PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in and relating to Calculating Devices for Use in the Tensile Testing of Materials

We, THE RESEARCH ASSOCIATION OF BRITISH RUBBER MANUFACTURERS, a Body Corporate duly organised under the Laws of Great Britain, BENJAMIN DAWSON PORRITT and RONALD GORDON NEWTON, both British Subjects and all of 105—107, Lansdowne Road, Croydon, in the County of Surrey, do hereby declare the nature of this invention to be as follows:—

This invention relates to a calculating device to be used in conjunction with machines for the tensile testing of materials, and especially for rubber. In carrying out such tests it is commonly required to calculate tensile stresses, referred to the original unstrained cross-sectional area of the specimen, from corresponding loads read from the test machine; or the reverse procedure may be involved, as for instance in calculating the loads required to produce pre-determined stresses in specimens of given cross-sectional area.

It is often not possible to make the specimens all of the same cross-sectional area. Consequently a separate calculation is usually needed for each specimen.

In calculations relating to such tensile tests it is a common practice to make use of both a list of " factors " and a slide rule of standard pattern. The number of processes to be carried out, as well as their complexity, introduces possibilities of several sources of error. Thus, in calulating tensile stress at break, in the case of dumb-bell shaped specimens of vulcanised rubber of constant width, the factor appropriate to the test in question must be taken from the list and set in the " A " scale of the slide rule by means of the cursor. The figure for the thickness of the dumb-bell must then be found on the " B " scale and also set against the cursor which must then be moved to the load value, read from the tensile test machine on the " B " scale. This figure is transferred to the " A " scale by means of the cursor. The figure found in the " A " scale then represents the tensile stress required, but the position of the decimal point must be determined by inspection.

This process is tedious and involves two movements of the cursor and one movement of the slide, during which concentration is required to ensure that the actions are performed in the correct order. Special sources of error exist in the possibilities that the factor may be taken incorrectly from the list; the figures for thickness and machine reading on the " B " scale may be taken in the wrong order, the relative positions of the " factor " and the thickness value (or the machine reading and the result required) may be reversed on the " A " and " B " scales, or the position of the decimal point may be determined incorrectly. Moreover it is not possible to check, even approximately, the result obtained without repeating the entire process with the precision and concentration required for full accuracy. The present invention removes most of the sources of error and reduces both the level of concentration and the number of actions required as well as making it possible to obtain the result more quickly. In addition there is no ambiguity about the position of the decimal point, and approximate checks on the result obtained may subsequently often be performed without moving either the cursor or the slide, and at all times are easy to accomplish. Finally, the device is self-contained since no list of " factors " is required for its operation.

The device consists essentially of two relatively movable members upon which are marked three logarithmic scales, all on the same basis, relating respectively to to cross-sectional area of the specimen, the load on the specimen, and the stress on the specimen, together with a reference mark for use in conjunction with the cross-section scale. The load scale and stress scale are placed on different members, as are also the cross-section scale and the reference mark. The scales and reference mark are so disposed that when the mark is brought opposite a given reading (x) on the cross-section scale, the reading (y) on the stress scale opposite to the point on the load scale representing z load units equals z/x.

If the load range of the tensile test

[*Price* 1/-]

Price 25p

machine can be changed, e.g., by changing the weight on the pendulum arm, so that the load reading has to multiplied by a factor to give the true load, the calculating device may have, for use with the changed load range, an additional scale for the load reading or for the stress, which automatically introduces the multiplication factor.

Two scales, in English and metric units respectively, may be provided for the same quantity, or the device may be made with some scales in English units and some in metric units, so that results in one system of units can be obtained directly from readings in the other system.

When one dimension of the cross-section of the specimen is constant, as is commonly the case with ring or dumb-bell shaped specimens of vulcanised rubber, the "cross-section" scale may be graduated in terms of the variable dimension, for instance the thickness (axial dimension) of rings or the thickness of dumb-bells. When the constant dimension has two or more standard values, as for instance in dumb-bell specimens, two or more reference marks, one appropriate to each standard value, are provided.

It is convenient to use straight scales arranged in a fixed and a movable member similar to those used in standard slide-rules, but circular scales on relatively rotatable concentric discs, or any other suitable arrangement, may be used.

The construction and use of the device will be made clearer by the following description of one embodiment illustrated in the accompanying drawing for use especially in testing vulcanised rubber, and required for the conversion of loads to stresses, or *vice versa*, under the following different conditions:—

(i) Using dumb-bell shaped specimens of constant width 0.25 inch and variable thickness, normally between ·0.08—0.12 inch but occasionally ranging down to 0.01 inch; loads in pounds; stresses in pounds per square inch.

(ii) As (i), but using the test machine with a small pendulum weight such that the load reading is 5.18 times the actual load on the specimen.

(iii) As (i), but using dumb-bell specimens 0.158 inch wide.

(iv) As (ii), but using dumb-bell specimens 0.158 inch wide.

(v) Using ring specimens of constant width 3.9 mm. and variable thickness, between 2.0 and 6.0 mm., loads in pounds; stresses in grams per square millimetre.

This embodiment of the apparatus consists of eight logarithmic scales which are all on equivalent bases. A convenient size for the scales is such that the distance between the mark corresponding to any number and that for a number ten times larger (or smaller) is exactly 5 inches.

In determining the relative positions of the scales it will be convenient to establish an arbitrary reference line near the right hand end of the rule.

Scale A in the drawing carries the mark 3,000 lbs/sq. in. at a distance of 0.100 inches to the left of the reference line. The smallest figure on this scale is 30 lbs/sq. in. and will thus lie 10.100 inches to the left of the reference line. The mark 100 lbs/sq. in. will lie 7.486 inches to the left of the reference line. This scale is intended for use with the small weight attached to the loading arm of the test machine (conditions (ii) and (iv)) and consequently the words "Small Weight" are added to this scale. The intervals on this scale, and on any of the other scales, can be divided up in any manner which is convenient, such as that shown in the drawing or in the conventional manner for slide rules.

Scale D relates to readings with the large (normal) weight in position, (conditions (i) and (iii)) and consequently the relative positions of the scales A and D must be determined by the ratio between the sensitivities of the machine with the different weights on the loading arm. For this reason the mark 518.0 lbs/sq. in. on the D scale must be placed opposite the marw 100.0 lbs/sq. in. on the A scale, and will consequently be positioned a distance of 7.486 inches to the left of the reference line. The mark 1,000 lbs/sq. in. will now occupy a position $7.846 - 5 \log_{10} \frac{1000}{518} =$ 6.057 inches to the left of the reference line.

Scale 10 is completed by adding the words "Large Weight" and dividing the logarithmic intervals as required.

In addition to the main scale on scale D there are also two reference marks shown as arrows in the drawing which are used with the thickness scales on the sliding part of the rule. In relation to the main scales of the rule the positioning of these marks is arbitrary but they must be in a definite relationship to each other, depending upon the widths of the dumb-bells which they represent.

It is convenient to arrange the mark for the large (0.25 inches wide) dumb-bell to be 1.400 inches to the left of the reference line. Marks corresponding to narrower dumb-bells will be placed to the right of this mark, nearer to the reference mark, and wider ones to the left. The distance from the large dumb-bell is given by the formula $5 \log_{10} \times \frac{d}{0.25}$ where d represents the width of the dumb-bell in inches (positive values are measures to the left and negative values to the right). For the small dumb-bell, 0.158 inches wide, the reference mark will consequently be $1.400 - 0.996 = 0.404$ inches to the left of the reference line. If dumb-bells wider than 0.25 inches are in use the dumb-bell mark will approach the main D scale, and, with the present embodiment of the device it would be impracticable to accommodate dumb-bells wider than 0.31 inches. If such wide dumb-bells were required, the entire rule could be made longer, or if small dumb-bells were not also required, the entire set of marks could be moved nearer to the reference line, or part of the right hand end of scale D could be sacrificed. This number of possibilities is available as a result of the circumstance that, in all, two points can be fixed arbitrarily, one controlling the load and stress scales and one controlling the thickness scale and reference mark, the two groups being otherwise independent. The other reference mark on this scale, labelled " Ring " will be described later.

The remaining scales on the front of the rule are the three scales on the reverse side of the slide. Two of these scales, (B and C) in the drawing are, in reality, one scale, the two sides being identical and exactly opposite each other. Scales B and C represent the load reading (in pounds) of the tensile test machine, and if the large dumb-bell thickness is 0.10 inches (normal) the breaking load in pounds will be $0.25 \times 0.10 = 0.025$ times the tensile stress at break. When the slide is in the " closed " position in the rule it is convenient to have scale C lying entirely within scale D so that the mark 25 pounds on Scale C should then be opposite the mark 1,000 pounds per square inch on Scale D, i.e., at 6.057 inches to the left of the reference line. For completion these scales require sub-dividing and describing by the words " Load Reading in Pounds " as in the drawing.

In arranging the figure 25 pounds on Scale C to be opposite 1,000 pounds per square inch on Scale D, the large dumb-bell thickness was taken as 100 thousandths of an inch. Consequently, in this position of the slide, the mark 100 on the thickness scale (graduated in thousandths of an inch) must be placed opposite the large dumb-bell reference mark, i.e., at a distance of 1.400 inches from the reference line.

In order to accommodate the thickness variation among normal dumb-bell specimens, the scale is extended on each side of the mark 100. The smallest thickness represented is 80 thousandths of an inch, the appropriate mark being $1.400 + 5 \log_{10} \frac{100}{80} = 1.885$ inches to the left of the reference line, and the largest thickness (120) will be $1.400 + 5 \log_{10} \frac{100}{120} = 1.004$ inches to the left of the reference line.

In order to use the scales on the obverse side of the slide, the slide is moved until the reference mark appropriate to the dumb-bell in use is opposite the thickness of the dumb-bell in thousandths of an inch. The load reading in pounds is then taken from the scale of the test machine and transferred into scale B or C, and simultaneously into scale A or D (whichever is required), by means of a cursor of normal design. In this manner the entire calculation is performed using only one setting of the rule and without having recourse to a list of " factors " which may be misread or transferred inaccurately to a normal type of slide rule. Since each scale is labelled distinctively, and moreover the numbers encountered in the different scales are of different orders, mistakes resulting from the employment of the wrong scale, (or of the values in the wrong order) are largely minimised. There is also rarely any difficulty in determining the position of the decimal point, since only occasionally are load readings recorded with value below the minimum of the scale, i.e., 4 pounds. This is of much importance when routine workers are performing the tests.

The scales on the reverse side of the slider are used in calculations concerned with condition (v), but before describing them in full, an additional scale situate on this side of the slide but intended for use with the obverse side of the slide, will be mentioned.

In many conventional slide rules, scales on the reverse side of the slide are used in conjunction with the A and D scales by the provision of small windows through which portions can be seen of the scales on the reverse side. A smiliar device is employed to extend the dumb-bell thickness scale to cover very small thicknesses. It is assumed that such small thicknesses would be used only in association with the small dumb-bell, and provision is made only for this combination. This supplementary thickness Scale G is essentially a continuation of that on the reverse side of the slide, being used in conjunction with a supplementary reference mark on the edge of the window. If it is not convenient to have the mark, and hence the window, immediately under the "small dumb-bell" reference mark on the obverse, the supplementary thickness scale and its reference mark may together be moved away from or towards the centre of the slide. In the embodiment now being described the whole has been moved 0.28 inches towards the centre; the numbers on this scale should be printed upside down so that they may be easily read when the rule is turned over.

Scales E and F are for use in tests on rings, condition (v), the scale E being used against scale A after turning the slide over. The normal ring thickness is 500 hundredths of a millimetre, (i.e., 5 mm), and it will be convenient, at this position, for scale E to lie entirely within scale A. The graduations of scale A are actually in lb/sq. inch, but for the purpose of ring calculations they are regarded as grams/sq. mm. The load reading in pounds equivalent to 100 gm/mm^2 will therefore be $\frac{100}{453} \times 5 \times 3.9 \times 2 = 8.6$ pounds (i.e., 100 gm/mm^2 ÷ factor for converting gm. to pounds × dimensions of ring × 2 (since there are two sides to the ring) which will thus be 7.486 inches to the left of the reference line. If, as is more usual, the results are required in kgm/sq. cm. it is only necessary to divide the result by 10.

The ring thickness scale F and ring reference mark may be placed arbitrarily, but it is convenient to place the ring mark about midway between those for the two dumb-bells, i.e., say 1.00 inches to the left of the reference line. It is useful to add the word "Ring" upside-down to remind the operator that the slide must be reversed in the grooves. The position of scale E was calculated for a normal ring thickness of 500 (i.e., 0.5 cm). The mark 500 must therefore be placed also 1.00 inches to the left of the reference line. The smallest thickness, (200) will thus be represented by a mark $1.00 + 5 \log_{10} \frac{5}{2} = 2.990$ inches to the left of the reference line.

If, as mentioned above, it is desired to obtain results in kg/cm^2 some instruction should be added, pointing out that although scale A is used for the result in the ring calculation the values have to be divided by 10 to obtain kilograms per square centimetre. If ring tests were to be carried out more frequently than dumb-bell tests with the small weight, it would be preferable to re-number scale A accordingly.

It will be understood that the example described is not to be considered in any way as restricting the invention, since the number, graduation, and arrangement of the scales may in practice be varied as found desirable.

Dated this 27th day of February, 1939.

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COMPLETE SPECIFICATION

Improvements in and relating to Calculating Devices for Use in the Tensile Testing of Materials

We, THE RESEARCH ASSOCIATION OF BRITISH RUBBER MANUFACTURERS, a Body Corporate duly organised under the Laws of Great Britain, of 105—107, Lansdowne Road, Croydon, in the County of Surrey, HENRY ROBERT HART, of 23, Surrey Street, Strand, London, W.C.2, HILDA MAY PORRITT, of "Desford," 39, Lansdowne Road, Worthing, in the County of Sussex, and CHRISTIAN HENDERSON, of 105—107, Lansdowne Road, Croydon, in the County of Surrey, all British Subjects, Legal Representatives of Benjamin Dawson Porritt, a British Subject, deceased, late of 105—107, Lansdowne Road, Croydon, in the County of Surrey, and RONALD GEORGE NEWTON, a British Subject, of 105—107, Lansdowne Road, Croydon, in the County of Surrey, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

This invention relates to a calculating device to be used in conjunction with machines for the tensile testing of materials, and especially for rubber. In carrying out such tests it is commonly required to calculate tensile stresses, referred to the original unstrained cross sectional area of the specimen, from corresponding loads read from the test machine; or the reverse procedure may be involved, as for instance in calculating the load required to produce pre-determined stresses in specimens of given cross-sectional area.

It is often not possible to make the specimens all of the same cross-sectional area. Consequently a separate calculation is usually needed for each specimen.

In calculations relating to such tensile tests it is a common practice to make use of both a list of " factors " and a slide rule of standard pattern. The number of processes to be carried out, as well as their complexity, introduces possibilities of several sources of error. Thus, in calculating tensile stress at break, in the case of dumb-bell shaped specimens of vulcanised rubber of constant width, the factor appropriate to the test in question must be taken from the list and set in the " A " scale of the slide rule by means of the cursor. The figure for the thickness of the dumb-bell must then be found on the " B " scale and also set against the cursor which must then be moved to the load value, read from the tensile test machine, on the " B " scale. This figure is transferred to the " A " scale by means of the cursor. The figure found in the " A " scale then represents the tensile stress required, but the position of the decimal point must be determined by inspection.

This process is tedious and involves two movements of the cursor and one movement of the slide, during which concentration is required to ensure that the actions are performed in the correct order. Special sources of error exist in the possibilities that the factor may be taken incorrectly from the list; the figures for thickness and machine reading on the " B " scale may be taken in the wrong order, the relative positions of the " factor " and the thickness value (or the machine reading and the result required) may be reversed on the " A " and " B " scales, or the position of the decimal point may be determined incorrectly. Moreover it is not possible to check, even approximately, the result obtained without repeating the entire process with the precision and concentration required for full accuracy. The present invention removes most of the sources of error and reduces both the level of concentration and the number of actions required as well as making it possible to obtain the result more quickly. In addition there is no ambiguity about the position of the decimal point, and approximate checks on the result obtained may subsequently often be performed without moving either the cursor or the slide, and at all times are easy to accomplish. Finally, the device is self-contained since no list of " factors " is required for its operation.

The device consists essentially of two relatively movable members upon which are marked three logarithmic scales, all on the same basis, relating respectively to the cross-sectional area of the specimen, the load on the specimen, and the stress on the specimen, together with a reference mark for use in conjunction with the cross-section scale. The load scale and stress scale are placed on different members, as are also the cross-section scale and the reference mark. The scales and reference mark are so disposed that when the mark is brought opposite a given reading (x) on the cross-section scale, the reading on the stress scale opposite to the point on the load scale representing z load units equals z/x.

If the load range of the tensile test machine can be changed, e.g., by changing the weight on the pendulum arm, so that the load reading has to be multiplied by a factor to give the true load, the calculating device may have, for use with the changed load range, an additional scale for the load reading or for the stress, which automatically introduces the multiplication factor.

Errors in the calibration of the load scale of the testing machine can be automatically corrected if the error is a constant percentage of the load reading, by slightly moving the load scale, or the stress scale, or the reference mark; if the error is not a constant percentage of the load reading, a specially graduated load or stress scale would be necessary.

Two scales, in English and metric units respectively may be provided for the same quantity, or the device may be made with some scales in English units and some in metric units, so that results in one system of units can be obtained directly from readings in the other system.

When the cross-section of the specimen is rectangular, and one dimension of the rectangle is constant, as is commonly the case with ring or dumb-bell shaped specimens of vulcanised rubber, the " cross-section " scale may be graduated in terms of the variable dimension, for instance the thickness (axial dimension) of rings or the thickness of dumb-bells. When the constant dimension has two or more standard values, as for instance in dumb-bell specimens, two or more reference marks, one appropriate to each standard value, are provided.

For testing specimens of circular cross-section the " cross-section " scale may be graduated in terms of the cross-sectional diameter; this scale is then graduated on a different basis from the others, the distance between two values bearing a given ratio to one another being twice the corresponding distance on the other scales.

It is convenient to use straight scales

arranged on a fixed and a movable member similar to those used in standard slide rules, but circular scales on relatively rotatable concentric discs, or any other suitable arrangement may be used.

The invention will be further described with reference to the accompanying drawings which illustrate one embodiment, for use especially in testing vulcanised rubber, and required for the conversion of loads to stresses or *vice versa*, under the following different conditions:—

(I) using dumb-bell shaped specimens of constant width 0.25 inch and variable thickness, normally between 0.08—0.12 inch but occasionally ranging down to 0.01 inch; loads in pounds; stresses in pounds per square inch.

(II) as (I), but using the test machine with a small pendulum weight such that the load reading is 5.18 times the actual load on the specimen.

(III) as (I), but using dumb-bell specimens 0.158 inch wide.

(IV) as (II), but using dumb-bell specimens 0.158 inch wide.

(V) using ring specimens of constant width 3.9 mm. and variable thickness, between 2.0 and 6.0 mm.; loads in pounds; stresses in grams per square millimetre.

In the drawings Fig. 1 is a front view of the calculating device and Fig. 2 a rear view of the slide. The embodiment of the apparatus illustrated by way of example, consists of eight logarithmic scales which are all on equivalent bases. A convenient size for the scales is such that the distance between the mark corresponding to any number and that for a number ten times larger (or smaller) is exactly 5 inches.

In determining the relative positions of the scales it will be convenient to establish an arbitrary reference line designated X in the drawing near the right hand end of the rule.

Scale A in the drawing carries the mark 3,000 lbs./sq. in. at a distance of 0.100 inches to the left of the reference line X. The smallest figure on this scale is 30 lbs./sq. inch and will thus lie 10.100 inches to the left of the reference line. The mark 100 lbs./sq. inch will lie 7.486 inches to the left of the reference line. This scale is intended for use with the small weight attached to the loading arm of the test machine (conditions (II) and (IV)) and consequently the words " Small Weight " are added to this scale. The intervals on this scale, and on any of the other scales, can be divided up in any manner which is convenient, such as that shown in the drawing or in the conventional manner for slide rules.

Scale D relates to readings with the large (normal) weight in position, (conditions (I) and (III) and consequently the relative positions of the scales A and D must be determined by the ratio between the sensitivities of the machine with the different weights on the loading arm. For this reason the mark 518.0 lbs./sq. inch on the D scale must be placed opposite the mark 100.0 lbs./sq. inch on the A scale, and will consequently be positioned a distance of 7.486 inches to the left of the reference line. The mark 1,000 lbs./sq. inch will now occupy a position 7.486 $- 5 \log_{10} \frac{1000}{518} = 6.057$ inches to the left of the reference line.

Scale D is completed by adding the words " Large Weight " and by dividing the logarithmic intervals as required.

In addition to the main scale on scale D there are also two reference marks Y and Z, shown as arrows in the drawing, which are used with the thickness scales on the sliding part of the rule. In relation to the main scales of the rule the positioning of these marks Y and Z is arbitrary but they must be in a definite relationship to each other, depending upon the widths of the dumb-bells which they represent.

It is convenient to arrange the mark Y for the large (0.25 inches wide) dumb-bell to be 1.400 inches to the left of the reference line. Marks corresponding to narrower dumb-bells will be placed to the right of this mark, nearer to the reference line, and wider ones to the left. The distance from the large dumb-bell mark is given by the formula

$$5 \log_{10} \frac{d}{0.25}$$

where d represents the width of the dumb-bell in inches (positive values of the distance are measured to the left and negative values to the right). For the small dumb-bell, 0.158 inches wide, the reference mark Z will consequently be 1.400 − 0.996 = 0.404 inches to the left of the reference line. If dumb-bells wider than 0.25 inches are in use the dumb-bell mark will approach the main D scale, and, with the present embodiment of the device it would be impracticable to accommodate dumb-bells wider than 0.31 inches. If such wide dumb-bells were required, the entire rule could be made longer, or if small dumb-bells were not also required, the entire set of marks could be moved nearer to the reference line, or part of the right hand end of scale D could be sacrificed. This number of possibilities is available as a result of the circumstance that, in all, two points can be fixed arbitrarily, one controlling the load and stress scales and one controlling the thickness scale and reference mark, the two groups being otherwise independent. The other reference mark R on this scale, labelled "Ring," will be described later.

The remaining scales on the front of the rule are the three scales on the obverse side of the slide. Two of these scales, (B and C in the drawing) are, in reality, one scale, the two sides being identical and exactly opposite each other. Scales B and C represent the load reading (in pounds) of the tensile test machine, and if the large dumb-bell thickness is 0.10 inches (normal) the breaking load in pounds will be $0.25 \times 0.10 = 0.025$ times the tensile stress at break. When the slide is in the "closed" position in the rule it is convenient to have scale C lying entirely within scale D so that the mark 25 pounds on scale C should then be opposite the mark 1,000 pounds per square inch on scale D, i.e., at 6.057 inches to the left of the reference line. For completion these scales require sub-dividing and describing by the words "Load Reading in Pounds" as in the drawing.

In arranging the figure 25 pounds on scale C to be opposite 1,000 pounds per square inch on scale D, the large dumb-bell thickness was taken as 100 thousandths of an inch. Consequently, in this position of the slide, the mark 100 on the thickness scale (graduated in thousandths of an inch) must be placed opposite the large dumb-bell reference mark Y, i.e., at a distance of 1.400 inches from the reference line X.

In order to accommodate the thickness variation among normal dumb-bell specimens, the scale is extended on each side of the mark 100. The smallest thickness represented is 80 thousandths of an inch, the appropriate mark being $1.400 + 5 \log_{10} \frac{100}{80} = 1.885$ inches to the left of the reference line, and the largest thickness (120) will be $1.400 \div 5 \log_{10} \frac{100}{120} =$ 1.004 inches to the left of the reference line.

In order to use the scales on the obverse side of the slide, the slide is moved until the reference mark appropriate to the dumb-bell in use is opposite the thickness of the dumb-bell, in thousandths of an inch. The load reading in pounds is then taken from the scale of the test machine and transferred into scale B or C, and simultaneously into scale A or D (whichever is required) by means of a cursor of normal design. In this manner the entire calculation is performed using only one setting of the rule and without having recourse to a list of "factors" which may be misread or transferred inaccurately to a normal type of slide rule. Since each scale is labelled distinctively, and moreover the numbers encountered in the different scales are of different orders, mistakes resulting from the employment of the wrong scale (or of the values in the wrong order) are largely minimised. There is also rarely any difficulty in determining the position of the decimal point, since only occasionally are load readings recorded with values below the minimum of the scale, i.e., 4 pounds. This is of much importance when routine workers are performing the tests.

The scales on the reverse side of the slider shown in Fig. 2 are used in calculations concerned with condition (V), but before describing them in full, an additional scale situate on this side of the slide but intended for use with the obverse side of the slide, will be mentioned.

In many conventional slide rules, scales on the reverse side of the slide are used in conjunction with the A and D scales by the provision of small windows through which portions can be seen of the scales on the reverse side. A similar device is employed to extend the dumb-bell thickness scale to cover very small thicknesses. It is assumed that such small thicknesses would be used only in association with the small dumb-bell, and provision is made only for this combination. This supplementary thickness scale G is essentially a continuation of that on the obverse side of the slide, being used in conjunction with a supplementary reference mark on the edge of the window, W. (In the normal position of the slide, the end marked V is to the right). If it is not convenient to have the mark, and hence the window, immediately under the "small dumb-bell" reference mark Z on the obverse side, the supplementary thickness scale and its reference mark may together be moved away from or towards the centre of the slide. In the embodiment now being described the whole has been moved 0.20 inch away from the centre; the numbers on this scale should be printed upside down so that they may be easily read when the rule is turned over.

Scales E and F are for use in tests on rings, condition (V), the scale E being used against scale A after turning the slide over and reversing it end-to-end, as shown in the upper drawing. The normal ring thickness is 500 hundredths of a millimetre, (i.e. 5 mm), and it will be convenient, at this position, for scale E to lie entirely within scale A. The graduations of scale A are actually in lb./sq. inch, but for the purpose of ring calculations they are regarded as grams/sq. mm. The load reading in pounds equivalent to 100 gm/mm² will therefore be $\frac{100}{453} \times 5 \times 3.9 \times 2 = 8.6$ pounds (i.e. 100 gm/mm² ÷ factor for converting gm to pounds × dimensions of ring × 2 (since there are two sides to the ring)) which will thus be 7.486 inches to the left of the reference line. If, as is more usual, the results are required in kgm/sq. cm. it is only necessary to divide the result by 10.

The ring thickness scale F and ring reference mark R may be placed arbitrarily, but it is convenient to place the ring mark about midway between those Y and Z for the two dumb-bells, i.e. say 1.00 inches to the left of the reference line. It is useful to add the word " Ring " upside-down to remind the operator that the slide must be turned over and reversed end-to-end in the grooves. The position of scale E was calculated for a normal ring thickness of 500 (i.e. 0.5 mm). The mark 500 must therefore be placed also 1.00 inches to the left of the reference line. The smallest thickness, (200) will thus be represented by a mark $1.00 + 5 \log_{10} \frac{5}{2} = 2.990$ inches to the left of the reference line.

If, as mentioned above, it is desired to obtain results in kg/cm² some instruction should be added, pointing out that although scale A is used for the result in the ring calculation, the values have to be divided by 10 to obtain kilograms per square centimetre. If ring tests were to be carried out more frequently than dumb-bell tests with the small weight, it would be preferable to renumber scale A accordingly.

It will be understood that the example described is not to be considered in any way as restricting the invention, since the number, graduation, and arrangement of the scales may in practice be varied as found desirable.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A calculating device, to be used in the tensile testing of materials for converting loads to stresses, or *vice versa*, for specimens of different cross-sectional areas, comprising two relatively movable members upon which are marked one or more logarithmic scales relating to each of the quantities: load, stress and cross-section, and one or more reference marks for use in conjunction with the cross-section scale or scales, the scales relating to load and stress respectively being placed on different members, and the cross-section scale or scales and reference mark or marks respectively on different members, the scales and mark or marks being so disposed that when, in using any appropriate combination of scales and mark, the mark is brought opposite a given reading (x) on the cross-section scale, the reading on the stress scale opposite to the point on the load scale representing z load units equals z/x.

2. A calculating device according to claim 1, for use with specimens whose cross-sectional area is a function of a single variable linear dimension of the section, characterised by having the cross-section scale or scales graduated directly in terms of the said variable linear dimension.

3. A calculating device according to either of the preceding claims adapted for use with specimens whose cross-section is a rectangle of which one side is variable and the other has two or more standard values, characterised by the provision of different reference marks corresponding to each of the said standard values.

4. A calculating device according to any of the preceding claims adapted for use in tests in which the load readings have to be multiplied by a constant factor to give the actual load, characterised by the provision of either a load scale, a stress scale, or a reference mark by which the multiplication factor is automatically introduced into the calculation of the result.

5. A calculating device according to any of the preceding claims wherein one or more of the scales are graduated in both English and metric units, or some scales are in English units and some in metric units, so that results in one system of units can be automatically obtained from readings in the other system.

6. A calculating device according to any of the preceding claims wherein the scales and reference mark or marks are disposed upon two straight members one of which is adapted to slide relative to the other in a direction parallel to their length.

7. A calculating device substantially as described with reference to the accompanying drawings.

Dated this 6th day of February, 1940.

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Agents for Applicants.

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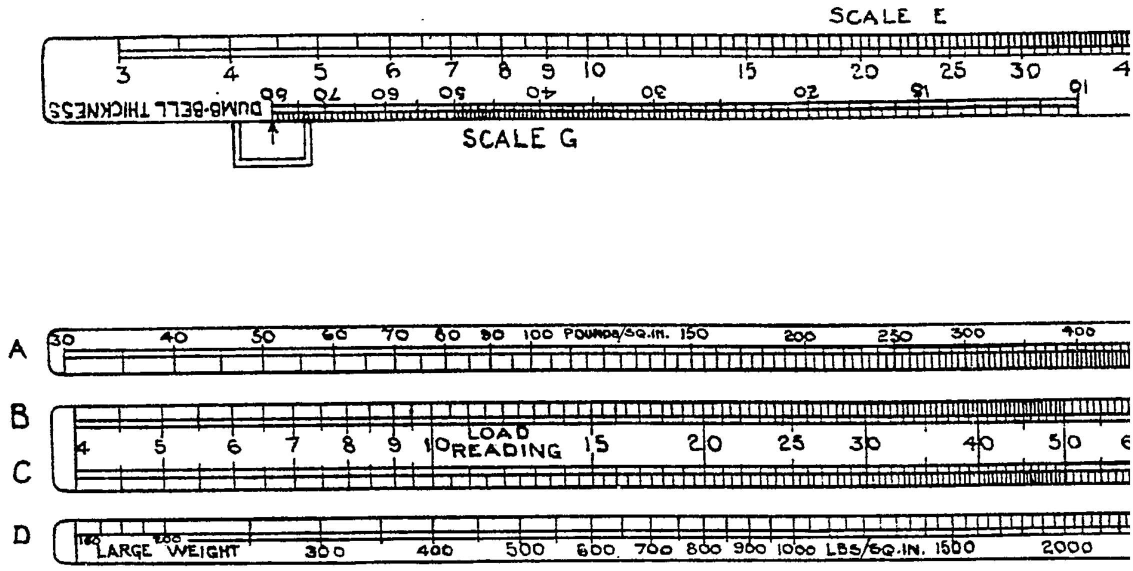
[This Drawing is a full-size reproduction of the Original.]



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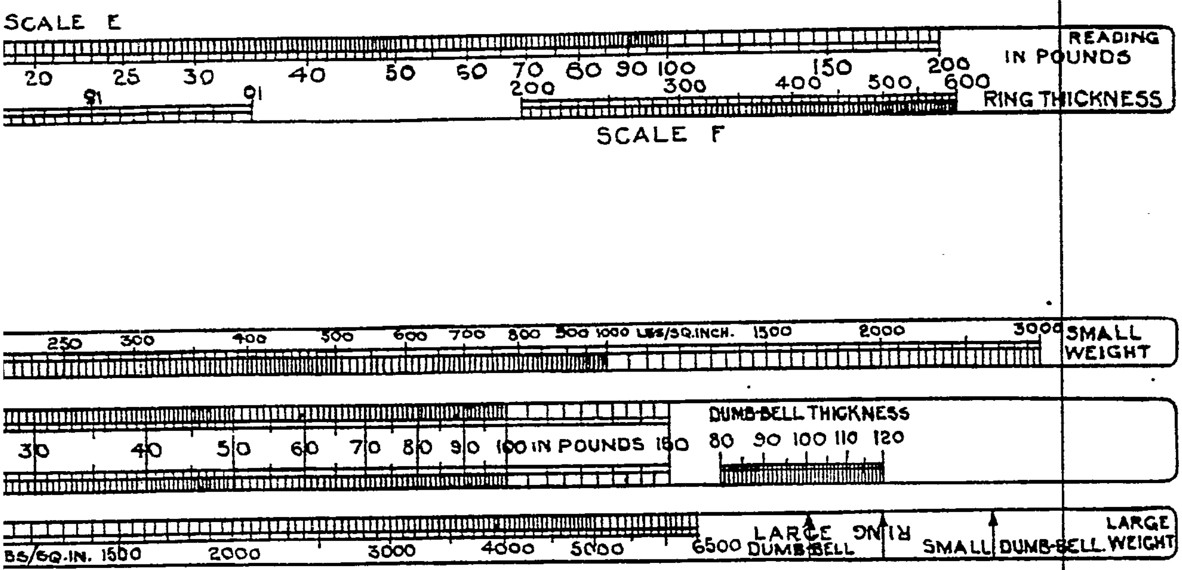

Maiby & Sons, Photo-Litho.

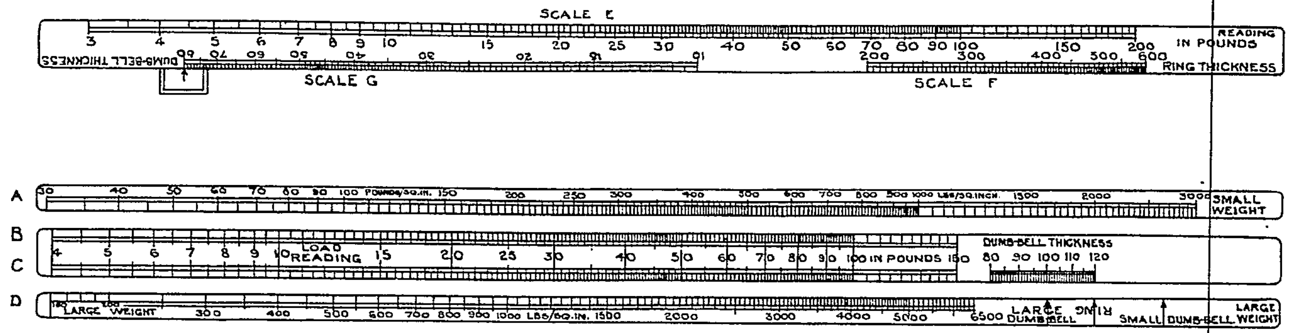

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FIG. 2.

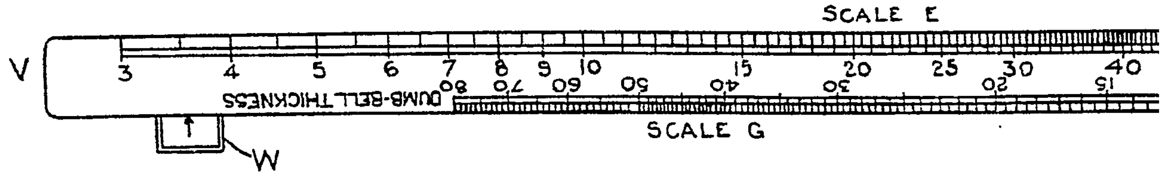

FIG. 1.

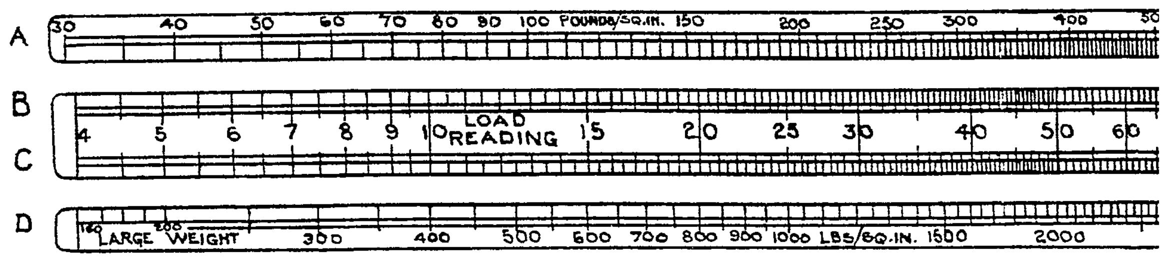

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FIG. 2.

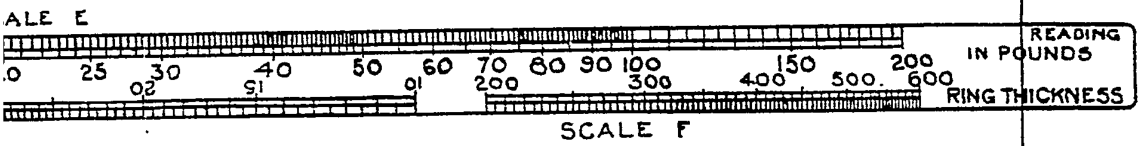


FIG. 1.

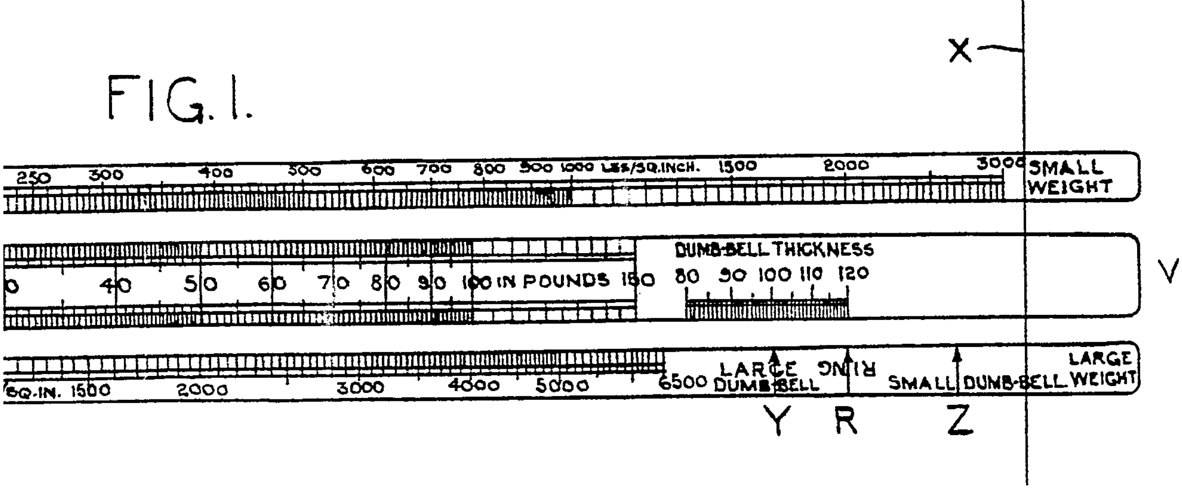


FIG. 2.

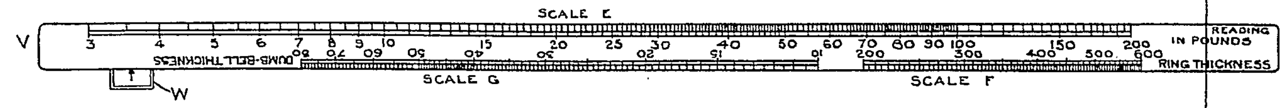
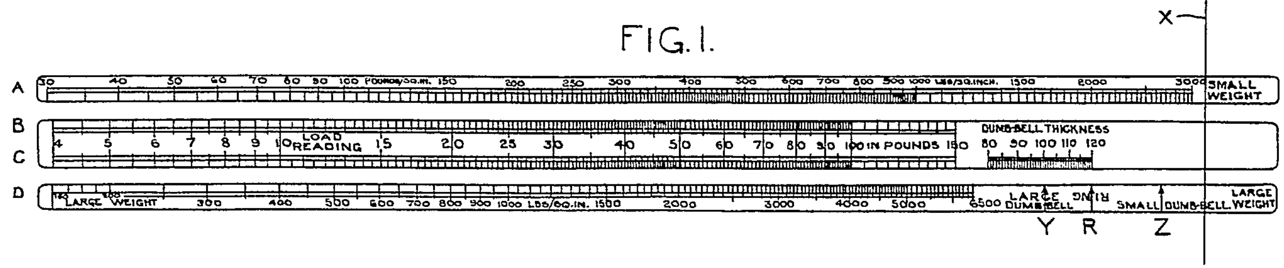


FIG. 1.



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