131,160

PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

A Calculating Device and Improvements in Calculating Apparatus with Multilinear Logarithmic Scales.

I, JOSHUA HAMILTON GLADSTONE, of 3, Coleman Street, London, E.C. 2, Chartered Accountant, 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:—

The invention relates to improvements in calculating apparatus employing a scale logarithmic in two dimensions, and also employing mechanical means for identifying pairs of readings in similar ratio by the similarity in length and direction of the lines joining them.

THE SCALE.

When a number of identical logarithmic scales are arranged in evenly stepped order, on a plane surface, parallel to one another, at equal distances, with their scales commencing in a straight base line, which is set at a sharply acute angle to the scale lengths, they form the well known multilinear logarithmic scale, see Figure I. It is used on a plain surface, or wrapped round a cylinder.

The multilinear scale is logarithmic in two dimensions. For, if, parallel to the base line AS, a series of lines were drawn, through all its scale points, they would divide not only the lines of the multilinear scale, but every line drawn in any direction across them proportionately and therefore logarithmically. Lines so divided are logarithmic scales. Such scales would intersect one another and the original scale at like scale points, if they all commenced with unity at the base line, and the figures at points of intersection on the multilinear scale would apply also to the intersecting scales.

The scale cycle lengths of such scales, (that is, the length along the particular scale in question from any scale point to the next like scale point,) will vary with the direction, increasing as the direction approaches that of the base line. Consequently, lengths gauging a like ratio, (such as, LT, LB, RT and RB, Figure I, which each gauge the ratio 3 is to 7,) must also vary with the direction, being proportionate to the corresponding cycle lengths. But two such lines, if parallel, will have equal cycle lengths; so that equal lengths of parallel lines will indicate pairs of readings in a like ratio. Two or more such parallel lines, if equidistant, will form another multilinear logarithmic scale.

The well known single-cycle form of the scale is shown in Figure II.

A "chequer" is any one of the small, similar parallelograms (see Figure I,) formed by two series of parallel lines, drawn in different directions, through any scale point and all other like points of the multilinear scale, each parallelogram containing an exact single cycle of the scale, cut up into sections. Each

[*Price* 6*d*.]

of these successive scale sections will commence at the exact scale point where the previous one was cut off by the margin of the "chequer."

The "Four Ways" Indicator.

An indicator, in some form, must, of necessity, be used with the multilinear scale. It must be capable of gauging temporarily the varying distances and directions on the scale and of registering again, on some other part of the scale, the distance and direction measured.

Consequently, indicating instruments must consist of pointers arranged on two separate supports, which are capable of independent movements, and capable of being fixed in any definite relationship and, when so relatively fixed, capable of parallel movement with respect to the scale itself, so that the direction and length of the second line measured shall correspond with the original measurements taken.

The number of pointers arranged to register simultaneously on like points, placed on one of these supports has been duplicated and otherwise increased, the second support has hitherto carried one such pointer only.

The present device duplicates and occasionally further increases the pointers, registering simultaneously on like points, on both supports.

The effect of this arrangement of the pointers is to supply at least four alternative ways of working. For, as the indicator registers on a pair of similar figures with each support, it automatically supplies (with its pointers, L and R, and T and B, see Figure I,) four gauge lines (LT, LB, RT and RB.) These gauge lines all run from one figure of the ratio, (in this example a 3,) to the other figure of the ratio, (a 7,) and each simultaneously gauges the same ratio, (3 is to 7.) As the four gauge lines consistently gauge a like ratio, they may be freely substituted for one another; so that, with such a "four ways" gauge, if a ratio is measured with any one of the gauge lines or "ways", there are four "ways" available for making the second measurement, and it is a matter of indifference which is used.

The choice of the like points, on which the two supports may be made to register, being unrestricted, the two lines joining these points on the scale, and also the corresponding lines; (LR and TB,) on the supports, may be in practically any directions.

The angle between these two selected directions on the scale being once determined, a similar angle must be constantly maintained between the corresponding lines joining the pair of indicating points, on each support.

When the pointers duly register on like scale points, in the two selected directions, the indicator is said to be "true" to the scale.

This registration may be facilitated by seeing that, when making any measurement, a line on one of the supports is parallel to a line on the scale, traversing the scale lengths, in the corresponding direction.

Construction.

A "four ways" indicator requires, in addition to the mechanism necessary for the well known indicators, a provision for keeping in registration on like points the pointers on the support which has hitherto had one pointer only. A repetition of the parallelising mechanism already in use will effect this.

The mechanism is therefore as follows:—

A couple of pointers are fixed on the one support, so as to register on the first pair of like points and a second couple are similarly fixed on the other support, so as to register on the second pair of like points.

The supports are attached to one another, by any parallelising mechanism. (This will maintain the correct angle between the lines joining the pair of indicating points on each support.

The supports, so connected, are attached to the scale, by any parallelising mechanism. (Which will keep the indicator "true" to the scale.)

Or, instead of the first mechanical parallelism, the two independent supports may be temporarily held in the required relative position, by any ordinary attachment.

Or, instead of the second mechanical parallelism, the instrument may be kept " true " by eye.

The choice of method is so diverse and other mechanism is so readily substituted, that I do not propose to restrict my claim to any form of construction.

The portion of the multilinear scale required may be reduced to the minimum possible, a single cycle, by choosing like points in adjacent " chequers " and making the direction of LR and TB conform with the directions of the " chequer " margins. The practical advantage resulting is that it enables the maximum extent to be given to the graduations.

Figure III illustrates a type of indicator suitable for use with the scale shown in Figure II, and designed to be kept " true " by the eye.

X and Y are guides, set at right angles to one another. A narrow vertical rod, V, passes through Y and a stouter horizontal arm, H, passes through X. Friction prevents the accidental shifting of the arms, when set.

Each arm supports a pair of pointers, all of which are read on the scale sections to their left.

On the horizontal arm, the left and right hand pointers are L and R, the upper margins of the T shaped feet, on which the instrument stands. These feet are made of thin metal plates. The distance between the indicating points on these two margins is made equal to the distance between like scale points in the corresponding direction, so that, when the instrument is placed " true " to the scale, the scale points that they indicate are like points.

The pointers on the vertical arm are T and B, the top and bottom ends of the rod. These ends are filed off square. The rod is bent, so that when the instrument is placed " true " and the arms so adjusted in the guides that B will register on the terminal point of one scale section, T will register exactly on the like point at the commencement of the succeeding scale section.

The feet of the horizontal arm rest on the scale, the vertical arm is raised slightly off the scale, to enable it to be adjusted, without disturbing the setting of the horizontal arm, which is usually the first to be set.

The lower margins of the feet, *l* and *r*, are used as alternative pointers, on occasions when, if L or R, had been used, the horizontal arm, or its shadow, would have interfered with the reading of some figure beneath it.

The scale may be one of numbers, trigonometrical, or other functions. These different scales will be so graduated, as to be available for use in association with one another, that is the associated scales would be set out with proper reference to the cycle length of the scale of plain numbers.

The scale markings may be round numbers, quantities or functions, arranged at logarithmic intervals, or the approximate numbers, quantities or functions may be shown at equal scale intervals.

Beyond the margins of the multilinear scale, (Figure II) logarithmic mantissæ may be indicated by decimal numbers (at D) and a supplementary scale (at C) having equal graduations showing further decimal places; and scale sections may for evolution be numbered (see N and M), or marked to distinguish alternate sections. Alternate sections are distinguished by a small cross, at the head or foot of the scale section. Unity has, in Figure II, been chosen as the commencing point of the cycle, in order to make the mantissæ start at nil.

The scale is provided with several parallel lines, traversing the scale section lengths, to aid the eye in placing the indicator " true," when the second parallelising mechanism is dispensed with. This feature is also illustrated in Figure II, by horizontal lines.

Additional pointers, indicating further like scale points, may be arranged on extensions of either or both supports, particularly for use with scales which

extend over more than one logarithmic cycle, such as the trigonometrical or log-log scales.

A practical example of the principles involved can be well illustrated on the small scale shown in Figure II. The letters, L, R, T and B, will, as before, be employed to indicate the pointers used; L for the left, R for the right hand pointer on the one support, T for the top, B for the bottom pointer on the second support.

For each measurement the indicator is set "true" to the scale. The relative adjustment of the pointers must not be altered between two corresponding measurements.

Find $^{32}/_{88}$ths successively of 220, 264, 286 and 341.

Set the pointer R on 88 and T on 32; then place L on 220 and T indicates 80; then place L on 264 and B indicates 96; then place R on 286 and T indicates 104; finally place R on 341 and B indicates 124.

It will be seen that while the ratio was measured by the line RT for all calculations, the lines LT, LB, RT and RB, were one after the other utilized for the second step.

Evolution may be performed by means of the marginal logarithmic mantissæ, or by selecting the proper unity point on the scale and dividing up the straight line between that point and the scale position of the figure of which the root is required. One of the means of so doing is by the use of a ruler and numbered or alternately marked scale sections. (See Figure II.) The "four ways" indicator, if it is set at the corresponding root of ten, will indicate, by repeated multiplication, or division, the remaining roots of the figure, when the decimal point is placed in the other possible positions. These varying roots of ten, being constants, may be marked on or about the scale; or simple all-root indicators can be made, for example, by placing on a card pointers which register on the cube roots of one, ten and a hundred and their repetitions in an adjacent "chequer," for finding the cube roots; or on the square roots of one and ten, for finding the square roots. These indicators are placed "true" by means of a line drawn on them, when in registration, parallel to the lines on the scale, used to keep the "four ways" indicator "true."

As an example, find the cube roots of 4.35, 43.5 and 435.

At the top of the scale section, in Figure II, containing the figure 435, there is a scale section number, 6, which has three, (the cube root characteristic,) as a factor. It is the sixth column from the top left hand unity point. $^{6}/_{3}$ is 2, indicating the second column.

Place a ruler against the scale markings of that unity point and of 435, and the point where the ruler crosses the scale in the second column from that unity point, indicates that the cube root of 4.35 is 1.63.

Set the "four ways" indicator with L on the top left hand unity point and B on 2.154, (the cube root of ten, marked on the scale,) again place L on 1.63 and B will indicate 3.52 the cube root of 43.5; again place L on 3.52 and B will indicate 7.57 the cube root of 435.

With scales about twelve and a half inches by ten, every calculation that can be worked on any slide rule can be worked, with a probable error of under one in ten thousand.

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 device, employing scales logarithmic in two dimensions, in combination with an indicating instrument, having two adjustable supports, each of which indicates at least two like scale points, substantially as and for the purposes described.

2. An instrument, constructed by any well known means, having two adjustable arms or other supports, each capable of indicating, simultaneously, more

than one like point, on scales logarithmic in two dimensions, substantially as and for the purposes described.

3. As improvements in a calculating device, according to Claim 1, the ruling of parallel lines traversing the scale section lengths of such scales; the numbering of scale sections, and the distinctive marking of alternate scale sections of such scales; the indication on or about such scales of the various roots of the number ten; and the construction of all-root indicators, all substantially as and for the purposes described.

Dated the Seventeenth day of August, 1918.

J. HAMILTON GLADSTONE.

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SHEET 1.

FIG. I.

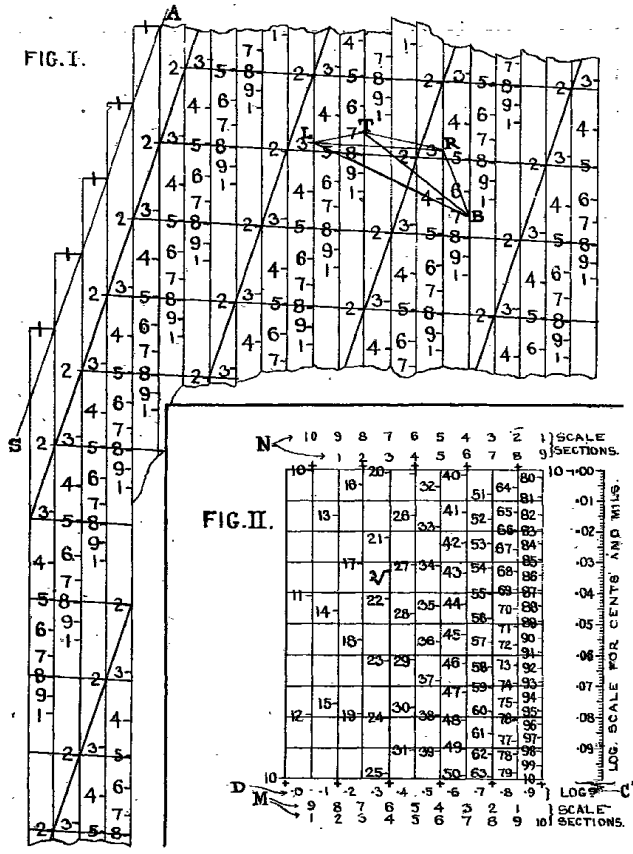

FIG. II.

SHEET 2.

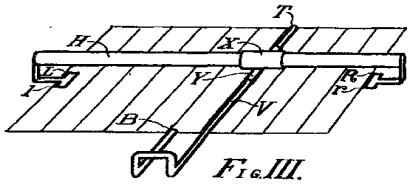

FIG. III.

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

FIG. I.

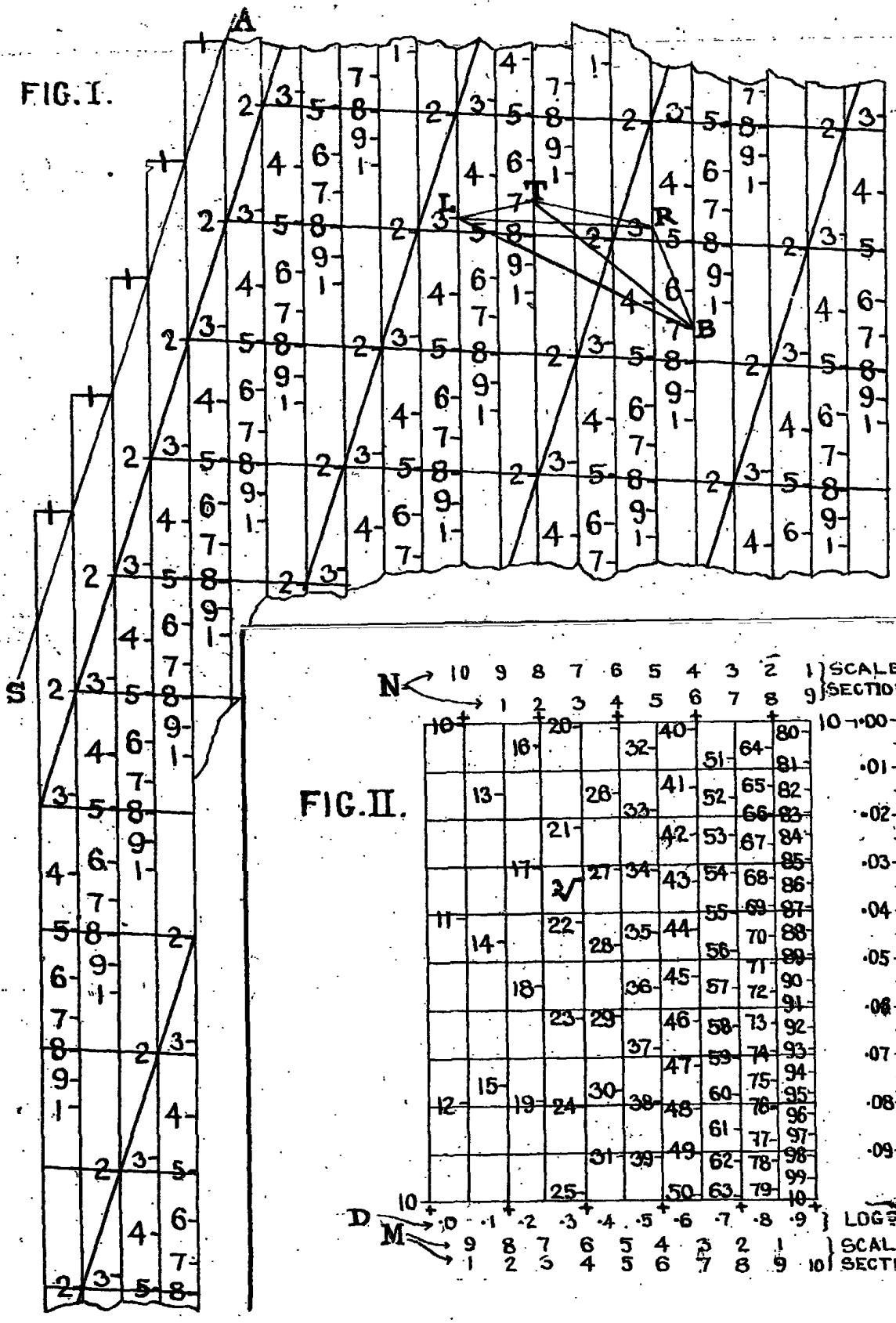

FIG. II.

SHEET 1.

SHEET 2.

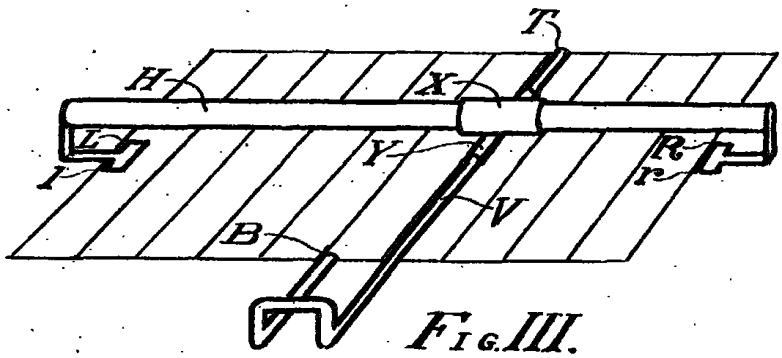

FIG. III.