reference B" aligned with the value 11.6 of the scale 9 described below. Also on the slide are two logarithmic scales 8 and 9 gradulated in "corrosion current density" and measured in milliamperes per square decimetre (mA/dm^2), and in microamperes per square centimetre ($\mu A/cm^2$), respectively, the value "1" of the scale 8 corresponding to the value "10" of the scale 9. Any scale indicating a current density in other units could be located in either of these positions.

At each position at which a value of the scale 7 corresponds with the reference B, there exists an unequivocal correspondence between a value of the scale 8 or 9 and the aligned value of the scale 10.

The rule shown in Figure 3 includes a body formed of two parts F1 and F2 and a slide M. In the upper part F1 of the body is a logarithmic scale 11 identical to the scale 7 of the rule illustrated in Figure 2. On the lower part F2 of the body are two further logarithmic scales 14 and 15, indicating thicknesses of metal deposited or corroded and graduated in microns per sec (μ/sec) and in microns per h. (μ/h) respectively.

A scale giving a thickness of metal deposited or corroded per unit time and graduated in any other units could be located in this position.

Slide M carries a logarithmic scale 12 graduated in specific gravity g/cm³, identical to the scale 1 of the rule of Figure 1. Also on the slide M is marked a logarithmic scale 13 graduated in electric current expressed as amp/dm² or any other units.

At each position at which the specific gravity of a metal (scale 12) corresponds with its electrochemical equivalent (scale 11), there exists for each current density (scale 13), a particular value of the thickness of this metal deposited or corroded, during the chosen time unit, i.e. a second on scale 14 or an hour on scale 15, the scales being appropriately aligned as a function of their coefficient of correspondence.

If desired, the fixed and movable scales may be interchanged, scales may be added or omitted, the rules may include cursors or fixed reference marks for facilitating readings, and the various rules described above may be included in a common instrument using one, two or more faces. The rules which have been shown as rectilinear may alternatively be circular in which case the slide will be a rotatable member or may be designed in any conventional manner, and may have the required length for the desired precision.

These rules may be made substantially of any material such as board, wood, plastics, of the type usually employed for the manufacture of slide rules.

The following examples illustrate calculations which may be made using rules according to the invention.

Example 1

Determination of the equivalence between "units" of lost thickness

The rules which is useful for this calculation is illustrated in Figure 1, the movable part of the rule being shown in the required position for a particular determination.

The corresponding values of thicknesses of metal corroded or deposited in mm/year (scale 4) inch per year (ipy) (scale 5) or mils per year (scale 6), may be directly read off, this reading being simplified if a cursor is provided.

The multiples or sub-multiples of the time or of the surface, and *vice versa*, may be found by employing the slide as would be done with a slide rule.

Ex.: What is the corrosion thickness in mm/year equivalent to 2 mils per month?

The rule of Figure 1 does not directly give the result, and it is necessary to commence by calculating in annual corrosion, working as with an ordinary slide rule.

The multiplication $2 \times 12 = 24$ (mils per year) is effected. The correspondence between the scale 6 and 4 shows that 24 mils per year is equivalent to 0.6 mm. per year.

Example 2

Determination of the equivalence between "units" of lost weight

The rule of Figure 1 is employed, the scales 2 and 3 of the movable rule giving equivalents of lost weight of metal in g/m².h. and in g/m² × 24 h.

Any multiple or sub-multiple of these units may be calculated by using the rule as a slide rule in the usual way.

Example 3

Equivalence between "units" of weight and "units" of thickness

The rule illustrated in Figure 1 is again employed. In order to find the equivalence between units of weight and thickness of metal corroded or deposited, the slide M is moved to bring the value of the specific gravity of the particular metal against the reference A (in the upper part F1 of the body. There then corresponds to each weight value, read on the scale 2 or 3 of the slide M, the equivalent thickness on the scale 4, 5 or 6 of the body.

Ex.: What is thickness per year (in the metric system) of corroded zinc corresponding to an attack of 2 mils per month and what is the equivalent weight in g/m².24 h?

As in Example 1, it is necessary to ascertain the thickness corroded per year, i.e. 24 mils (or 0.024 ipy) and 0.6 mm. per year. The value of the specific gravity of zinc read on scale 1 (denoted by Zn) is disposed opposite the reference A, and there is read on scale 3 the corroded weight corresponding to the thickness indicated on scale 4, i.e. 12 g/m² per day for 0.6 mm. per year.

Example 4

Determination of the weight of metal corroded, knowing a corrosion current

The rule illustrated in Figure 2 is used. The reference for the metal under consideration (or its equivalent g/coulomb × 10⁴) scale 7 is disposed opposite the reference B. To each value of the corrosion current read on scale 8 or 9 of the slide M, there corresponds the equivalent value of the weight of metal lost on the scale 10.

Ex.: What is the weight of zinc lost, if it is in the presence of another, more noble metal (for example Cu), such that the corrosion current is 20 μA/cm²?

By placing the index Zn of the scale 7 opposite the reference B, the loss of weight can be read on scale 10, opposite 20 μA/year indicated on scale 9, i.e. 5.8 g/m².24 h.

EXAMPLE 5

Determination of electrolytic deposits

Using the rule of Figure 3, the reference of the specific gravity of the deposited metal read on the scale 12 is brought opposite the reference of its electrochemical equivalent read on the scale 11, and the scales 14 and 15 give a reading of the thickness of metal deposited per unit time in accordance with the current density employed, read on the scale 13.

Ex.: What is the thickness of Zn deposited per hour and per second for a current of 20 A/dm^2?

The two reference symbols Zn on the scales 11 and 12 are brought into coincidence and opposite 20 amp/dm^2 on scale 13 and the thickness deposited is read on the scale 14 or 15, i.e. 0.095 μ/sec or 340 μ/h.

If it is desired to determine the thickness deposited under these conditions in a given time (for example 12 minutes), the operation $\frac{340 \times 12}{60}$ is performed, using the rule as an ordinary simple slide rule, giving an answer of 68μ.

WHAT WE CLAIM IS:—

1. A slide rule for calculating by direct reading the rates of corrosion or of electrodeposition of a metal, such rule comprising a body and a slide movable with respect to said body, said slide or said body carrying two or more logarithmic scales indicating specific gravity, weight of metal corroded or deposited per unit surface in a given time, or current density and either the body or the slide carrying two or more logarithmic scales indicating thickness of metal corroded or deposited per unit time, weight of metal corroded or deposited per unit surface in a given time or electrochemical equivalents.

2. A slide rule according to Claim 1, wherein said slide includes a first logarithmic scale indicating specific gravity, and a second and third scale each indicating weight of metal per unit surface deposited or corroded in a given time, the second and third scales being calibrated in different units, and the body having three logarithmic scales calibrated in different units of thickness of metal deposited or corroded in a given time.

3. A slide rule according to Claim 1, wherein said slide includes two logarithmic scales calibrated in different units of current density, while the body has two logarithmic scales, one indicating electrochemical equivalents and the other indicating weight of metal per unit surface deposited or corroded in a given time.

4. A slide rule according to Claim 1, wherein said slide includes a first logarithmic scale indicating specific gravity, and a second logarithmic scale indicating current density, and the body includes one logarithmic scale indicating electrochemical equivalents, two logarithmic scales calibrated in different units and indicating thickness of metal deposited or corroded in a given time.

5. A slide rule according to any preceding claim, and including a cursor to facilitate reading of the scales.

6. A slide rule constructed and arranged substantially as hereinbefore described, with reference to and as illustrated in Figure 1 of the accompanying drawings.

7. A slide rule constructed and arranged substantially as hereinbefore described, with reference to and as illustrated in Figure 2 of the accompanying drawings.

8. A slide rule constructed and arranged substantially as hereinbefore described, with reference to and as illustrated in Figure 3 of the accompanying drawings.

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1113256 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

FIG. 1

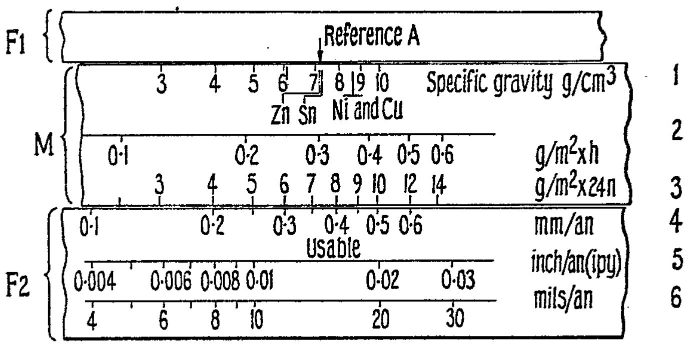

FIG. 2

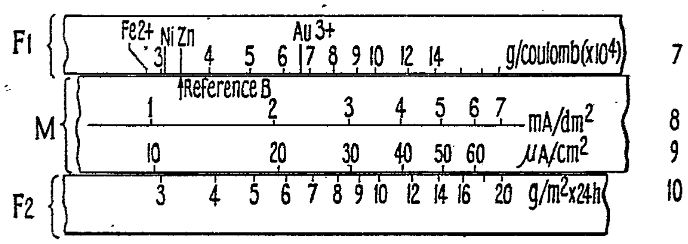

FIG. 3