# PATENT SPECIFICATION

Application Date: Oct. 20, 1938. No. 30421/38. **520,442**

Complete Specification Left: Oct. 17, 1939.

Complete Specification Accepted: April 24, 1940.

PROVISIONAL SPECIFICATION

## Mechanical Calculator

We, THE ENGLISH ELECTRIC COMPANY LIMITED, a Company registered under British Law, of Queen's House, 28, Kingsway, London, W.C.2, and ALBERT JOHN RICHES, a British Subject, of Siemens Works, Stafford, do hereby declare the nature of this invention to be as follows:—

Many calculations are performed by adding or subtracting quantities which are trigonometric functions of given quantities. In other cases one is given certain trigonometric functions of quantities and an answer is required involving the sum or difference of other trigonometric functions of the same quantities. The present invention consists broadly of a mechanical calculator having one or more trigonometric scales and relatively movable index members enabling one to read off sums or differences of lengths on the scales. The invention can be stated more precisely after consideration of certain specific forms thereof for performing electrical calculations.

If the power factor of the load on an a.c. electric supply system be cos $\phi$ and if it be desired by the addition of static or synchronous condensers or other power factor correcting apparatus to improve the power factor by raising it to a new value cos $\phi_1$ the necessary reactive kilo-volt-amperes expressed as a fraction of the existing kilowatts load will be equal to tan $\phi$ – tan $\phi_1$. In applying the invention to power factor calculations an evenly divided scale is marked off along the bottom edge of the slide of a slide rule in the position corresponding to the usual logarithmic scale conventionally known as the C scale while a special scale is marked along the upper edge of the slide in place of the conventional B scale such that any reading on the lower scale is the tangent of an angle of which the cosine is given immediately above this reading on the upper scale. The top special scale is marked off in the following manner:—

The tangent of an angle of which the cosine is 0.95 is 0.328; hence a mark is made on the upper scale opposite 0.328 on the lower scale, this graduation being marked 0.95. In the same way other graduations marked 0.9, 0.85 etc. are obtained down to a value corresponding to the lowest power factor likely to be found in practice. Intermediate graduations may be obtained and marked in the same manner if desired. Unity on the top scale is, of course, opposite zero on the bottom scale. Assuming that this zero mark is at the left hand end of the scale power factor calculations may be performed in the following manner:—

The slide is inserted in the stock of the rule. Given, for example, that existing power factor is 0.7 lagging and it is required to improve power factor to 0.85 the value 0.7 on the top scale of the slide is set to coincide with the right hand end of the scales on the stock. A cursor on the rule is set on 0.85 on the top scale of the slide. With the cursor in this position the left hand end of the scales on the slide—i.e. the zero line on the bottom scale—is set coincident with the cursor line and the value 0.4 is read off the bottom scale on the slide against the right hand end of the scales on the stock. Now it is clear that the latter reading is a numerical measure of the distance between the two chosen points on the top scale and is thus the difference between the tangents corresponding to the two given cosines. It therefore follows that the necessary reactive kilo-volt-amperes (leading) is 0.4 (or 40%) of the existing kilowatts load. It will be clear at once how such a slide rule can be used to calculate the resulting new power factor given that the added reactive KVA is a certain percentage of the KW load. Many other types of power factor calculation can readily be performed with the rule.

The scales as described above may conveniently be put on the back of a calculating slide, the front of which has the usual B and C logarithmic scales to co-operate with the usual A and D scales on the stock. When it is desired to do power factor calculations this slide is taken out and reversed. Since, however, the special scales as described are not used in conjunction with the A and D

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scales they need not be adjacent thereto and can quite well be marked—if the slide be wide enough—on the middle part of the slide in between the usual B and C scales. Various other modifications of this slide rule form of the invention will be obvious.

Since the mode of use of the above described scales corresponds exactly to the mode of use of the logarithmic scales on the ordinary circular side rule or watch calculator another form of the invention consists in such a watch calculator with the special scale as described marked thereon either alternative or additionally to the usual logarithmic scales.

Since all that is necessary for use in conjunction with a member bearing the scales as described is a pair of index marks movable relative to the scales and to each other—the end of the normal scales and cursor serving as these index marks in the described slide rule form of the invention and the index line on the glass face and the index pointer serving as these in the watch calculator form of the invention—a still simpler form of slide rule according to the invention is possible. This form comprises a rule without a slide and having thereon the said two scales, one on the upper edge and one on the lower edge two relatively movable cursors slidable on the rule and means for locking the cursors together so that they move as one unit on the rule. It will be clear that in carrying out the above described power factor calculation one cursor is set over one power factor value, the second cursor over the other and the two after being locked together are moved bodily until one of them is over the zero line on the evenly divided scale when the desired fraction or percentage is read off under the other cursor line.

The invention can now be more precisely defined in view of the foregoing description of specific examples thereof. Thus the invention consists primarily of a member having thereon two graduated scales connected by the desired trigonometrical relationship, two index marks which can be set independently of each other against different graduations on one of the scales and means for setting the other scale so as to measure off the distance between the two index marks. The invention also consists in the modification comprising a slide rule having one of the said scales on one edge of the stock and the other on the adjacent co-operating edge of the slide whereby one scale can be set to measure the distance between two chosen points on the other; ordinary logarithmic scales may be marked on the other pair of edges of stock and slide.

It will be appreciated how in graduating the first described slide rule form of the invention the evenly divided scale could have been along the top and the other scale along the bottom edge of the slide or that the graduations could have been marked off from an end line at the right hand end of the slide, the calculations then all being performed with reference to the left hand end graduations on the stock. In like manner various other ways of setting out the scales in a manner appropriate to the particular form of slide rule or watch calculator will be readily understood.

Dated this 20th day of October, 1938.

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## COMPLETE SPECIFICATION

# Mechanical Calculator

We, THE ENGLISH ELECTRIC COMPANY LIMITED, a Company registered under British Law, of Queen's House, 28, Kingsway, London, W.C.2, and ALBERT JOHN RICHES, a British Subject, of Siemens Works, Stafford, 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:—

Many calculations are performed by adding or subtracting quantities which are trigonometric functions of given quantities. In other cases one is given certain trigonometric functions of quantities and an answer is required involving the sum or difference of other trigonometric functions of the same quantities. The present invention is concerned with a mechanical calculator for performing calculations involving conversion into trigonometric functions and the addition or subtraction of such functions. Thus the invention comprises a member having thereon two graduated scales, one of which is evenly divided and represents a trigonometric function of the quantities represented by the other scale, or of some function of the quantities represented by the other scale, two index marks which can be set independently of each other against different graduations on the unevenly divided scale and means for setting the evenly divided scale so as to measure off the distance between the two index marks. The inven-

tion also consists in the modification comprising a slide rule, or like calculator, having one of the said scales on one member and the other on an adjacent co-operating member movable relatively thereto whereby the evenly divided scale can be set to measure the distance between two chosen points on the other. The invention can take either of the two well-known forms of the slide rule and the circular watch calculator. Ordinary logarithmic scales for performing other calculations may be included on the same device. In a particularly useful arrangement the evenly divided scale may represent a trigonometric function of a quantity of which the other scale represents another trigonometric function. Thus one scale may be a tangent scale and the other a corresponding sine or cosine scale. The invention is particularly useful as applied to the performance of alternating current electrical calculations.

If the power factor of the load on an a.c. electric supply system be cos $\phi$ and if it be desired by the addition of static or synchronous condensers or other power factor correcting apparatus to improve the power factor by raising it to a new value cos $\phi_1$ the necessary reactive kilo-volt-amperes expressed as a fraction of the existing kilowatts load will be equal to tan $\phi$ – tan $\phi_1$. A form of slide rule suitable for carrying out such power factor calculations and according to the invention is shown in two different positions in Figs. 1 and 2 of the accompanying drawings. In these Figures an evenly divided scale is marked off along the bottom edge of the slide 1 at $C_1$ in the position corresponding to the usual logarithmic scale conventionally known as the C scale while a special scale is marked along the upper edge of the slide at $B_1$ in place of the conventional B scale such that any reading on the lower scale is the tangent of an angle of which the cosine is given immediately above this reading on the upper scale. The top special scale is marked off in the following manner:—

The tangent of an angle of which the cosine is 0.95 is 0.328; hence a mark is made on the upper scale opposite 0.328 on the lower scale, (or 32.8 if this scale be marked to shew percentages), this upper graduation being marked 0.95. In the same way other graduations marked 0.9, 0.85 etc. are obtained down to a value corresponding to the lowest power factor likely to be found in practice. Immediate graduations may be obtained and marked in the same manner if desired. Unity on the top or $B_1$ scale is, of course, opposite zero on the bottom or $C_1$ scale. Assuming that this zero mark is at the left hand end of the scale, power factor calculations may be performed in the following manner:—

The slide 1 is inserted in the stock 2 of the rule. Given, for example, that existing power factor is 0.7 lagging and it is required to improve power factor to 0.85 the value 0.7 on the top or $B_1$ scale of the slide is set to coincide with the index mark 2*a* on the stock (which may be the right hand end of the A and D scales), as shown in Fig. 1. A cursor 3 on the rule is set on 0.85 on the $B_1$ scale. With the cursor in this position the left hand end of the scales on the slide—i.e. the zero line on the $C_1$ scale—is set coincident with the cursor line as shown in Fig. 2 and the value 0.4 (or 40%) is read off the $C_1$ scale against the index mark 2*a* on the stock. Now it is clear that the latter reading is a numerical measure of the distance between the two chosen points on the $B_1$ scale and is thus the difference between the tangents corresponding to the two given cosines. It therefore follows that the necessary reactive kilo-volt-amperes (leading) is 0.4 (or 40%) of the existing kilowatts load. It will be clear at once how such a slide rule can be used to calculate the resulting new power factor given that the added reactive KVA is a certain percentage of the KW load. Many other types of power factor calculation can readily be performed with the rule.

The scales $B_1$ and $C_1$ as described above may conveniently be put on the back of a calculating slide, the front of which has the usual B and C logarithmic scales to co-operate with the usual A and D scales on the stock. When it is desired to do power factor calculations this slide is taken out and reversed, so as to be as shown in the Figures. Since, however, the special scales as described are not used in conjunction with the A and D scales they need not be adjacent thereto and can quite well be marked—if the slide be wide enough—on the middle part of the slide in between the usual B and C scales.

Various other modifications of this slide rule form of the invention will be obvious. Thus the scale $B_1$ may be on the slide and the scale $C_1$ on the stock of the rule so that the scales are relatively movable and the scale $C_1$ can be set directly to read off the distance between two points on the scale $B_1$. The scale $C_1$ could equally well be on the slide and the scale $B_1$ on the stock.

The mode of use of the above described scales corresponds exactly to the mode of use of the logarithmic scales on the ordinary circular slide rule or watch calculator; hence another form of the invention consists in such a watch calculator with the special $B_1$ and $C_1$

scales, as described, marked thereon either alternatively or additionally to the usual logarithmic scales.

Since all that is necessary for use in conjunction with a member bearing the $B_1$ and $C_1$ scales as described is a pair of index marks movable relative to the scales and to each other—the mark $2\alpha$ and the cursor-line serving as these index marks in the rule illustrated and the index line on the glass face and the index pointer serving as these in the watch calculator form of the invention—a still simpler form of slide rule according to the invention is possible. This form comprises a graduated rule without a slide, two relatively movable cursors slidable on the rule and means for locking the cursors together so that they move as one unit on the rule; the upper scale on the rule is, for example, the $B_1$ scale illustrated and the lower scale the $C_1$ scale illustrated so that the rule will look like the slide 1 of Figs. 1 and 2 removed from the stock. It will be clear that in carrying out the above described power factor calculation one cursor is set over one power factor value, the second cursor over the other and the two after being locked together are moved bodily until one of them is over the zero line on the evenly divided scale when the desired fraction or percentage is read off this scale under the other cursor line.

The form of the invention illustrated and described in detail is specifically for solving problems in which it is necessary to find the sum or difference of tangents corresponding to given cosines. It will, of course, be understood that when the invention is applied for example to problems involving finding the sum or difference of tangents corresponding to given angles, the evenly divided scale $C_1$ will still represent tangents but the scale $B_1$ will represent not cosines but the angles themselves. Thus, in this form of the invention, the evenly divided scale $C_1$ represents a trigonometric function of the quantities represented by the scale $B_1$ while in the form illustrated and described in detail the scale $C_1$ represents a trigonometric function of the angle of which some other trigonometric function is represented by the other scale.

It will be appreciated how in graduating the illustrated form or the last described slide rule form of the invention the evenly divided scale could have been along the top and the other scale along the bottom edge of the slide or that the graduations could have been marked off from an end line at the right hand end of the slide, the calculations then all being performed with reference to the left hand end graduations on the stock. In like manner various other ways of setting out the scales in a manner appropriate to the particular form of slide rule or watch calculator will be readily understood.

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 mechanical calculator for performing calculations involving conversion into trigonometric functions and addition or subtraction of such functions comprising a member having thereon two graduated scales, one of which is evenly divided and represents a trigonometric function of the quantities represented by the other scale or of some function of the quantities represented by the other scale, two index marks which can be set independently of each other against different graduations on the unevenly divided scale, and means for setting the evenly divided scale so as to measure off the distance between the two index marks.

2. A mechanical calculator for performing calculations involving conversion into trigonometric functions and addition or subtraction of such functions, comprising a member having an evenly divided scale thereon and an adjacent and co-operating member having thereon a scale which represents a trigonometric function of the quantities represented by the other scale or of some function of the quantities represented by the other scale, the two members being relatively movable whereby the evenly divided scale may be set to measure off the distance between two chosen points on the other scale.

3. A mechanical calculator according to claim 1 in the form of a slide rule in which the said scales are both on the slide, the said index marks being formed by a mark on the stock of the rule and the line on the cursor slidably mounted on the rule.

4. A mechanical calculator according to Claim 1 in the form of a watch calculator in which the said scales are on the graduated disc of the calculator, the said index marks being formed by the usual index mark on the glass cover and the usual index pointer.

5. A mechanical calculator according to Claim 2 in the form of a slide rule in which one of the said scales is on the slide and the other on the stock of the rule.

6. A mechanical calculator according to any preceding Claim having thereon other scales—including logarithmic scales—for performing ordinary operations such as multiplication, division and evolution.

7. A mechanical calculator according to Claim 3 in which the said scales are on the back of the slide, the front of the slide

carrying the conventional B and C scales for co-operation with conventional A and D scales on the stock.

8. A mechanical calculator according to Claim 1 comprising a rule—without a slide—on which the said scales are marked, two cursors independently slidable thereon to serve as the said index marks, and means for locking the cursors together after independent setting thereof whereby they may be moved as one member along the scales on the rule.

9. A mechanical calculator according to any preceding Claim in which the graduations of the two scales represent two different trigonometric functions of the same angle.

10. A mechanical device for performing electrical calculations relating to power factor comprising a device according to Claim 9 in which the evenly divided scale represents tangents while corresponding graduations on the other scale represent the cosines of the same angles.

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

Dated this 28th day of September, 1939.

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Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1940.

[This Drawing is a reproduction of the Original on a reduced scale.]

Fig. 1.

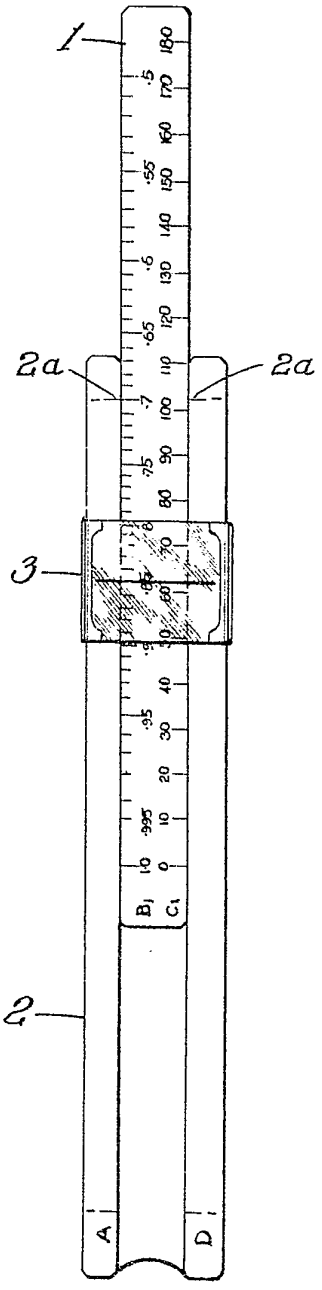
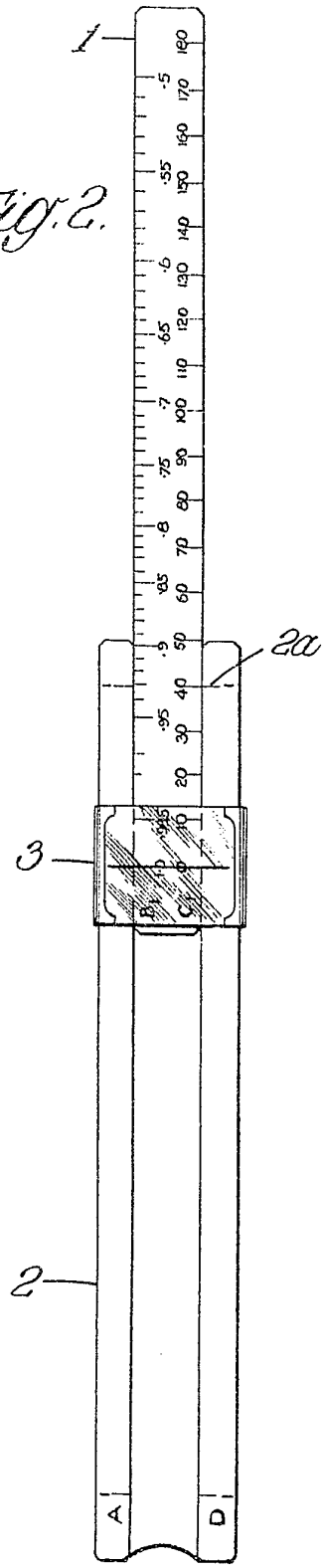



Fig. 2.

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