PATENT SPECIFICATION

829,868

DRAWINGS ATTACHED.

Date of filing Complete Specification : March 29, 1956.

Application Date : March 23, 1955. No. 8452/55.

Complete Specification Published : March 9, 1960.

Index at Acceptance:—Class 106(1), B3(L : N : S : V), B5(B : F : G4 : G17).

International Classification :—C05g.

COMPLETE SPECIFICATION.

Improvements in and relating to Slide-Rule Calculating Devices.

SPECIFICATION NO. 829,868

INVENTOR: JOHN ALLEN WOODROFFE STACEY

By a direction given under Section 17(1) of the Patents Act 1949 this applic proceeded in the name of Paristor Limited, a British Company, of 1, Crown Court, Cheapside, London, E.C.2.

THE PATENT OFFICE,
16th August, 1960

DS 79719/1(11)/4023 200 8/6

manner that the reciprocal of the value of one is equal to the sum of the reciprocals of the values of two others.

For example if two electrical resistances of values R1 and R2 are connected in parallel, a single resistance of value R equivalent to that arrangement is determined by the well known equation.

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2}$$

Similar relations exist when two condensers are connected in series; and between certain lens characteristics.

The aim of the invention is to enable an operator to ascertain rapidly the value of any one factor in an equation of the aforesaid type when he knows, or has selected, values for the other two factors: or to ascertain related pairs of values of any two factors which will fit the equation for a known or selected value of the third factor. For example he may wish to ascertain one or more pairs of values for R1 and R2 which connected in parallel will be of equivalent

marked as a base line on the cursor, and, when the cursor is mounted on the stock, being coincident with the said straight line on the stock, the parts being relatively slidable in the direction of the parallel edges of the stock to allow the curve to be moved to any desired position along the stock in relation to the co-ordinates thereon, and readings to be taken from the points of intersection of the curve and the co-ordinates.

In order that the invention can be more clearly understood the theory underlying the construction of a slide rule according thereto will first be set forth.

Consider two resistance of values R1 and R2 in parallel.

The value of the resultant resistance is given by

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2}$$

Rewriting this in terms of R1 gives

$$\frac{1}{R1} = \frac{1}{R} - \frac{1}{R2}$$

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COMPLETE SPECIFICATION.

Improvements in and relating to Slide-Rule Calculating Devices.

I, JOHN ALLEN WOODROFFE STACEY, a British Subject, formerly of 29 King Street, Guildhall, London, E.C.2, now of 3 Tokenhouse Buildings, London, E.C.2, do hereby declare the invention, for which I pray that a patent may be granted to me and the method by which it is to be performed, to be particularly described in and by the following statement :—

This invention relates to slide-rule calculating devices, and is concerned with slide rules adapted to determine the values of parameters which are related in such a manner that the reciprocal of the value of one is equal to the sum of the reciprocals of the values of two others.

For example if two electrical resistances of values R1 and R2 are connected in parallel, a single resistance of value R equivalent to that arrangement is determined by the well known equation.

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2}$$

Similar relations exist when two condensers are connected in series; and between certain lens characteristics.

The aim of the invention is to enable an operator to ascertain rapidly the value of any one factor in an equation of the aforesaid type when he knows, or has selected, values for the other two factors: or to ascertain related pairs of values of any two factors which will fit the equation for a known or selected value of the third factor. For example he may wish to ascertain one or more pairs of values for R1 and R2 which connected in parallel will be of equivalent value to a single resistance of known or selected value R.

With this end in view the invention consists in a slide-rule calculating device comprising a parallel-edged stock having a straight line parallel to one edge, and a series of intersecting calibrated rectangular logarithmic co-ordinates at 45° to said straight line, and a transparent cursor slidable on said stock, carrying a curve which is that part of a rectangular hyperbola, plotted against logarithmic co-ordinates, which lies on one side of the axis of symmetry of the said hyperbola, the said axis of symmetry being marked as a base line on the cursor, and, when the cursor is mounted on the stock, being coincident with the said straight line on the stock, the parts being relatively slidable in the direction of the parallel edges of the stock to allow the curve to be moved to any desired position along the stock in relation to the co-ordinates thereon, and readings to be taken from the points of intersection of the curve and the co-ordinates.

In order that the invention can be more clearly understood the theory underlying the construction of a slide rule according thereto will first be set forth.

Consider two resistance of values R1 and R2 in parallel.

The value of the resultant resistance is given by

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2}$$

Rewriting this in terms of R1 gives

$$\frac{1}{R1} = \frac{1}{R} - \frac{1}{R2}$$

[*Price* 3*s*. 6*d*.]

Price 4s 6d.

For any given value of R, $\frac{1}{R}$ is a constant, say K, so let

$$\frac{1}{R} = K$$

Then $$\frac{1}{R1} = \frac{KR2 - 1}{R2}$$

Or $$R1 = \frac{R2}{KR2 - 1}$$

Now this is the equation of a curve of the form

$$y = \frac{ax + b}{cx + d}$$

and represents a rectangular hyperbola. If, for any given value of R, this curve is plotted on logarithmic graph paper, with values of R1 and R2 set out as ordinates and abcissae respectively, a rectangular hyperbola is produced, and any point on that curve will give a direct reading of values of R1 and R2 which when connected in parallel will give the selected value of R.

In order that the invention may be more easily understood and readily put into practice a convenient embodiment thereof will now be described by way of example with reference to the drawings accompanying the Provisional Specification herewith, and the drawing accompanying this Specification comprising Figure 5, representing a slightly modified form of cursor for a slide-rule according to the invention.

Referring to Figure 1 of the aforesaid drawings it may be noted that by taking several different values of R, and using rectangular logarithmic co-ordinates, a series of rectangular hyperbolae can be plotted. Since these curves are all symmetrical about the line *a* passing through the origin at 45° to the co-ordinates of the curve, it is only necessary to consider part of one half of the curve, for example the part of the curve between this 45° line and a parallel line *b* spaced therefrom. Since a ratio of 10 : 1 for R1 : R2 is sufficient for the majority of practical problems, only those portions of the curves between the 45° line through the origin and the second line *b* parallel thereto passing through the point (10, 1) need be considered.

The only change in the equation which produces this family of curves is in the value of the constant K, so that all the curves are exactly the same shape and consequently if a curve of the correct shape were drawn on a transparent cursor which would slide along the 45° line through the origin, this cursor curve could be superimposed on each of the curves, in Figure 1 by this simple sliding motion along the lines *a*, *b*.

Furthermore, from this formula it is apparent that when R1=R2 this point plotted on any of the curves lies on the 45° line through the origin.

In addition when R1=R2, R1=2R
so that log R1=log 2R
=log 2+log R.

This formula represents the spacing of the values of R on logarithmic paper.

It follows that for all values of R1=R2, i.e. at all points along the line *a* of Figure 1, the value of R is spaced at a constant distance equal to log 2, along the line *a*, from the value of R1=R2. Thus if along line *a* are inserted the values of R at the points of intersection of the co-ordinates therewith it is clear that for any selected value of R along the line *a* the aforesaid curve showing the relations of R, R1 and R2 would be located to intersect line *a* at a point spaced by a distance further away from the origin equal to log 2 along the line *a* from the point thereon representing the selected value of R.

This relationship can be clearly seen from Figure 2 of the drawings wherein the various values of R, have been inserted at the appropriate points along the line *a*, and it will be seen that for R=5 the curve intersects line *a* at a distance equal to log 2 forward of the selected point R=5, and at a value R1=R2=10. Similarly as shown in dotted lines in Figure 2 the curve set to a value R1=R2=4, intersects line *a* at a distance equal to log 2 from the point R=2. The curve indicates at any point the values of R1 and R2 which, when connected in parallel, will provide an equivalent resistance of value R, and these values can be read off by noting the abcissae and ordinate which intersect at the selected point on the curve. For example, referring to the dotted lines in Figure 2 it will be seen that for a value R=2, the curve indicates that R1=R2=4 will in parallel provide an equivalent value of resistance: and it also indicates that the same result will be achieved if R1=6 and R2=3 (since the curve runs through the intersection of these co-ordinate lines).

In accordance with the invention advantage is taken of the aforesaid relationship illustrated in Figure 2 by providing a cursor on which is formed a reference line, and also the rectangular hyperbola spaced from the reference line by a distance equal to log 2, along an edge of the cursor which is adapted to be aligned with the line *a* of the graph in Figures 1 and 2. It will be apparent that by sliding the cursor along the line *a* (assuming that the curve on the cursor extends to the line *b* of the graph) the reference line can be located on any desired value of R whereafter the curve will indicate the relationship of values of R1 and R2 (for any value of either) which will, in parallel, provide an equivalent resistance R. Alternatively if the curve is moved to intersect the point at which co-ordinates of selected values of R1 and R2 intersect, the reference line will then indicate on the scale marked along line *a* the value R of the equivalent single resistance. A slide-rule so constructed is illustrated in Figure 3, and the cursor removed from the stock is separately illustrated in Figure 4.

Summarising the above discussion it will be seen that the cursor mentioned above is provided with a reference line co-operating with a logarithmic scale of values of R marked on a graph along the 45° line from the origin and this reference line is disposed log 2 along this 45° line from the point at which the curve cuts the 45° line. By setting the cursor with the reference line against a given value of R on the scale (i.e. the 45° line through the origin) the curve will be disposed in a position such that values of R1 and R2 which in parallel will give the selected value of R, can be read directly from it.

The invention thus provides a slide rule calculating device adapted to provide a solution of an equation in which the reciprocal of one factor is equal to the sum of the reciprocals of two other factors, for any known or selected value(s) of one or two of said factors, and incorporates a stock exhibiting rectangular co-ordinates set out to logarithmic scales, and calibrated with values of two of said factors, and a cursor slidable in relation to said stock, incorporating a reference line whereby the cursor can be set to any desired position on said stock, and a curve scaled to co-operate with said co-ordinates on said stock, representing the relationship of said two factors for any given value of the third factor.

The slide rule may comprise a stock member bearing co-ordinates which are related to an orgin adjacent to one corner of the stock member and extending at 45° to the longitudinal axis of said stock member, said co-ordinates respectively representing the finite values of the two unknowns within predetermined limits, and a cursor bearing a hair line in the form of a rectangular hyperbola obtained by plotting, against rectangular logarithmic co-ordinates, one unknown against the other unknown, for a given value of the known value, said cursor being slidable longitudinally of the stock member with the axis of symmetry of the hyperbola coincident with a line passing through the origin at 45° to the co-ordinates, and carrying also a reference line cutting said axis of symmetry at a point whose co-ordinates represent half the value of either unknown, at the point when the hyperbola cuts said axis.

A device embodying the invention is particularly applicable to the determination of electrical resistance and capacity values and in a slide rule made in accordance with the invention for this purpose the co-ordinates on the stock member represent the logarithmically plotted values of resistance or capacity while the point at which the reference line cuts the axis of symmetry for a given position of the cursor represents the value of resistance or capacity whose reciprocal equals the sum of the reciprocals of the resistance or capacity values represented by the point at which the hyperbola cuts the axis of symmetry for the same given position of the cursor.

Thus by setting the cursor with the reference line in register with a particular value on the scale, the values the sum of whose reciprocals equals the reciprocal of said particular value, are represented by the co-ordinates of points along the hyperbola, those co-ordinates being marked at intervals on the stock member to permit their values to be read-off.

In order to obtain similar readings corresponding to values within a predetermined percentage above or below the particular value to which the reference is set in register as mentioned above, the cursor may be provided with auxiliary reference lines disposed at distance to either side of the main reference line representing predetermined percentage deviations, each of these auxiliary reference lines having its corresponding auxiliary hyperbola marked on the cursor with the point at which said hyperbola cuts the 45° line located at distance log 2 from the associated auxiliary reference line.

To give percentage tolerances further hyperbolae are drawn on the cursor at distances representing ±5%, ±10% and ±20% of the value of resistance R, and again due to the log/log graph paper these distances will be constant for all parts of the scale. Thus if two R1/R2 lines cross within the area enclosed by the ±5% hyperbolae, resistors of these indicated values in parallel will give ±5% of the required resistance R. In the same way values within ±10% or ±20% of the required value of R may be determined using the ±10% or ±20% hyperbolae.

The reference line for the value of R is also calibrated in terms of ±5%, ±10%, ±20% and to find the actual maximum ohmic variation in the value of resistors of say ±5% tolerance the cursor is set to read the given value of R, and the two appropriate tolerance lines will read the upper and lower limits in resistance value.

A slightly modified form of cursor according to the invention to achieve the same result is shown in Figure 5 of the drawings.

In this case the auxiliary hyperbolae shown in Figure 4 are omitted and the cursor is provided e.g. at its top edge, as shown in Figure 5, with a scale of markings calibrated in steps of $\pm 5\%$ tolerance in the value of a variable, e.g. a resistance, on each side of the reference line by which the cursor is set. By using a marking on this scale representing a selected percentage tolerance as the setting line for the cursor, different resultant readings of the hyperbola on the graph markings of the stock of the slide rule can be obtained. As shown in Figure 5 the cursor may be provided with two perpendicular markings, arbitrarily located one on each side of the curve, extending downwards from the upper edge at 45° to the edge, and labelled W1 or V1 and W2 or V2 respectively. These correspond to the co-ordinate lines on the stock member, and enable an operator to determine which value should be regarded as R1 or C1, and which as R2 or C2 when using the power/voltage ratio scale.

The same principles can be applied to condensers in series, and the scale is equally applicable to values of either R or C between 1 and 10. Any value of resistor or condenser outside this range may be read-off, in any convenient unit, by multiplication of the scale reading by the appropriate multiple of 10. The slide rule suitably calibrated may also be employed for calculating the focal length of a lens determined by the well-known formula

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

With this arrangement if the main reference line is set to a given value, then co-ordinates of points along any one of the auxiliary hyperbolae represent values the sum of whose reciprocals is equal to the reciprocal of a value which differs from the value to which the main reference line is set by the percentage deviation appropriate to said hyperbola. Further, the corresponding auxiliary reference line will register on the scale with the value which equals the value to which the main reference line has been set less said percentage.

The device may also be calibrated to give wattage ratios for resistors and voltage ratios for condensers. Thus if the wattage required for resistance R1 is W1 and for R2 is W2 (Fig. 5), then:

$$\frac{W1}{W2} = \frac{R2}{R1}$$

Similarly in the case of condensers if the voltage across condenser of capacity C1 is V1, and the voltage across of capacity C2 is V2, then:

$$\frac{V1}{V2} = \frac{C1}{C2}$$

These ratios can be marked on the cursor by a series of lines *c* (Fig. 4) parallel to the 45° axis of symmetry of the hyperbolae as shown in Figure 3, the same calibration being applicable to both resistors and condensers.

The constructional details of a slide-rule according to the invention may be of conventional form. For example the stock may be a strip of opaque plastic on which the co-ordinates are marked; or a strip of paper or the like on which they are printed may be secured, e.g. by adhesive, thereto. The cursor may be of transparent plastic with flanges to engage the opposite edges of the stock, and the usual spring means to hold it firm against one edge. The reference line and curve may conveniently be marked directly on the transparent cursor.

It should be understood that the invention is not limited solely to the constructional details of the form described above which may be modified, in order to meet various conditions and requirements encountered, without departing from the scope of the invention.

WHAT I CLAIM IS:—

1. A slide-rule calculating device comprising a parallel-edged stock having a straight line parallel to one edge, and a series of intersecting calibrated rectangular logarithmic co-ordinates at 45° to said straight line, and a transparent cursor slidable on said stock, carrying a curve which is that part of a rectangular hyperbola, plotted against logarithmic co-ordinates, which lies on one side of the axis of symmetry of the said hyperbola, the said axis of symmetry being marked as a base line on the cursor, and, when the cursor is mounted on the stock, being coincident with the said straight line on the stock, the parts being relatively slidable in the direction of the parallel edges of the stock to allow the curve to be moved to any desired position along the stock in relation to the co-ordinates thereon, and readings to be taken from the points of intersection of the curve and the co-ordinates.

2. A slide-rule as claimed in Claim 1 wherein the co-ordinates are calibrated, and the form of the curve determined, from values of parameters related in such a manner that the reciprocal of the value of one parameter is equal to the sum of the reciprocals of the values of two others.

3. A slide-rule as claimed in Claim 1 or 2 wherein either or both of the relatively movable parts is or are provided with auxiliary markings to allow readings to be taken in respect of variations by comparatively small percentages of one or more of the parameters.

4. A slide-rule calculating device sub-

stantially as described herein with reference to the drawings accompanying the Provisional Specification or to Figs. 1 to 3 of these drawings and the drawing accompanying the Complete Specification of this invention.

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PROVISIONAL SPECIFICATION.

Improvements in and relating to Slide-Rule Calculating Devices.

I, JOHN ALLEN WOODROFFE STACEY, a British Subject, of 29 King Street, Guildhall, London, E.C.2, do hereby declare this invention to be described in the following statement:—

This invention relates to slide-rule calculating devices, and is concerned with slide rules adapted to determine the values of parameters which are related in such a manner that the reciprocal of the value of one is equal to the sum of the reciprocals of the values of two others.

For example if two electrical resistances of values R1 and R2 are connected in parallel, a single resistance of value R equivalent to that arrangement is determined by the well known equation

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2}$$

Similar relations exist when two condensers are connected in series; and between the focal length of a lens and the radii of curvature of its surfaces.

The aim of the invention is to enable an operator to ascertain rapidly the value of any one factor in an equation of the aforesaid type when he knows, or has selected, values for the other two factors: or to ascertain related pairs of values of any two factors which will fit the equation for a known or selected value of the third factor. For example he may wish to ascertain one or more pairs of values for R1 and R2 which connected in parallel will be of equivalent value to a single resistance of known or selected value R.

In order that the invention can be more clearly understood the theory underlying the construction of a slide rule according thereto will first be set forth.

Consider two resistances of values R1 and R2 in parallel.

The value of the resultant resistance is given by

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2}$$

Rewriting this in terms of R1 gives

$$\frac{1}{R1} = \frac{1}{R} - \frac{1}{R2}$$

For any given value of R, $\frac{1}{R}$ is a constant, say K, so let

$$\frac{1}{R} = K$$

Then $$\frac{1}{R1} = \frac{KR2 - 1}{R2}$$

or $$R1 = \frac{R2}{KR2 - 1}$$

Now this is the equation of a curve of the form

$$y = \frac{ax + b}{cx + d}$$

and represents a rectangular hyperbola. Further if the logarithms of both sides of the equation be taken the equation still represents a rectangular hyperbola.

Accordingly if, for any given value of R, this curve is plotted on logarithmic graph paper with values, of R1 and R2 set out as ordinates and abcissae respectively, a rectangular hyperbola is produced, and any point on that curve will give a direct reading of values of R1 and R2 which in parallel will give the selected value of R.

In order that the invention may be more easily understood and readily put into practice a convenient embodiment thereof will now be described by way of example with reference to the accompanying drawings in which:—

Figure 1 shows a graph upon which the scales on the slide rule are based, the intermediate lines of the logarithmic paper being omitted for clarity;

Figure 2 shows the graph area and the calibration used on the slide rule;

Figure 3 shows a calibrated slide rule and cursor in position thereon: and

Figure 4 represents the cursor removed from the slide rule.

Referring to Figure 1 of the drawings herewith it may be noted that by taking several different values of R, a series of rectangular hyperbolae can be plotted. Since these curves are all symmetrical about the line *a* passing through the origin at 45° to the co-ordinates of the curve, it is only necessary to consider one half of the curve, for example the part of the curve between this 45° line and a parallel line *b* spaced therefrom.

Furthermore, a ratio of 10 : 1 for R1 : R2 is sufficient for the majority of practical problems, so that only those portions of the curves between the 45° line through the origin and the second line parallel thereto passing through the point (10, 1) need be considered.

The only change in the equation which produces this family of curves is in the value of the constant K, so that all the curves are exactly the same shape and consequently if a curve of the correct shape were drawn on a transparent cursor which would slide along the 45° line through the origin, this cursor curve could be superimposed on each of the curves in Figure 1 by this simple sliding motion.

Furthermore, from the formula it is apparent that when R1=R2 this point plotted on any of the curves lies on the 45° line through the origin.

In addition when R1=R2, R1=2R
so that log R1=log 2R
=log 2+log R.

It follows that for all values of R1=R2, i.e. at all points along the line *a* of Figure 1, the value of log R is spaced at a constant distance equal to log 2, along the line *a*, from the value of log R1. Thus if along line *a* are inserted the values of R at the points of intersection of the co-ordinates therewith it is clear that for any selected value of R along the line *a* the aforesaid rectangular hyperbola showing the relations of R, R1 and R2 would be located to intersect line *a* at a point spaced by a distance further away from the origin equal to log 2 along the line *a* from the point thereon representing the selected value of R.

This relationship can be clearly seen from Figure 2 of the accompanying drawings wherein the various values of R have been inserted at the appropriate points along the line *a*, and it will be seen that for R=5 the rectangular hyperbola intersects line *a* at a distance equal to log 2 forward of the selected point R=5, and at a value R1=R2=10. Similarly as shown in dotted lines in Figure 2 the curve intersects line *a* at a distance equal to log 2 from a selected point R=2. The curve indicates at any point the values of R1 and R2 which, in parallel, will provide an equivalent resistance of value R, and these values can be read off by noting the abscissa and ordinate which intersect at the selected point on the curve. For example, referring to the dotted lines in Figure 2 it will be seen that for a value R=2, the curve indicates that R1=R2=4 will in parallel provide an equivalent value of resistance: and it also indicates that the same result will be achieved if R1=6 and R2=3 (since the curve runs through the intersection of these co-ordinate lines).

In accordance with the invention advantage is taken of the aforesaid relationship illustrated in Figure 2 by providing a cursor on which is formed a reference line, and also the rectangular hyperbola spaced from the reference line by a distance equal to log 2, along an edge of the cursor which is adapted to be aligned with the line *a* of the graph in Figures 1 and 2. It will be apparent that by sliding the cursor along the line *a* (assuming that the curve on the cursor extends to the line *b* of the graph) the reference line can be located on any desired value of R whereafter the curve will indicate the relationship of values of R1 and R2 (for any value of either) which will in parallel provide an equivalent resistance. Alternatively if the curve is moved to intersect the point at which co-ordinates of selected values of R1 and R2 intersect the reference line will then indicate on the scale marked along line *a* the value R of the equivalent single resistance. A slide-rule so constructed is illustrated in Figure 3, and the cursor removed from the stock is separately illustrated in Figure 4.

Summarising the above discussion it will be seen that the cursor mentioned above is provided with a reference line co-operating with a logarithmic scale of values of R marked on a graph along the 45° line from the origin and this reference line is disposed log 2 along this 45° line from the point at which the curve cuts the 45° line. By setting the cursor with the reference line against a given value of R on the scale (i.e. 45° line through origin) the curve will be disposed in a position such that values of R1 and R2 which in parallel will give the selected value of R, can be read directly from it.

Accordingly the present invention consists in a slide rule calculating device adapted to provide a solution of an equation in which the reciprocal of one factor is equal to the sum of the reciprocals of two other factors, for any known or selected value(s) of one or two of said factors, comprising a stock incorporating rectangular co-ordinates set out to logarithmic scales, and calibrated with values of two of said factors, and a cursor slidable in relation to said stock, incorporating a reference line whereby the cursor can be set to any desired position on said stock, and a curve scaled to co-operate with said co-ordinates on said stock, representing the relationship of said two factors for any given value of the third factor.

The slide rule may comprise a stock member bearing co-ordinates which are related to an origin adjacent one corner of the stock member and extending at 45° to the longitudinal axis of said stock member, said co-ordinates respectively representing the logarithms of finite values of the two unknowns within pre-determined limits, and a cursor bearing a hair line in the form of a rectangular hyperbola obtained by plotting the logarithm of one unknown against the logarithm of the other unknown for a given value of the known value, said cursor being slidable longitudinally of the stock member with the axis of symmetry of the hyperbola coincident with a line passing through the origin at 45° to the co-ordinates, and carrying also a reference line cutting said axis of symmetry at a point whose co-ordinates represent the logarithm of half the value of either unknown, at the point when the hyperbola cuts said axis.

A device embodying the invention is particularly applicable to the determination of electrical resistance and capacity values and in a slide rule made in accordance with the invention for this purpose the co-ordinates on the stock member represent the logarithms of values of resistance or capacity while the point at which the reference line cuts the axis of symmetry for a given position of the cursor represents the value of resistance or capacity whose reciprocal equals the sum of the reciprocals of the resistance or capacity values represented by the point at which the hyperbola cuts the axis of symmetry for the same given position of the cursor.

Thus by setting the cursor with the reference line in register with a particular value on the scale, the values the sum of whose reciprocals equals the reciprocal of said particular value, are represented by the co-ordinates of points along the hyperbola, those co-ordinates being marked at intervals on the stock member to permit their values to be read-off.

In order to obtain similar readings corresponding to values within a predetermined percentage above or below the particular value to which the reference is set in register as mentioned above, the cursor may be provided with auxiliary reference lines disposed at distances to either side of the main reference line representing predetermined percentage deviations, each of these auxiliary reference lines having its corresponding auxiliary hyperbola marked on the cursor with the point at which said hyperbola cuts the 45° line located at distance log 2 from the associated auxiliary reference line.

To give percentage tolerances further hyperbolae drawn on the cursor at distances representing ±5%, ±10% and ±20% of the value of resistance R, and again due to the log/log graph paper these distances will be constant for all parts of the scale. Thus if two R1/R2 lines cross within the area enclosed by the ±5% hyperbolae, in parallel, resistors of these indicated values will give ±5% of the required resistance R. In the same way values within ±10% or ±20% of the required value of R may be determined using the ±10% or ±20% hyperbolae.

The reference line for the value of R is also calibrated in terms of ±5%, ±10%, ±20%, and to find the actual maximum ohmic variation in the value of resistors of say ±5% tolerance the cursor is set to read the given value of R, and the two appropriate tolerance lines will read the upper and lower limit in resistance value.

The same principles can be applied to condensers in series, and the scale is equally applicable to values of either R or C between 1 and 10. Any value of resistor or condenser outside this range may be read-off, in any convenient unit, by multiplication of the scale reading by the appropriate multiple of 10. The slide rule suitably calibrated may also be employed for calculating the focal length of a lens determined by the well-known formula

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

With this arrangement if the main reference line is set to a given value, then co-ordinates of points along any one of the auxiliary hyperbolae represent values the sum of whose reciprocals is equal to the reciprocal of a value which differs from the value to which the main reference line is set by the percentage deviation appropriate to said hyperbola. Further, the corresponding auxiliary reference line will register on the scale with the value which equals the value to which the main reference line has been set less said percentage.

The device may also be calibrated to give wattage ratios for resistors and voltage ratios for condensers. Thus if the wattage required for resistance R1 is W1 and for R2 is W2, then :

$$\frac{W1}{W2} = \frac{R2}{R1}$$

Similarly in the case of condensers, if the voltage across condenser C1 is V1, and the voltage across C2 is V2, then :

$$\frac{V1}{V2} = \frac{C1}{C2}$$

These ratios can be marked on the cursor by a series of lines *c* parallel to the 45° axis of symmetry of the hyperbolae as shown in Figure 3, the same calibration being applicable to both resistors and condensers.

The constructional details of a slide-rule according to the invention may be of conventional form. For example the stock may be a strip of opaque plastic on which the co-ordinates are marked, or a strip of paper or the like on which they are printed may be secured e.g. by adhesive thereto. The cursor may be of transparent plastic with flanges to engage the opposite edges of the stock, and the usual spring means to hold it firm against one edge. The reference line and curve may conveniently be marked directly on the transparent cursor.

It should be understood that the invention is not limited solely to the constructional details of the form described above which may be modified, in order to meet various conditions and requirements encountered, without departing from the scope of the invention.

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Abingdon : Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1960.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2,
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829,868 COMPLETE SPECIFICATION
1 SHEET This drawing is a reproduction of the Original on a reduced scale.

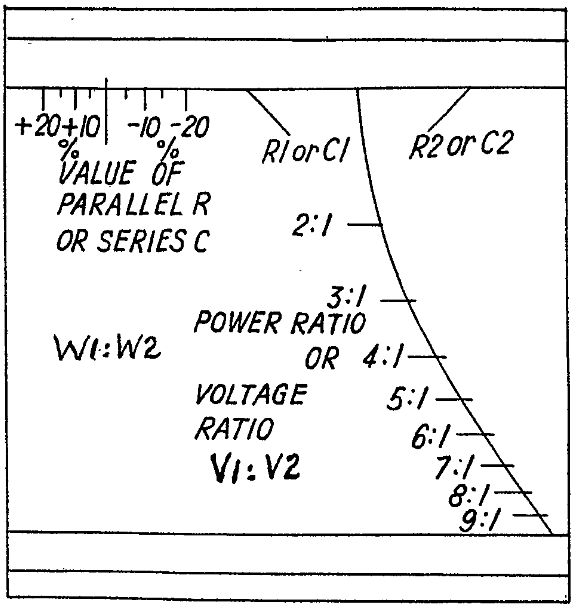


Fig. 5.

FIG. 1.

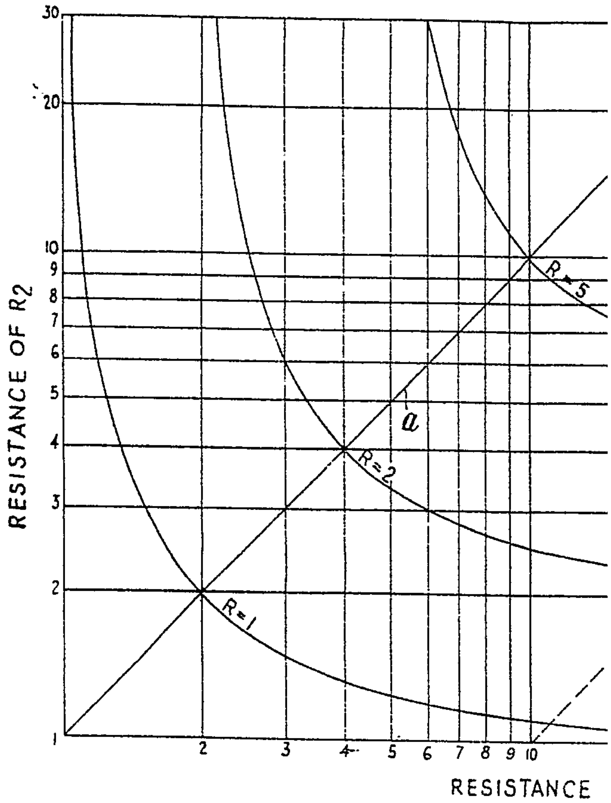
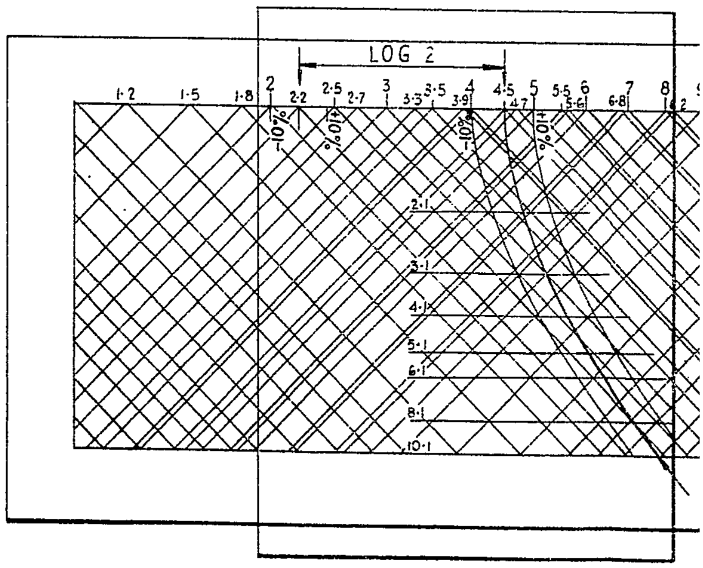

RESISTANCE OF R2
RESISTANCE
R=1
R=2
R=5
a
30
20
10
9
8
7
6
5
4
3
2
1
2
3
4
5
6
7
8
9
10

FIG. 3.


LOG 2
-10%
+10%
-10%
+10%
2·1
3·1
4·1
5·1
6·1
8·1
10·1

829,868 PROVISIONAL SPECIFICATION
2 SHEETS

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

FIG. 1.

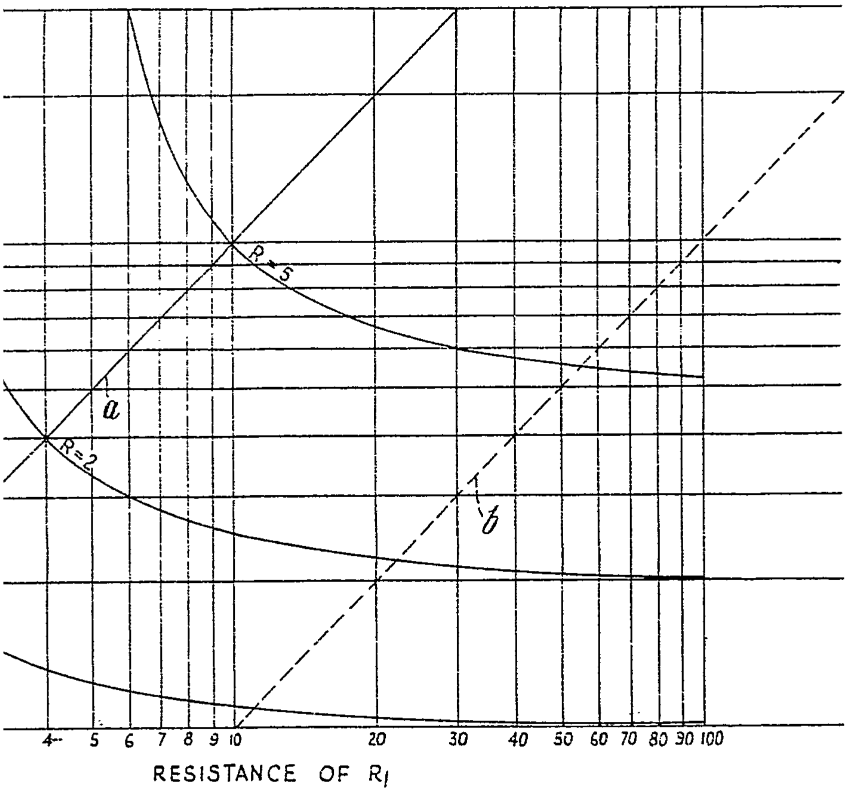
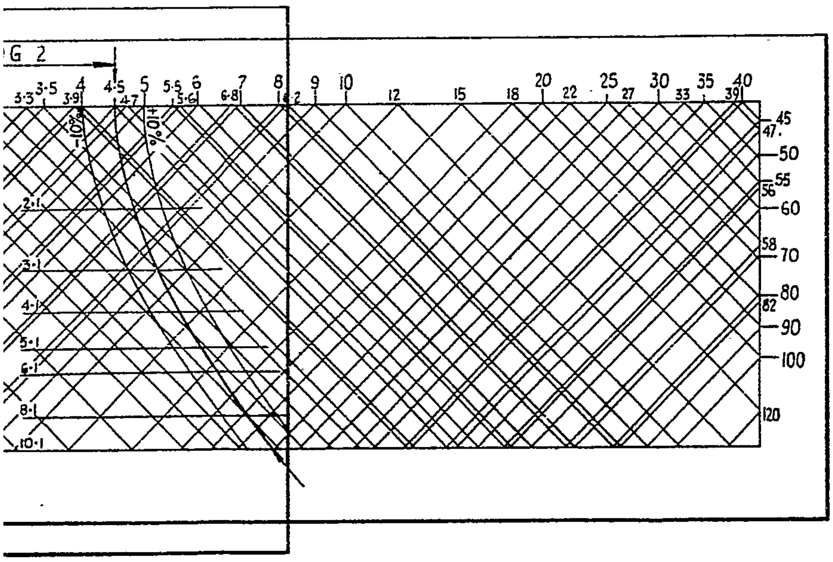


FIG. 3.



829,868 2 SHEETS

PROVISIONAL SPECIFICATION

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SHEET 1

FIG. 1.

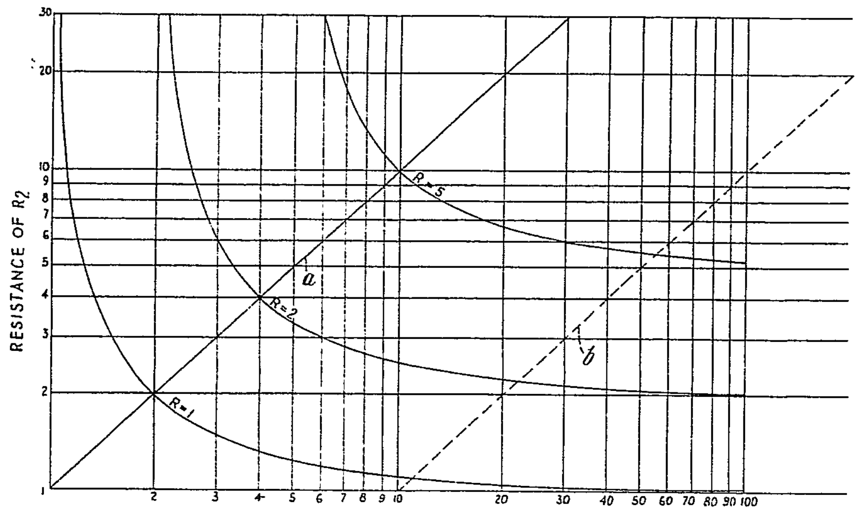


FIG. 3.

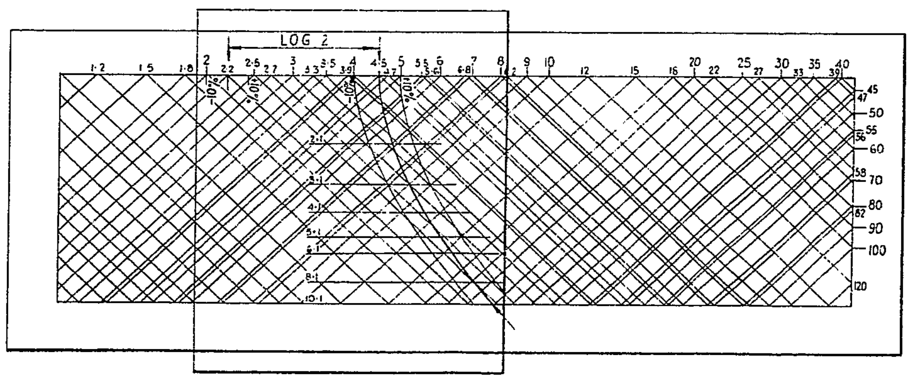
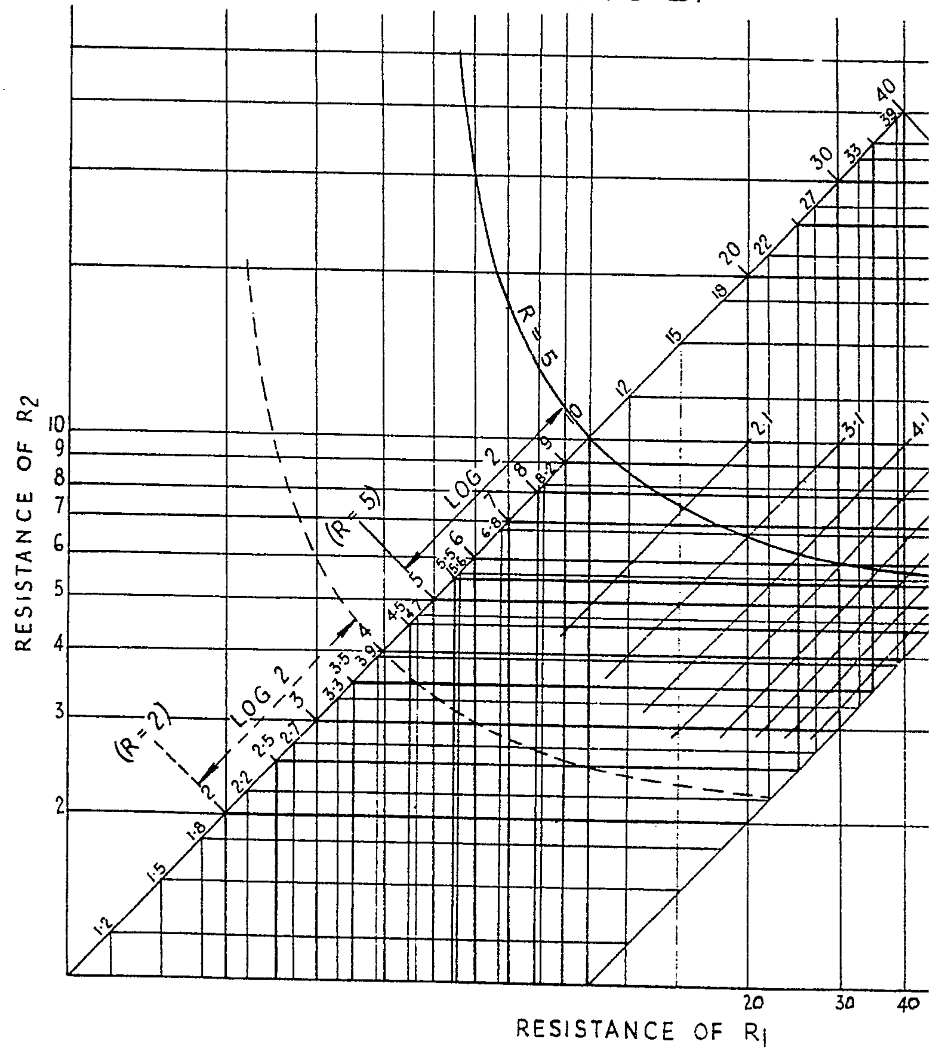


FIG. 2.


RESISTANCE OF R2
RESISTANCE OF R1
R = 5
LOG 2
LOG 2
(R = 5)
(R = 2)
10
9
8
7
6
5
4
3
2
20
30
40

829,868 PROVISIONAL SPECIFICATION
2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEET 2

; 2.

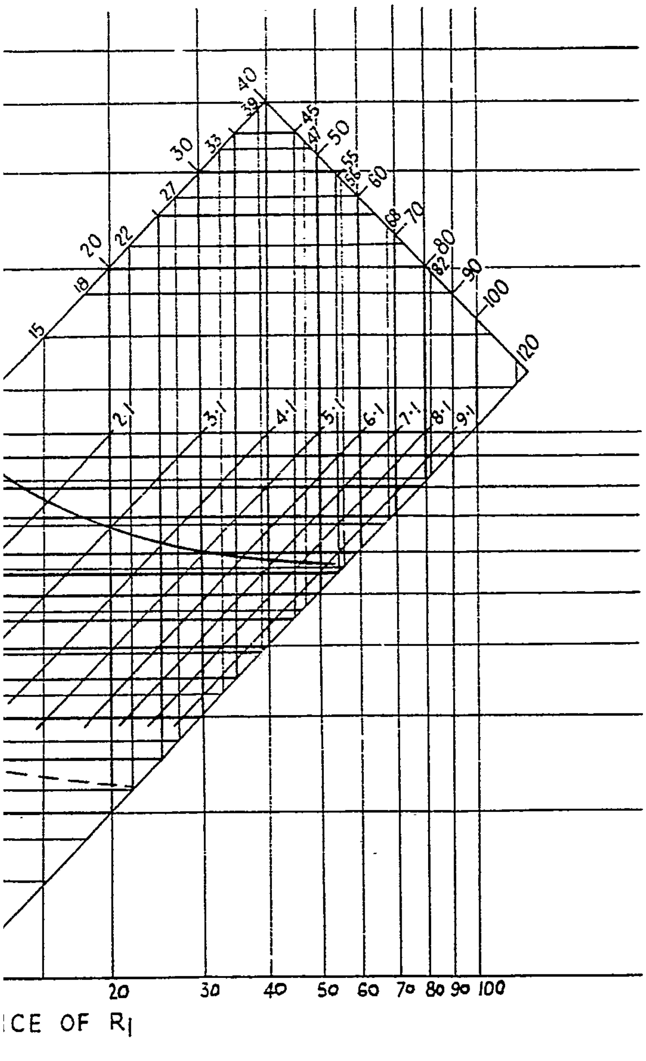
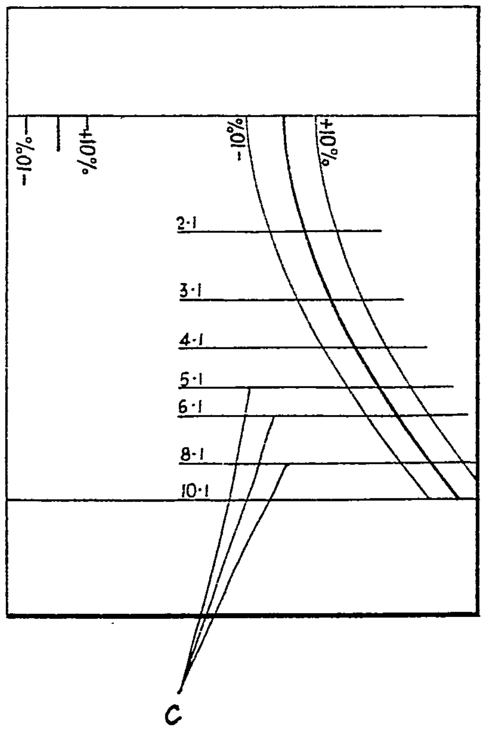


FIG. 4.



829,868 PROVISIONAL SPECIFICATION
2 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEET 2

FIG. 2.

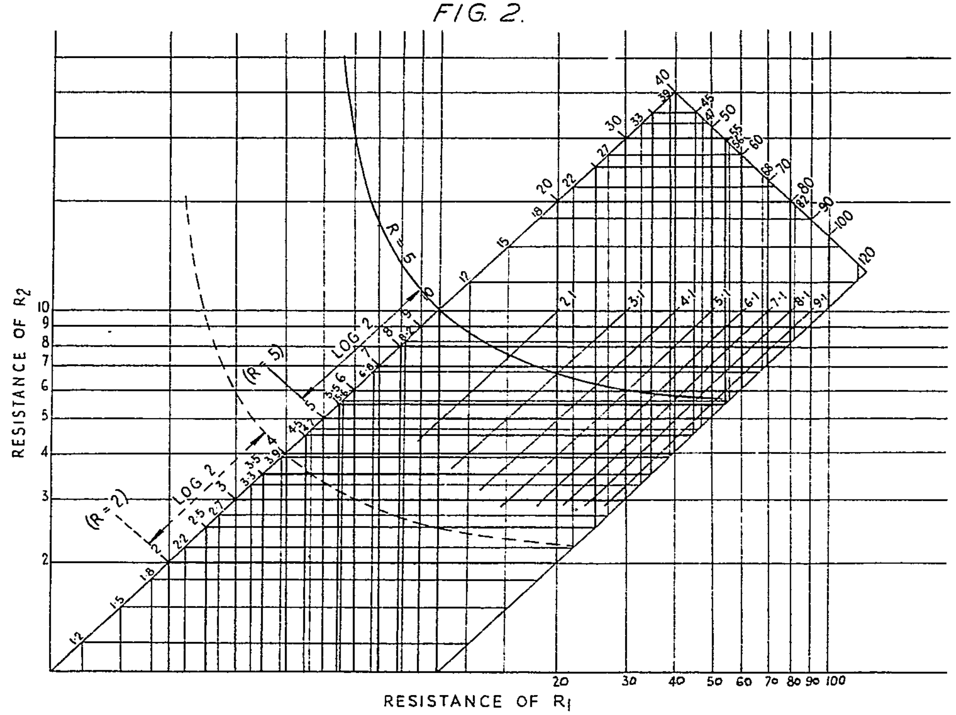


FIG. 4.