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COMPLETE SPECIFICATION.

Improvements in Logarithmic Calculating Instruments.

I, ROBERT HENRY SMITH, Civil and Mechanical Engineer, of Ellerslie, Brunswick Road, Sutton, in the County of Surrey, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This instrument consists of three parts each in the form of a tube, but the outer tube being so short as to be better called a ring. These tubes are arranged one inside the other and sliding on each other telescopically. The three tubes are all of the same material and are preferably made of thin metal.

The inner tube is the longest of the three. On it is placed spirally a logarithmic scale, that is, a scale of lengths proportional to the logarithms of whole and fractional numbers from one to ten. It is therefore termed the scale tube. Throughout the central part of its length upon which the scale is placed, it is made of slightly less outside diameter than at either end. Thus the second tube which fits these ends does not rub upon the scale so as to abrade or dirty its surface. The second tube is called the holder tube because in using the instrument this tube is held in one hand continuously throughout any series of operations, the manipulations being entirely performed by the other hand. This second tube is shorter than the inner one so that at all times there is sufficient length of the inner or scale tube projecting beyond one or both ends of the holder tube to enable one to grasp the scale tube in order to slide it inside the holder tube. Each tube being considerably longer than the one outside it also ensures that the one may be slid upon the other through a long range and with an easy fit between the two without rock shake or side-play sufficient to cause inaccuracy in the settings or readings.

The second or holder tube has cut in it two opposite slots throughout a central length somewhat longer than that occupied by the spiral logarithmic scale. The parts not cut away by these slots form two opposite bars rigidly connecting the two uncut ends of the tube. At the four ends of the two edges of one of these bars are formed four small rectangular projections whose projecting corners are used as four reading indices or horns. These reading indices are thus placed upon and attached to the tube which carries them in a very rigid manner without overhanging or springy parts so that the pairs of indices cannot be sprung or bent out of their correct relative positions and so that no adjusting device for drawing them from time to time into true relative position is necessary. This arrangement of tubes without overhanging or projecting parts also obviates the risk of such parts catching each other or the dress or fingers of the operator when being moved past each other in the process of manipulation, whereby they are, in other similar instruments, frequently bent out of shape.

The breadth of each bar is made about twenty *per cent* of the circumference of the tube, leaving the breadth of each slot about thirty *per cent* of the same. The circumferential distance between each pair of reading horns is intermediate between these two dimensions being made about twenty-six *per cent* of the whole circumference. Each pair of horns at the two ends of one edge have their reading corners placed exactly on the same line parallel to the axis of the tube and at a distance apart exactly equal to the axial length of the spiral logarithmic scale

[*Price* 8*d.*]

so that when one horn is placed at the beginning of the scale marked 100 the other horn is precisely at its end marked 1000.

The pair of horns fashioned on the right hand edge of the bar have their reading corners placed precisely 26 *per cent* of the circumference distant from the right hand edge of the slot and this edge of the slot is cut with exactitude straight and parallel to the axis of the tube. With the exception of the parts here particularly mentioned exactitude in the cutting of the various edges and corners of the instrument is of no importance whatever for accurate calculation. It is important that the holder tube should slide upon the scale tube without shake and that both these tubes should be accurately straight.

The third or outer ring tube is of short length and slides with an easy fit upon the holder tube. On its two edges there are a top and a bottom reading projection. These two are alternative indices for setting and reading but there is no necessary particular relation between their positions nor any necessary particular length between them.

The three tubes being made of the same material, preferably of thin metal, change of temperature or the like influence produces equal expansion or contraction in all three so that such change does not produce either slackness or tightness in the fit of one upon the other tube with consequent easy sliding without shake or side-play at all times. This result is obtained without the use of felt or other soft packing between the tubes such as has been required in other similar instruments.

The instrument being composed of these three parts is called the Ring-Holder Scale Logarithmic Calculator, or more shortly the R-H-S log rule, this name being a mnemonic materially assisting the recollection of the correct manipulation of the instrument.

As at present made the outside diameter of the instrument being only about seven eights of an inch and its length only about nine inches, it is very easily carried in the pocket, and draughtsmen may use it as a case in which to hold drawing pencils or like instruments.

Yet the spiral scale is about fifty inches long and it is thus capable of giving in calculation as high a grade of accuracy as a straight logarithmic slide rule of double this length. A straight slide rule of this length costs many times as much as does this construction; is extremely clumsy to use, and is not conveniently portable. The fifty inch scale is sub-divided by lines to three-place figures and by ordinary and easy eye-estimation of the fractional values of the divisions, four-figure results are read from it. This degree of accuracy corresponds with the limits of exactitude required in the great bulk of engineering, architectural and industrial calculations. But I reserve the right to manufacture the instrument in any larger or smaller size than here stated that may be found convenient

Fig. 1 shews the scale tube apart from the holder and ring tubes. The beginning of the spiral scale is marked 100 and the end is marked 1000. The intermediate numbers are marked at suitable points all along the length. Around the top of the central part of smaller diameter is marked a circular scale of 50 equal parts. The spiral scale is formed in 20 complete spiral turns. The number of complete turns from the beginning of the scale to any point of it may be counted by means of a straight scale of 20 equal parts engraved on the right hand edge of one of the slots in the holder tube; this scale being numbered however, from 0 up to 10. The fraction of one complete spiral turn is measured by help of the 50-part circular scale. By combining the two readings from the straight and circular scales the length of any part of the spiral scale from its beginning may be measured in thousandth parts of the whole length from beginning to end. This reading forms the 3-figure mantissa of the logarithm of the corresponding number; and by this measurement of the logarithm exponential calculations, such as compound interest and similar sums in geometrical progression with any positive whole or fractional powers or roots, may be easily performed. These scales are not used for ordinary multiplication or division. To take this reading of the

mantissa of the logarithm the lower right hand horn h of the holder tube is placed upon the spiral scale at the number whose logarithm is desired, and the logarithm is read off by the right hand edge of the slot in the holder by help of the straight scale combined with the uniform circular scale. The zero of the top circular scale is displaced circumferentially from the beginning of the spiral scale by twenty-six *per cent* of the circumference, namely the same distance as from the horn to the right hand edge of the slot.

Both spiral scale and top circular scale are printed upon paper which is cemented upon the metal tube, and afterwards covered with special hard and transparent varnish.

Figs. 2, 3 and 4 shew the holder and ring together without the scale tube. Fig. 2 is a view facing the slot containing the right hand horns and the straight holder scale. Fig. 3 is a view facing the bar which carries no horns, but on which is marked the above scale. In these figures the two indices on the ring R are marked r and r^1. Fig. 4 is a view facing the other bar carrying the four horns $h\,h^1\,i\,i^1$. In Fig. 4 the ring R is removed. Any calculation performed by this instrument involves three settings and a final reading of the result. The three settings correspond to the three factors in $\frac{M_1\,M_3}{D_2}$ where $M_1 M_3$ are two multipliers and D_2 is a devisor, or, otherwise stated, correspond to the three given terms of a sum in proportion. The settings are performed in the order $M_1\,D_2\,M_3$. Firstly, holding the holder in the left hand, the scale tube is slid inside it so as to bring the number M_1 as printed on the spiral scale under one of the horns of the holder. Next the ring is grasped in the right hand and slid on the holder so as to make one of its horns read D_2 on the scale. Thirdly, the scale tube is again taken hold of by the right hand and slid inside the holder until the same ring horn reads M_3 on the scale. Lastly the result $Q = \frac{M_1\,M_3}{D_2}$ is read off the scale at the same holder horn as was used in the first operation.

If a simple multiplication $M_1\,M_3$ is to be performed, then in the second setting the ring horn is placed at either 100 or 1000 on the scale since $D_2 = 1$.

If a simple division $M_1 \div D_2$ is to be performed, then in the third setting the scale is set so as to bring 100 or 1000 under the ring horn since in this case $M_3 = 1$

Thus the sliding operations are always performed in the order scale tube, ring, scale tube, or S.R.S; while the settings or readings on S are made by help of the indices or horns in the order holder, ring, ring, holder or H R R H.

At the end of these operations the holder horn used in the first setting may be situated beyond the limits of the spiral scale; if so, the reading of the result is to be taken by the other holder horn in the same axial line; that is, i instead of h or *vice versa*, or i^1 instead of h^1 or *vice versa*. If the scale were extended these two horns would in every position read the same series of figures, the one representing a number ten times greater than the other.

If when the first setting to M_1 is made by one of the right hand holder horns $h\,i$, this setting causes the place of the number D_2 on the scale S to be hidden by either bar of the holder, then the first setting is to be shifted to make one of the left hand holder horns $h^1\,i^1$ read M_1. This shifting involves a rotation of the scale tube in the holder tube, equal to the angle between h and i and as this angle is greater than that covered by the bar but less than that of the slot, the reading M_1 must now necessarily be visible. In other instruments of this class there is always a certain series of results which cannot be worked accurately because of necessary readings on the scale being hidden by parts of the instrument. In my invention there are no such cases.

The alternative indices on the ring R are provided to avoid ever having the holder indices covered and hidden by the ring. In the second setting if, when the ring index r is set upon D_2 the body of the ring covers either set of holder horns, then the index r^1 must be used instead of r when the holder horns will be neces-

sarily uncovered. This rule amounts to the direction that the ring is never to be slid on the holder so that either r or r^1 goes beyond the limits $h\,h^1$ or $i\,i^1$.

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. In a cylindric logarithmic calculating instrument with a spiral scale, the placing of the two needful sets of indices directly on the bodies of tubes sliding outside the tube carrying the spiral logarithmic scale, so that these indices are held rigidly in fixed positions in these tubes without any overhanging or slender and springy parts, the errors due to the springing of the parts supporting the indices being therefore eliminated; and so that in the sliding motions necessary in the manipulation of the instrument the one set of indices passes the other freely without possibility of catching these others or the fingers or dress of the manipulator and thereby becoming strained out of true relative position.

2. In the nest of three tubes referred to in Claim (1) making each tube considerably longer than that next outside it the parts of the instrument being thus readily made so as to slide easily to an accurate fit one on the other without rock, shake, or side play sufficient to cause inaccuracy in the settings or readings.

3. The making of the three tubes all of the same material and preferably of one and the same metal, whereby they may be made to fit each other accurately while sliding on each other easily without packing of any soft material between them and whereby, the three tubes expanding and contracting in the same ratio with change of temperature or the like influence they maintain their good fit in spite of such expansions and contractions.

4. The placing of the primary indices on the edges of two opposite slots in a metal tube outside the tube carrying the scale so that these slots permit the manipulator to see all the parts of the scale needed at any one time during the manipulation while at the same time the two bars separating the slots hold together the two ends of the tube in a substantial and rigid manner, thereby preventing the indices carried by the tube being sprung out of their true relative positions and obviating the necessity of any adjusting device to draw these points from time to time into correct relative position.

5. The proportioning of the circumferential widths of the slots and the bars referred to in Claim (4) and of the circumferential distance between the pairs of indices so that, while leaving the bars wide and therefore stiff all possibility of parts of the scale required to be seen being hidden by the bars or other parts of the instrument is eliminated, each slot having a width more than a quarter of the circumference, each bar a width less than a quarter of the circumference and each pair of indices being placed apart a distance intermediate between the widths of the slot and of the bar in the manner substantially hereinbefore described and illustrated.

6. In cylindric logarithmic calculating instruments consisting of tubes sliding one on the other and the tube carrying the logarithmic scale not being the outer tube, the making of that part of the scale tube occupied by the scale of slightly less diameter than its other parts so that the outer tube sliding upon these larger parts and fitting them, may not rub, abrade or dirty the scale surface.

7. The combination of the parts substantially as hereinbefore described and illustrated so as to form a logarithmic calculating instrument reading with accuracy upon an open scale to three and four figures and yet so compact that it is readily portable in the coat pocket.

Dated this Twenty-fifth day of August, 1899.

(Signed) ROBERT H. SMITH.

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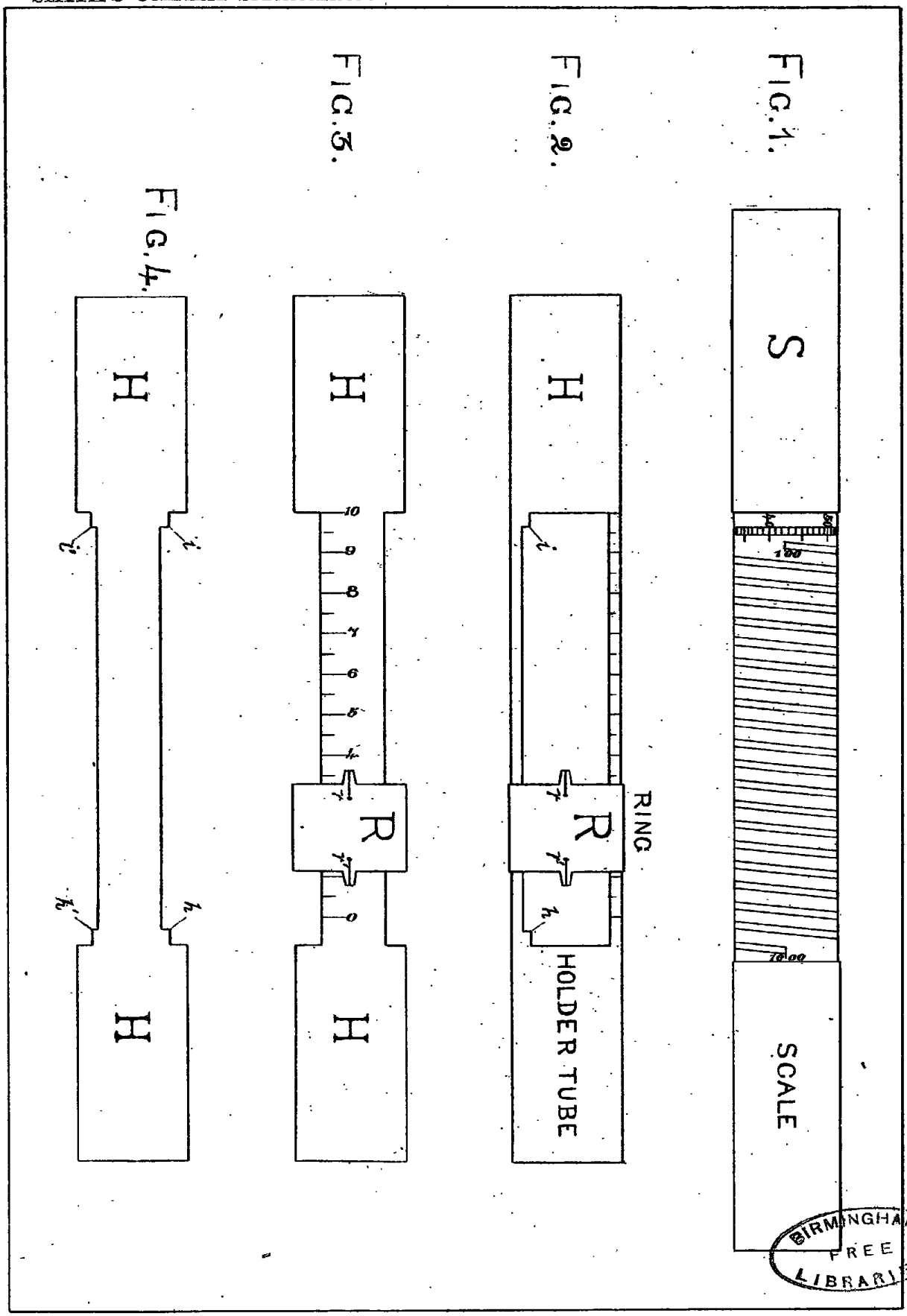
SMITH'S Complete Specification.

(1 SHEET)



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

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