PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in Calculating Apparatus

I, RICHARD GEORGE DUCE, British Subject, of 51, Earls Court Square, London, S.W.5, do hereby declare the nature of this invention (which has been communicated to me by HERBERT JOHN DUCE, British Subject, of 6, Prince Alfred Terrace, Ireland Island, Bermuda), to be as follows:—

The invention relates to calculating apparatus of the kind depending on logarithms. It is primarily intended for carrying out mathematical operations which are adapted to be effected by the use of tables of logarithms.

The simplest calculating device based on the principle of logarithms is the common slide rule, but its accuracy is limited, though forms have been constructed in which the effective length corresponding to a difference of 1 in the characteristic was increased by inscribing the scale in a helix on the surface of a drum.

The basic idea of the present invention is that of replacing the graduated scale of a slide rule by a table of antilogarithms. It is clear that in such a table consecutive members bear a constant ratio to each other, the argument or logarithm increasing in equal additive steps.

According to the invention the appliance consists essentially of two or more assemblies with releasable positive coupling means therebetween to permit independent or related movement, and each assembly comprises a drum bearing an antilogarithm table in rows and columns with last and first rows spaced apart by substantially the same distance as consecutive rows, a screen rotatable with small clearance around the drum and having apertures arranged on a multistart helix to expose the numbers in one row in sequence through successive apertures as the screen is rotated, transfer mechanism by which the drum is rotated by an amount equivalent to the spacing between consecutive rows when the screen is moved from a position in which the end number in a row is exposed to a position in which the next number that should be exposed is in an adjacent row, the next helical line of apertures being so located that the said next number is exposed when the screen has been moved from a position exposing said end number by an amount equal to that by which it is moved to expose the next number along the row to the one previously exposed, and a viewing slot or window limiting the observer's view to one row.

Preferably the drum also has upon it the equivalent of a difference table in the form of an axially extending scale in line with each row and subdivided into as many graduated parts as the mean difference between the successive numbers in the row, including the first number of the next succeeding row, the said scales being equal in length, and a transparent screen rotatable with small clearance around the difference portion of the drum and carrying as many dots as there are rows of numbers, the dots being equidistantly spaced on a single helix of pitch equal to the length of the said scales and located to indicate on the scale visible through the viewing slot a graduation corresponding to the rotational position of the screen.

Further features of the invention will appear from a description now to be given by way of example of a calculating appliance in accordance with the invention. This appliance has two assemblies of antilogarithm drum and associated parts and a coupling device movable selectively into three positions. It is intended primarily for multiplication and division and works to five significant figures.

The first assembly comprises a drum mounted in bearings on a baseplate, two screens rotatable about the drum and a fixed screen. The drum carries a table of antilogarithms to base 10 of the arguments (logarithms) .000, .001, .002 . . . . .999 arranged in ten columns and one hundred rows all equally spaced and with the first row following the hundredth at the same distance as successive rows. Thus the first row contains the antilogarithms of .000 to .009, namely 10000, 10023, 10046, 10069, 10093, 10116, 10139, 10162, 10186, 10209. Likewise the last or hundredth row contains the antilogarithms of .990 to .999, namely 97724

97949, 98175, 98401, 98628, 98855, 99083, 99312, 99541, 99770.

The antilogarithms just described occupy the left hand part of the drum, which will be called the antilogarithm section. The right hand part of the drum will be called the difference section, since it serves the same purpose as the usual difference tables. In line with each row of antilogarithms there is a graduated scale in the difference section. All the one hundred scales are of the same length and commence at the same right section of the cylindrical surface of the drum, so that they also all finish at the same right section. Each scale is divided into a number of equal graduations obtained as follows. The nine differences between the ten antilogarithms in the row concerned and the difference between the last one in that row and the first in the next are averaged and this provides the number of graduations. Thus the scale in line with the first row has 23 graduations and that in line with the last 228.

Between the two sections of the drum there is a two-figure number in line with each row and scale. These numbers are the first and second decimal places of the respective argument (logarithm). The third decimal place is marked on a fixed screen to be described later and is 0 for the first column, 1 for the second, and so on to 9 for the tenth. The fourth and fifth decimal places are ascertained when required by means of the difference section as will be explained later.

Around the antilogarithm section of the drum a cylindrical screen is rotatable with small clearance but with no appreciable end play. The screen is opaque and has in it one hundred slots each of the right size and shape to expose one of the numbers on the drum. The slots are so arranged that when one exposes the number in the first column and first row, nine others expose in the first column the numbers in the 11th, 21st, 31st . . . . and 91st rows. At the same time ten slots expose in the second column the numbers in the 2nd, 12th, 22nd . . . 92nd rows, and so on to the tenth column, where ten slots expose the numbers in every tenth row from the 10th to the 100th. It will be seen that the slots are located on a ten-start helix. This screen will be called the antilogarithm screen.

A screen is similarly rotatable around the difference section of the drum but is transparent and has no slots. On this difference screen there are one hundred dots equally spaced along a helix in such a manner that in what will be called the first position of the difference screen the first dot is at the left hand end of the difference scale in the first row, the second is on the scale in the second row at a distance from the left equal to one hundredth of the length of the scale, and so on. The hundredth dot will then be on the scale in the hundredth row short of the right hand end by one hundredth of the scale length.

The casing has a cover over the assembly, in which there is a thin fixed screen close to the rotating screens. The fixed screen has a slot of such shape and size that through it one and only one row of antilogarithms can be seen together with its associated difference scale and the first two decimal numbers of the argument. It is just above the slot in this fixed screen that the third decimal place of the argument is entered.

The fourth and fifth figures of the argument are inscribed in a similar way to the first and second but on the difference screen, the slot in the fixed screen being long enough to bring one of these numbers into view. The number 00 is in line with the dot furthest to the left, the number 01 with the next, and so on, the number 99 being in line with the dot furthest to the right. The number showing at any time is the number of hundredths of the scale length from the left of the scale to the dot, and the actual number on the scale graduation nearest to the dot is the difference to be added to the number visible through the antilogarithm screen to give the antilogarithm of the argument of which the first five decimal places are shown as indicated.

For instance assume that the twenty-fifth row on the drum is under the slot of the fixed screen and the antilogarithm screen is turned to expose the number in the fifth column, namely 17539. Above this number 4 appears on the fixed screen, and between the two sections of the drum the number 24 appears. Assume also that the difference screen is turned to show the number 28 in the slot of the fixed screen. The dot now visible is 28/100 of the scale length from the left of the scale. This scale has 40 graduations, and the nearest one to the dot is 11. The argument or logarithm shown by this setting is .24428, and the antilogarithm or number is 17539+11=17550.

The drum bearings are in two plates one at each end of the appliance and mounted on the base. Four plates between the first two carry bearings, two for the antilogarithm screen and two for the difference screen, the drum and screens being rotatable independently of each other in so far as the mounting is concerned. For convenience in description the plates will be regarded as being numbered from the left, the drum being supported by the first and sixth, the antilogarithm screen by the second and third and the difference screen by the fourth and fifth.

All the three moving elements just referred to are provided with ratchet gear similar to that of a typewriter platen to define each of the one hundred positions which each can occupy with the figures centred fairly in the slot of the fixed screen.

The antilogarithm screen has a raised portion to serve as a handwheel for rotating it, this portion being immediately to the left of the second plate. To the left again is a portion on which gear teeth are cut, and further to the left transfer gear with ten teeth to cooperate with a pinion journalled in the first plate. This pinion meshes with a gear having one hundred teeth cut on the extreme left hand end of the drum. The effect of this arrangement is that, when the antilogarithm screen is turned, the antilogarithms of one row are exposed in turn from left to right. A further step of the screen brings the first slot of the next helix into position and at the same time turns the drum one step to show the first number in the next row. The transfer mechanism operates in a corresponding manner on backward rotation.

The antilogarithm screen also has a portion with gear teeth at the right hand end between the third and fourth plates. The purpose of the two gears will be described later. The difference screen has at its right hand end just beyond the fifth plate a raised portion to serve as a handwheel for rotating it and beyond this a portion on which gear teeth are cut. At the left hand end the difference screen has a single tooth for actuating transfer mechanism.

A second assembly of drum and screens as just described is carried in the same plates at the same level as but behind the first assembly and can be viewed a row at a time through a slot in a second fixed screen as in the case of the first assembly. The two assemblies differ in the widths of some of the gear faces, but they are alike in the other parts specifically described.

A coupling frame is mounted in the plates between the drums to slide longitudinally into any one of three defined positions, but it is held at all positions against rotation. The frame carries four pinions, which are free to rotate independently of the frame and of each other but are not capable of sliding along the frame. The first position of the frame is that in which it is furthest to the left, the third that in which it is furthest to the right, the second being between these two.

One of the pinions is located to engage the gear teeth near the left hand ends of the two antilogarithm screens. It engages those of the second screen in the second position but not in the first and third. The gear teeth on the first antilogarithm screen are made wide enough to remain always in mesh with the pinion, so as to ensure correct engagement of the pinion with the gear teeth of the second screen when moving to the second position from either of the others.

Another pinion is located to engage the gear teeth at the right hand ends of the difference screens. It engages those of the second screen in the third position but not in the first and second. The gear teeth on the first difference screen are made wide enough to retain engagement with the pinion in all position for the reason mentioned above.

The other two pinions engage the gear teeth at the right hand ends of the first and second antilogarithm screens respectively and are made wide enough to retain this engagement in all three positions. In the first and second positions these pinions have no other engagement, but in the third position each one is so located that it is moved one tooth forward by the transfer tooth on the respective difference screen when the latter passes from its hundredth to its first position or vice versa. The first position of the difference screen is that in which the dot furthest to the left is visible through the slot in the fixed screen, and the hundredth position that in which the dot furthest to the right is so visible.

The foregoing description makes it clear how the assemblies and the elements thereof cooperate, but a better understanding of the apparatus will be facilitated by enumerating briefly the various effects obtained. In each assembly the drum is not directly rotatable by hand but is only rotated through the transfer mechanism from the corresponding antilogarithm screen, this transfer mechanism being operative irrespective of the position of the coupling frame.

In the first position of the coupling frame both antilogarithm screens and both difference screens are independent, and any one of the four can be rotated by hand without affecting any other. In the second position of the coupling frame the two antilogarithm screens are coupled together, and as a result any rotation of one is accompanied by an exactly equal rotation of the other. The difference screens are still independent of each other and of the antilogarithm screens. When the coupling frame is moved to the third position, there is no direct connection between the two antilogarithm screens, but the difference screens are coupled together, so that any movement of one is accompanied by an exactly equal movement of the other in the same direction. At the same time each difference screen is coupled to its associated antilogarithm screen by the transfer mechanism. Since the two difference screens are not necessarily in exactly similar positions, the transfers may not take place simultaneously, hence the necessity for releasing the direct connection between the two antilogarithm screens.

Some examples will show how the appliance is used for calculation. Suppose it is required to evaluate.

$$\frac{26167 \times 52312}{32569}$$

The coupling frame is set into its first position to uncouple all the elements and the four screens are set into their first positions, in which the antilogarithm screens both expose the numbers 10000 and the dots of both difference screens are at 0 on their respective scales. The first antilogarithm screen is rotated in a forward direction until the number 26122 (the nearest number lower than 26167) comes into view; this is the number in the 42nd row and 8th column, so the screen will have been rotated from position 1 through 417 changes of position to position 418. The 42nd graduation scale (0—60) will have come into view, and the first difference screen is rotated in a forward direction until the dot is in the position nearest to the 45 (26167—26122) graduation; this is position 76 and the screen will have been rotated from position 1 through 75 changes of position.

The coupling frame is next set to its second position, and the second antilogarithm screen is rotated in a forward direction until the number 52240 comes into view; this is the number in the 72nd row and 9th column and the screen will have been rotated from position 1 through 718 changes of position to position 719. The coupling frame is next set to its third position. The 72nd graduation scale (0—120) will come into view and the second difference screen is rotated in a forward direction until the dot is in the position nearest to the 72 (52312—52240) graduation; this is position 61 and the screen will have been rotated from position 1 through 60 changes of position. Rotation of the second antilogarithm screen will have caused the first screen to rotate through the same number of changes of position in the same direction, that is, to position 136 (position 418 plus 718 changes of position gives position 1136 which is position 136, the cycle recommencing after position 1000); the number in the 14th row and 6th column, that is, 13646, will then be in view. Similarly the rotation of the second difference screen will have caused the first screen to rotate to position 36 (position 76 plus 60 changes of position give position 136, which is position 36, the cycle recommencing after position 100) and the dot will be nearest to the 11 graduation. Also the first difference screen in being rotated through its 100th to the 1st position will have caused the antilogarithm screen to be rotated one position forward, that is to position 137, and the number 13677 will be in view. Thus 13688 (13677 plus 11) is the (first five figures of the) product of 26167 multiplied by 52312.

To divide by 32569 the coupling frame is set to its first position, and the second antilogarithm screen is rotated until the number 32509 is in view, that is, to position 513, and the second difference screen until the dot is nearest to graduation 60, that is, to position 81. The coupling frame is then set to its second position, and the second antilogarithm screen is rotated in a reverse direction to position 1, that is, through 512 changes of position, which will cause the first antilogarithm screen to be rotated to position 625 (position 137 minus 512 changes of position). The coupling frame is then set to its third position, and the second difference screen is rotated in a reverse direction to position 1, that is, through 80 changes in position, which will cause the first difference screen to be rotated to position 56 (position 36 minus 80 changes of position) and the dot will be nearest to the 53 graduation. Also the first difference screen, in being rotated through its 1st to the 100th position will have caused the first antilogarithm screen to be rotated one position in a reverse direction, that is, to position 624, and the number 41976 will be in view. Thus 42029 (41976 + 53) is the (first five figures of the) required evaluation.

To obtain the square root of 26167, one assembly is set to read this number in its antilogarithm section; it will then read 41775 in the argument section. With the coupling frame in its first position the other assembly is set to read 41775/2 or 20888, in its argument section; it will then read 16176 in its antilogarithm section, and this is the first five figures of the required evaluation, ignoring decimal points. To obtain the square root of 2616.7, the second assembly is set to read

141775/2 or 70888 in its argument section; it will then read 51153 in its antilogarithm section.

Additional assemblies can be fitted to extend the scope of the appliance to include dealing directly with calculations involving other functions such as trigonometrical functions of angles. For example, one such assembly might cover sines of angles over the range of the angle whose sine is .10000 to the angle whose sine is 1.0000.

Many variations in the size and degree of accuracy of the instrument are possible, since the arrangements would apply generally with any number of rows and columns of antilogarithms except that in most cases the arguments if shown would have to be shown in a non-repeating sequence.

Dated the 27th day of March, 1945.
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COMPLETE SPECIFICATION

Improvements in Calculating Apparatus

I, RICHARD GEORGE DUCE, British Subject, of 51, Earls Court Square, London, S.W.5, do hereby declare the nature of this invention (which has been communicated to me by HERBERT JOHN DUCE, British Subject, of 6, Prince Alfred Terrace, Ireland Island, Bermuda), and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention relates to calculating apparatus of the kind depending on logarithms. It is primarily intended for carrying out mathematical operations which are adapted to be effected by the use of tables of logarithms.

The simplest calculating device based on the principle of logarithms is the common slide rule, but its accuracy is limited, though forms have been constructed in which the effective length corresponding to a difference of 1 in the characteristic was increased by inscribing the scale in a helix on the surface of a drum.

The basic idea of the present invention is that of replacing the graduated scale of a slide rule by a table of antilogarithms. It is clear that in such a table consecutive members bear a constant ratio to each other, the argument or logarithm increasing in equal additive steps.

According to the invention the appliance consists essentially of two or more assemblies with releasable positive coupling means therebetween to permit independent or combined movement, and each assembly comprises a drum bearing an antilogarithm table in rows and columns with last and first rows spaced apart by substantially the same distance as consecutive rows, a screen rotatable with small clearance around the drum and having apertures arranged on a multi-start helix to expose the numbers in one row in sequence through successive apertures as the screen is rotated, transfer mechanism to rotate the drum by an amount equivalent to the spacing between consecutive rows when the screen is moved from a position in which the end number in a row is exposed to a position in which the next number that should be exposed is in the next adjacent row, the next helical line of apertures being so located that the said next number is exposed when the screen has been moved from a position exposing said end number by an amount substantially equal to that by which it is moved to expose the next number along a row to the one previously exposed, and means such as a viewing slot or window for directing the observer's view to one row of numbers.

Preferably the drum also has upon it the equivalent of a difference table in the form of an axially extending scale in line with each row and subdivided into as many equal parts as the mean difference between the successive numbers in the row, including the first number of the next succeeding row, the said scales being equal in length, and a transparent screen is rotatable with small clearance around the difference portion of the drum and carries as many dots as there are rows of numbers, the dots being equidistantly spaced on a single helix of pitch equal to the length of the said scales and located to indicate on the scale visible through the viewing slot or like means a graduation corresponding to the rotational position of the screen.

According to another aspect of the invention each assembly comprises a table of antilogarithms uniformly spaced in rows and columns with constant differences between the arguments (logarithms), selection means to indicate any one of the antilogarithms of the table, means for applying relative movement to the table and the selection means to perform a mathematical operation, and a transfer device associated with the selection means to bring the next adjacent row or column of consecutive antilogarithms into cooperation therewith at the appropriate time.

The table of logarithms in each assembly is advantageously associated with a set of difference scales each one graduated to indicate mean proportional differences between a sequence of consecutive antilogarithms, and an indicator is provided to mark on any difference scale the difference required to increase the antilogarithms indicated to the quantity in question (which is smaller than the next higher antilogarithm), the indicator being movable in relation to the difference scale, and transfer means being provided by which the selection means can when required be actuated by the relative movement of the indicator and difference scale.

The invention provides a calculating appliance in compact form with a high degree of accuracy and yet simple to operate, since the quantities operated on and the results are read off direct in figures.

The invention is illustrated by a calculating appliance with two assemblies for five-figure numbers shown in the accompanying drawings, in which:—

Figure 1 is a plan view of the appliance with most of the cover removed and with one assembly shown in section on the centre line;

Figure 2 is an end elevation taken in section on the line II—II of figure 1, the cover being shown in place;

Figure 3 shows on an enlarged scale part of the markings on the drum developed on to a flat surface; and

Figure 4 is a detail.

The appliance shown comprises a base 1 on which six plates are mounted to constitute bearings for the working parts. The plates are all parallel and are referenced in pairs. The two outside plates 2, 2 form end bearings, and between them there is a pair of plates 3, 3 and another pair 4, 4. The plates 2, 3 and 4 support two assemblies, which are alike except for certain details of the gear drive. These differences will be referred to subsequently, but in the drawings some references are shown on one assembly and some on the other. The assembly A is shown in section and the assembly B in plan.

The essential parts of each assembly are a cylindrical drum 5 journalled in recesses in the end plates 2, 2 and not otherwise supported, a cylindrical screen 6 journalled in the plates 3, 3 which will be called the antilogarithm screen, and another cylindrical screen 7 journalled in the plates 4, 4 which will be called the difference screen. The screens 6 and 7 are quite close to the surface of the drum 5, but due to the exigencies of drawing they have been shown not only further from the drum than in actual practice but also very much thicker than in reality.

The drum 5 carries a table 8 of antilogarithms to base 10 of the arguments (logarithms) .000 .001, .002 . . . .999 arranged in ten columns and one hundred rows all equally spaced as shown in figure 3 and with the first row following the hundredth at the same distance as successive rows. Thus the first row contains the antilogarithms of .000 to .009, namely 10000, 10023, 10046, 10069, 10093, 10116, 10139, 10162, 10186, 10209. Likewise the last or hundredth row contains the antilogarithms of .990 to .999, namely 97724, 97949, 98175, 98401, 98628, 98855, 99083, 99312, 99541, 99770.

The antilogarithms just described occupy the left hand part of the drum under the screen 6 which will be called the antilogarithm section. The right hand part of the drum under the screen 7 will be called the difference section, since it serves the same purpose as the usual difference tables. In line with each row of antilogarithms there is a graduated scale 9 in the difference section. All the one hundred scales are of the same length and commence at the same right section of the cylindrical surface of the drum, so that they also all finish at the same right section. Each scale 9 is divided into a number of equal graduations obtained as follows. The nine differences between the ten antilogarithms in the row concerned and the difference between the last one in that row and the first in the next are averaged and this provides the number of graduations. Thus the scale 9 in line with the first row 8 has 23 graduations and that in line with the last 228.

Between the two sections of the drum 5 there is a two-figure number as shown at 10 in line with each row and scale. These numbers are the first and second decimal places of the respective argument (logarithm), and they are visible between the screens 6 and 7 as shown in figure 1. The third decimal place is marked on a fixed screen to be described later and is 0 for the first column, 1 for the second, and so on to 9 for the tenth. The fourth and fifth decimal places are ascertained when required by means of the difference section as will be explained later.

Around the antilogarithm section of the drum 5 the antilogarithm screen 6 is rotatable with small clearance but with no appreciable end play. The screen is opaque and has in it one hundred slots 11, 11 each of the right size and shape to expose one of the numbers on the drum. The slots are so arranged that when one exposes the number in the first column and first row, nine others expose in the first column the numbers in the 11th, 21st, 31st . . . . and 91st rows. At the same time ten slots expose in the second column the numbers in the 2nd, 12th, 22nd . . . . 92nd rows, and so on to the tenth column, where ten slots expose the numbers in every tenth row from the 10th to the 100th. It will be seen that the slots are located on a ten-start helix.

The difference screen 7 is similarly rotatable around the difference section of the drum 5 but is transparent and has no slots. On the difference screen there are one hundred dots 12, 12 equally spaced along a helix in such a manner that, in what will be called the first position of the difference screen, the first dot is at the left hand end of the difference scale in the first row, the second is on the scale in the second row at a distance from the left equal to one hundredth of the length of the scale, and so on. The hundredth dot will thus be on the scale in the hundredth row short of the right hand end by one hundredth of the scale length. In figure 1 the part of the helix on the under side is also shown though actually out of sight.

A cover 13 is fitted over the two assemblies, in which there is a thin fixed screen 14 close to the rotating screens of each assembly. Here again the thickness and spacing are exaggerated for clarity in drawing. Each fixed screen has a slot of such shape and size that through it one and only one row of antilogarithms can be seen together with its associated difference scale and the first two decimal numbers of the argument. When viewed as in figure 1 it is just above the slot in the fixed screen 14 that the third decimal place of the argument is entered.

The fourth and fifth figures of the argument are inscribed at 15 in a similar way to the first and second but on the difference screen, the slot in the fixed screen 14 being long enough to bring one of these numbers into vie. The number 00 is in line with the dot furthest to the left, the number 01 with the next, and so on, the number 99 being in line with the dot furthest to the right. The number showing at any time is the number of hundredths of the scale length from the left of the scale 9 to the dot, and the actual number on the scale graduation nearest to the dot is the difference to be added to the number visible through the antilogarithm screen 6 to give the antilogarithm of the argument of which the first five decimal places are shown as indicated.

For instance assume that the twenty-fifth row on the drum 5 is under the slot of the fixed screen 14 and the antilogarithm screen 6 is turned to expose the number in the fifth column, namely 17539. Above this the number 4 appears on the fixed screen 14, and on the drum 5 between the screens 6 and 7 the number 24 appears. Assume also that the difference screen 7 is turned to show the number 28 in the slot of the fixed screen 14. The dot now visible is 28/100 of the scale length from the left of the scale. This scale has 40 graduations, and the nearest one to the dot is 11. The argument or logarithm shown by this setting is .24428, and the antilogarithm or number is 17539+11=17550.

The antilogarithm screen 6 has a raised portion 16 projecting through the cover 13, by which it can be rotated for performing a calculation. Likewise the difference screen 7 has a raised portion 17 for the same purpose. The drum 5 is not moved direct by hand but only indirectly as will be subsequently described.

A coupling frame designated by the general reference C is mounted in the plates 2, 3, 4 for longitudinal sliding. The frame comprises two rod portions 18 and 19 terminating at the outside in knobs 20, 20, by which the frame can be moved. The inner ends of the rod portions 18 and 19 terminate in oval plates 21, 21 coupled together positively by links 22, 22. A ratchet 23 cooperates with a spring 24 to define three positions which the coupling frame C can occupy. The position shown in figure 1 may be called the first position and the others in succession the second and third.

A pinion 24^1 is freely rotatable on the rod 18 but is held against longitudinal movement. The antilogarithm screen 6 of assembly A has a gear wheel 25 mounted on it which is wide enough to engage the pinion 24^1 in all three positions of the latter. A gear wheel 26 is mounted on the antilogarithm screen 6 of assembly B but is of such width and position that it only meshes with the pinion 24^1 in the second position of the coupling frame C.

Another pinion 27 is mounted in the same manner as 24^1 on the rod 19 to mesh with a gear wheel 28 on the difference screen 7 of assembly A, the width of the gear wheel 28 being such that engagement with the pinion 27 is maintained in all three positions of the frame C. A gear wheel 29 is mounted on the difference screen 7 of assembly B but is of such width and position that it only meshes with the pinion 27 in the third position of the coupling frame C.

Two pinions 30, 30 are mounted on long spindles 31, 31 journalled for free rotation in the plates 21, 21, one pinion being associated with each of the assemblies A and B. Each pinion 30 meshes with a gear wheel 32 mounted on the antilogarithm screen 6 and having 100 teeth, and the face width of the pinion is such that the meshing engagement is maintained in all three positions of the coupling frame C. Each difference screen 7 has at its left hand end a single tooth 33 adapted to engage the pinion 30 only when the coupling frame C is in its third position. The circumferential position of the tooth 33 on the screen 7 is such that, when the difference screen 7 is rotated forward by one step from its hundredth to its first position, the gear wheel 32 is rotated one tooth pitch forward and correspondingly for reverse rotation. The parts 30, 32 and 33 thus constitute transfer mechanism.

Each drum 5 has at its antilogarithm end a gear wheel 34 with 100 teeth. At the same end each antilogarithm screen has a gear wheel 35 of the same diameter but with ten teeth only. The gear wheels 34 and 35 both mesh with a pinion 36 journalled in the left hand plate 2 and in a bracket 37 attached thereto. The teeth of the gear wheel 35 are so placed that they only engage the pinion 36 when the antilogarithm screen is moved to bring the end slot 11 of one helical line into position under the slot of the screen 14 in place of the slot at the other end of the adjacent helical line.

The transfer mechanism just described comes into action each time the antilogarithm screen 6 is rotated from the tenth to the eleventh position or the twentieth to the twentyfirst and so on, including the hundredth to the first, and it has the effect of bringing the next succeeding row of antilogarithms on the drum 5 into position under the slot in the fixed screen 14 to be exposed in turn through the next helical line of slots 11 in the antilogarithm screen 6. The reverse action takes place on reverse rotation of the antilogarithm screen 6.

It is necessary for the drums 5, 5 and the rotating screen 6, 7 to be properly positioned to bring the drum markings and screen slots and markings into register with the slots in the fixed screen 14. For this purpose a spring 38 is mounted as shown in figure 4 on the base 1 and has a **V**-shaped end 39 to make engagement between the teeth of the gear wheel 28 in the same manner as in the case of a typewriter platen. Similar springs engage the gear wheel 29, the pinions 30, 30 and the pinions 36, 36. Thereby both drums and the four rotating screens have their positions defined.

It has been stated above that certain of the pinions and gear wheels are made of sufficient face width to remain always in meshing engagement with other gear wheels or pinions. The reason for this feature is in part to ensure the effect just described and in part to ensure that the respective gears are in position to make correct engagement on the movement of the coupling frame C where that engagement has only to be made in one particular position of the frame.

From the above description it will be seen that in the first position of the coupling frame C both antilogarithm screens 6, 6 and both difference screens, 7, 7 are independent, and any one of the four can be rotated by hand without affecting any other. In the second position of the coupling frame the two antilogarithm screens 6, 6 are coupled together, and as a result any rotation of one is accompanied by an exactly equal rotation of the other. The difference screens 7, 7 are still independent of each other and of the antilogarithm screens 6, 6. When the coupling frame C is moved to the third position, there is no direct connection between the two antilogarithm screens 6, 6, but the difference screens 7, 7 are coupled together, so that any movement of one is accompanied by an exactly equal movement of the other in the same direction. At the same time each difference screen 7 is coupled to its associated antilogarithm screen 6 by the transfer mechanism. Since the two difference screens 7, 7 are not necessarily in exactly similar positions, the transfers may not take place simultaneously, hence the necessity for releasing the direct connection between the two antilogarithm screens 6, 6.

Some examples will show how the appliance is used for calculation. Suppose it is required to evaluate

$$\frac{26167 \times 52312}{32569}$$

The coupling frame is set into its first position to uncouple all the elements, and the four screens are set into their first positions, in which the antilogarithm screens both expose the numbers 10000 and the dots of both difference screens are at 0 on their respective scales. The antilogarithm screen 6 of assembly A is rotated in a forward direction until the number 26122 (the nearest number lower than 26167) comes into view; this is the number in the 42nd row and 8th column, so the screen will have been rotated from position 1 through 417 changes of position to position 418. The 42nd graduated scale 9 of the difference portion (0—60) will have come into view, and the difference screen 7 of assembly A is rotated in a forward direction until the dot is in the position nearest to the 45 (=26167—26122) graduation; this is position 76 and the screen will have been rotated from position 1 through 75 changes of position.

The coupling frame C is next set to its second position, and the antilogarithm screen 6 of assembly B is rotated in a forward direction until the number 52240 comes into view; this is the number in the 72nd row and 9th column and the screen will have been rotated from position 1 through 718 changes of position to position 719. The coupling frame C is next set to its third position. The 72nd graduated scale 9 of the difference portion (0—120) will come into view, and the difference screen 7 of assembly B is rotated in a forward direction until the dot is in the position nearest to the 72 (=52312—52240) graduation; this is position 61 and the screen will have been rotated from position 1 through 60 changes of position.

Rotation of the antilogarithm screen 6 of assembly B will have caused the screen 6 of assembly A to rotate through the same number of changes of position in the same direction, that is, to position 136 (position 418 plus 718 changes of position gives position 1136 which is position 136, the cycle recommencing after position 1000); the number in the 14th row and 6th column, that is, 13646, will then be in view. Similarly the rotation of the difference screen 7 of assembly B will have caused the difference screen 7 of assembly A to rotate to position 36 (position 76 plus 60 changes of position gives position 136, which is position 36, the cycle recommencing after position 100), and the dot will be nearest to the 11 graduation. Also the difference screen 7 of assembly A in being rotated through its 100th to its 1st position will have caused its associated antilogarithm screen 6 to be rotated one position forward, that is to position 137, and the number 13677 will be in view. Thus 13688 (13677 plus 11) is the (first five figures of the) product of 26167 multiplied by 52312.

To divide by 32569 the coupling frame C is set to its first position, and the antilogarithm screen 6 of assembly B is rotated until the number 32509 is in view, that is, to position 513, and the difference screen 7 of assembly B until the dot is nearest to graduation 60, that is, to position 81. The coupling frame C is then set to its second position, and the antilogarithm screen 6 of assembly B is rotated in a reverse direction to position 1, that is, through 512 changes of position, which will cause the antilogarithm screen 6 of assembly A to be rotated to position 625 (position 137 minus 512 changes of position). The coupling frame C is then set to its third position, and the difference screen 7 of assembly B is rotated in a reverse direction to position 1, that is, through 80 changes in position, which will cause the first difference screen to be rotated to position 56 (position 36 minus 80 changes of position) and the dot will be nearest to the 53 graduation. Also the difference screen 7 of assembly A in being rotated through its 1st to its 100th position will have caused its associated antilogarithm screen 6 to be rotated one position in a reverse direction, that is to position 624, and the number 41976 will be in view. Thus 42029 (41976+53) is the (first five figures of the) required evaluation.

To obtain the square root of 26167, one assembly is set to read this number in its antilogarithm and difference sections as above described; it will then read 41775 in the argument section. With the coupling frame in its first position the other assembly is set to read 41775/2 or 20888, in its argument section; it will then read 16176 in its antilogarithm and difference sections, and this is the first five figures of the required evaluation, ignoring decimal points. To obtain the square root of 2616.7, the second assembly is set to read 141775/2 or 70888 in its argument section; it will then read 51153 in its antilogarithm and difference sections.

Additional assemblies can be fitted to extend the scope of the appliance to include dealing directly with calculations involving other functions such as trigonometrical functions of angles. For example, one such assembly might cover sines of angles over the range from the angle whose sine is .10000 to the angle whose sine is 1.0000. Further coupling means would be required for any additional assemblies.

Many variations in the size and degree of accuracy of the instrument are possible, since the arrangements would apply generally with any number of rows and columns of antilogarithms except that in most cases the arguments if shown would have to be shown in a non-repeating sequence.

Having now particularly described and

ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A calculating appliance of the logarithmic type comprising two or more assemblies and releasable positive coupling means therebetween to permit independent or combined movement, each assembly comprising a drum bearing an antilogarithm table in rows and columns with last and first rows spaced apart by substantially the same distance as consecutive rows, a screen rotatable with small clearance around the drum and having apertures arranged on a multi-start helix to expose the numbers in one row in sequence through successive apertures as the screen is rotated, transfer mechanism to rotate the drum by an amount equivalent to the spacing between consecutive rows when the screen is moved from a position in which the end number in a row is exposed to a position in which the next number that should be exposed is in the next adjacent row, the next helical line of apertures being so located that the said next number is exposed when the screen has been moved from a position exposing said end number by an amount substantially equal to that by which it is moved to expose the next number along a row to the one previously exposed and means for directing the observer's view to one row of numbers.

2. An appliance as claimed in claim 1, in which the drum has upon it the equivalent of a difference table in the form of an axially extending scale in line with each row subdivided into as many equal parts as the mean difference between the successive numbers in the row, including the first number of the next succeeding row, the said scales being equal in length and starting at the same right section of the drum, and in which a transparent screen is rotatable with small clearance around the difference portion of the drum and carries a plurality of dots equidistantly spaced on a single helix of pitch equal to the length of the said scales and located to indicate a number of divisions corresponding to the rotational position of the screen on the scale associated with the row containing the number to which the observer's eye is directed.

3. An appliance as claimed in claim 2 in which the coupling means between two assemblies is adapted to be set into three positions, firstly, one in which the four rotatable screens are all capable of independent movement, secondly, one in which the two screens for cooperation with the antilogarithm tables are coupled for equal movement and the two screens for cooperation with the difference scales are free, and thirdly, one in which the screens for cooperation with the difference scales are coupled together for equal movement and each said screen is coupled by transfer mechanism to the screen adapted to cooperate with the associated antilogarithm table, the last named screens being otherwise independent.

4. A calculating appliance of the logarithmic type in which two or more assemblies are adapted to be coupled together for combined movement or uncoupled for independent movement, and in which each assembly comprises a table of antilogarithms uniformly spaced in rows and columns with constant differences between the arguments (logarithms), selection means to indicate any one of the antilogarithms of the table, means for applying relative movement to the table and the selection means to perform a mathematical operation, and a transfer device associated with the selection means to bring the next adjacent row or column of consecutive antilogarithms into cooperation therewith at the appropriate time.

5. An appliance as claimed in claim 4 in which the table of antilogarithms is associated with a set of difference scales each one graduated to indicate mean proportional differences between a sequence of consecutive antilogarithms, and an indicator is provided to mark on any difference scale the difference required to increase the antilogarithm indicated to the quantity in question (which is smaller than the next higher antilogarithm), the indicator being movable in relation to the difference scale and transfer means being provided by which the selection means can when required be actuated by the relative movement of the indicator and difference scale.

6. An appliance as claimed in any of claims 1 to 5 in which the antilogarithm table of each assembly has ten columns and one hundred rows.

7. An appliance as claimed in claim 6 in which the argument (logarithm) is entered as to its first two digits in line with each row of antilogarithms, as to its third digit on a fixed member in a location corresponding to the several columns, and, where difference scales as claimed in claim 2 or 5 are provided, as to its fourth and fifth digits on the difference indicating means so that the two final digits exhibited correspond to the difference indicated.

8. An appliance as claimed in any of claims 1 to 5 in which the antilogarithms entered in the table of at least one assembly are functions other than plain

numbers, such as trigonometrical functions.

9. A calculating appliance substantially as described herein with reference to the accompanying drawings.

Dated the 15th day of March, 1946.
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[This Drawing is a reproduction of the Original on a reduced scale.]

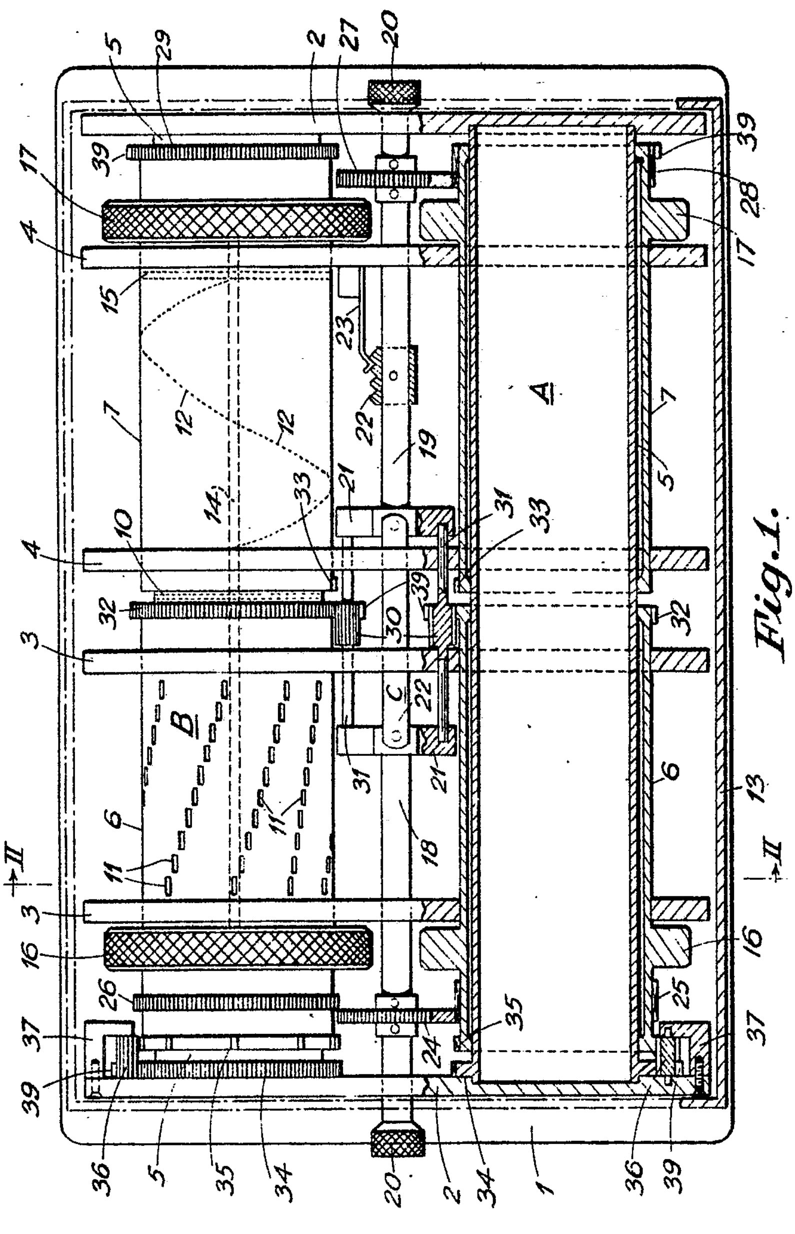


Fig. 1.

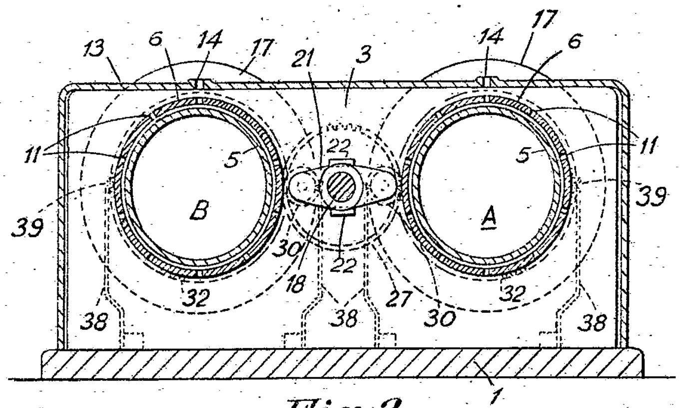
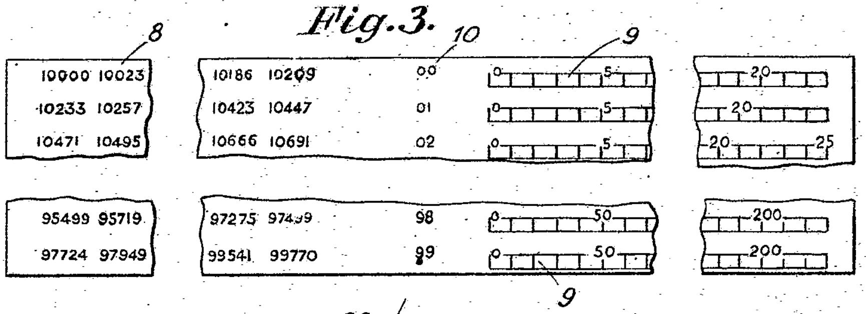


Fig. 2.

Fig. 3.



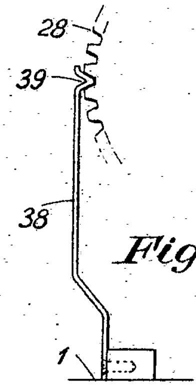


Fig. 4.