Sept. 14, 1926. 1,599,904

P. LÖTZBEYER

CALCULATING DEVICE IN THE FORM OF A SLIDE RULE

Filed June 27, 1924 2 Sheets-Sheet 1

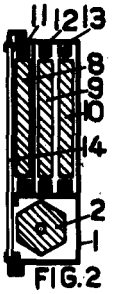

FIG. 2

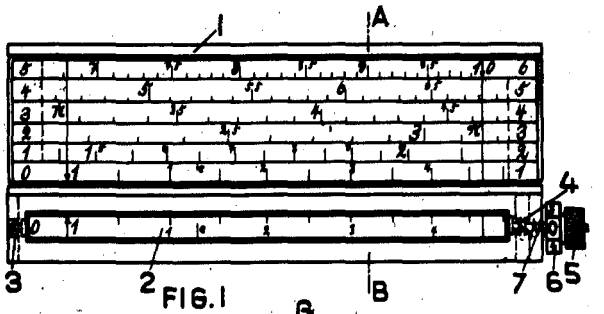

FIG. 1

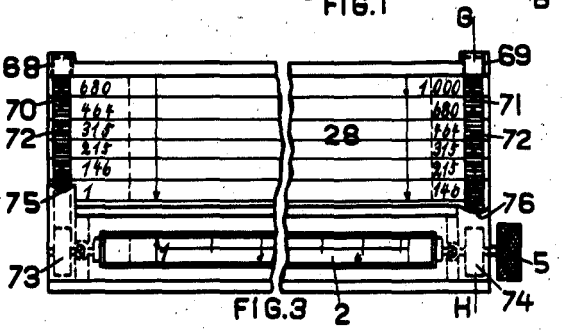

FIG. 3

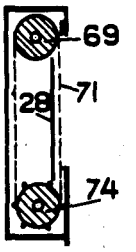

FIG. 4

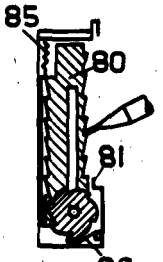

FIG. 5

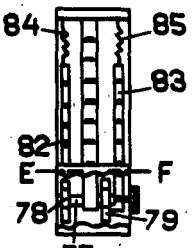

FIG. 6

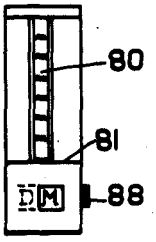

FIG. 7

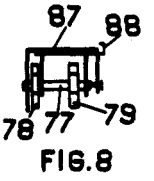

FIG. 8

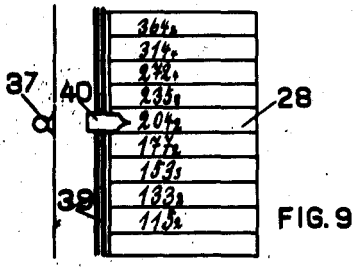

FIG. 9

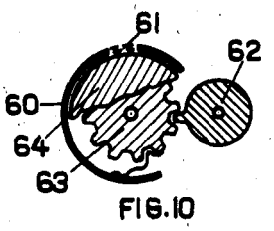

FIG. 10

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CALCULATING DEVICE IN THE FORM OF A SLIDE RULE

Filed June 27, 1924 2 Sheets-Sheet 2

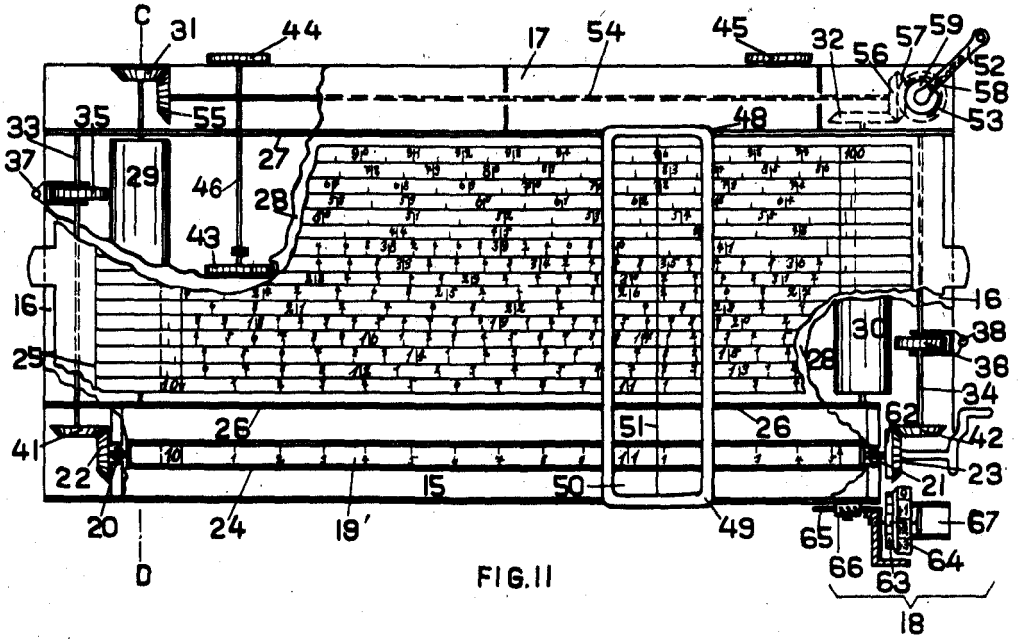

FIG. 11

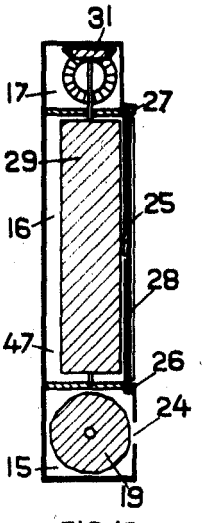

FIG. 12

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Patented Sept. 14, 1926. 1,599,904

UNITED STATES PATENT OFFICE.

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CALCULATING DEVICE IN THE FORM OF A SLIDE RULE.

Application filed June 27, 1924, Serial No. 722,746, and in Germany July 1, 1923.

My invention relates to a calculating device in the form of a slide-rule of handy shape and with a large unit of measure. This improved calculating-device or slide-rule is illustrated by way of example in the accompanying drawings in which Figure 1 is a plan thereof; Figure 2 is a section in line A—B of Fig. 1, seen from the right to the left; Figure 3 is a plan of a device for the simplied adjusting of a rotary body which forms a part of the slide-rule to the result of the calculation; Figure 4 is a section in the line G—H of Fig. 3, seen from the left to the right; Figures 5, 6, 7, 8 show a modification of the device shown in Figs. 3 and 4, Fig. 8 being a section in line E—F of Fig. 6, seen from above; Figures 9 and 10 are details of an adjusting and transfer-device which is illustrated in Figure 11 in plan, a part of the covering plate of the device being broken off at the upper left hand corner of the figure; and Figure 12 is a section in line C—D of Fig. 11, seen from the left to the right.

In a casing 1 is arranged a regular prism 2 of hexagonal cross-section showing on its six surfaces the part-pieces of the logarithmic numerical scale or graduation with the logarithmic unit 50 cm. The prism 2 extends in the longitudinal direction of the casing of the device or rule, and the ends of the axle of the prism lie in guide-ways provided at the sides of the casing where they cooperate with springs 3 and 4 in order to facilitate the step-wise rotation of the prism and to cause it to contact smoothly at its end with the covering-plate of the casing. The prism can be turned by means of a knob 5, but in connection with the lead-numbers mentioned later on it may be rotated nearly completely mechanically by means of cog-wheels and an endless steel-band, as will be more fully described hereinafter.

The prism which projects at its righthand end beyond the side-wall of the casing carries a counting-disk 6 which is also hexagonal and shows the numerals 0–5. It is pressed against the knob 5 by means of a compression spring 7 and engages it with a plurality of projections so that it is turned together with the knob 5, but can be turned also independently thereof after having been shifted to the left so as to be uncoupled from the knob and to compress the spring 7.

Parallelly to the prism 2 extends the scale- or graduation-chamber in which superposed slides 8 9 10 can be shifted in guide-ways 11 12 13. Each slide is provided with a scale or graduation at both rims. The upper slide 8 is shown in its computation position. Above the three slides and the prism is arranged a slide 14 which consist of glass and is provided on its bottom slide with a line (not shown).

In this way slide-rules of, for instance, a logarithmic unit of 50 cm. (length 53 cm., width 4.3 cm., height 1.3 cm.) can be reduced to a length of from 11 to 11.5 cm., a width of 5.2 cm., and a height of 1.2 cm.

In the constructional form shown by way of example the slide 8 is provided at its front with the logarithmic scale of the numbers and at its rear with the scale of the reciprocal numbers (inverse scale or graduation); the slide 9 is provided at its front with the square numbers and at its rear with the cubic numbers; and the slide 10 is provided at its front with the sine scale or graduation and at its rear with the tangent scale or graduation; each scale or graduation consists of six equal parts. It is possible to add in a convenient manner other scales or graduations, and if, as occurs oftentimes, transfers from one scale or graduation to another scale or graduation take place the slide-rule may have double the length.

The manner of use of this slide-rule is practically the same as with an undivided slide-rule; anyhow, a few particular points must be observed, viz:

The part-pieces of the scales or graduations show on the lefthand side the leading numbers from 0 to 5, and on the right-hand side the lead-numbers from 1 to 6, partly in colored fields. The lead-numbers on the left side are valid for adjustments on the left, and the lead-numbers on the right side are valid for adjustments on the right.

Example I: 1.5×4.

The rotary prism is turned until the part-graduation showing the quantity or magnitude 1.5 appears. Then this quantity or magnitude is adjusted by means of the cursor and thereafter the slide designated with 1 is adjusted in the same manner as in an undivided slide-rule. Now the cursor is adjusted on the number 4 of the slide and the prism is turned further for 3 graduations in conformity with the lead-number 3 of the left side. In order to obviate mistakes, the

counting-disk 6 is used for that adjustment.

In the same manner such calculations as, for instance, 1.5 × 5, or 1.5 × 6, and the like, are carried through.

Example II: 6.5 × 5.

The cursor is moved to the number 6.5 of the rotatory prism; the slide bearing the number 5 is adjusted on the line of the cursor. The prism is turned rearwards for 4 graduations (division) according to the lead-number 5 on the left. Reading-off under the mark 1 "left" on the rotatory prism shows the result 1.3.

It does not seem necessary to give further examples. But it is necessary to call attention to the feature that when square numbers or cubic numbers, as well as square roots and cubic roots, are read off, and also when sine quantities or values or tangent quantities or values are read off, the lead numbers of the part graduations of the slide and of the prisms must agree with each other.

Great accuracy can be obtained when the slide-rule is manufactured of a metal, and its applicability can be rendered multifarious by the provision of a large number of slides. The manipulation can be simplified very much by the provision of mechanical turning devices operated in connection with the lead numbers.

I now proceed to describe the modified form illustrated in Figures 11 and 12, of which details are shown in Figures 9 and 10. This device is an adjusting and transfer-device, combined with an automatic device for ascertaining the number of the digits. In the example shown the device is intended for a comparatively large unit of measure which forms a whole or total.

The casing is divided into three parts 15 16 17; at the righthand lower corner is provided a small by-chamber 18 in which are housed the means for ascertaining the number of the digits; the cover of the casing is broken away over this by-chamber, as well as at the upper lefthand corner of the main casing.

In the casing-part 15 is located the rotatory body or hexagonal prism 19, on the six surfaces of which the part-scales or graduations of a logarithmic scale or graduation are provided in their proper succession. The body or prism 19 is also in this case, as in Figs. 1 and 2, supported elastically (at 20 and 21) for the purpose of facilitating, the adjustment of its individual surfaces, and is connected at its ends with bevel-wheels 22 and 23. In the cover of the casing, above the prism, is a longitudinal sight slot 19', through which that prism side which is the uppermost at the time being can be seen. The casing part 16 contains in its upper part the calculation plate or slide 25 which is shiftable in guideways 26 and 27 and bears the part-scales or graduations of a logarithmic scale or graduation like that of the prism 19. Below the slide 25 is located a plate 28 bearing on its ends the lead-numbers or the limit numbers; a part of the plate is shown in Fig. 9. Below the plate 28 are arranged, near the lateral ends of the casing, two rollers 29 and 30 which lie crosswise in the casing and are connected with bevel-wheels 31 and 32 meshing with bevel-wheels 55 and 56 secured to a shaft 54 to which I shall revert later on.

Parallelly to the rollers or cylinders 29 and 30 are arranged shafts 33 and 34 of square section, and on them are adjusting wheels 35 and 36 which can be shifted along said shafts by means of adjusting knobs 37 and 38, each of which is connected with a short horizontal fork-like member holding the appertaining adjusting-wheel (35, or 36 respectively) between its prongs. Each fork-like member is provided with a hand 40 (Fig. 9), with the aid of which the appertaining adjusting-wheel (35, or 36 respectively) is adjusted to the scale or graduation required. The square shafts 33 and 34 project into the casing part containing the rotatory prism and are here provided with bevel-wheels 41 and 42 meshing with bevel-wheels 22 and 23 connected with said prism.

Righthand from the cylinder 29 is located a cog-wheel 43 (Fig. 11); another such wheel is located lefthand from the cylinder 30; it is covered by the cover of the casing and not visible from this reason. Both these cog-wheels mesh with a rack provided at the bottom-surface of the slide 25 and serving for the fine-adjustment thereof. Each cog-wheel 43 is secured to a shaft 46 which extends outwards, near the bevel-wheels 55 and 56, and is there provided with a small disk 44, or 45 respectively, serving as handle for turning the respective shaft (46). Below the cylinders or rollers 29 is a space or chamber 47 (Fig. 12) in which one or more other, additional, calculation slides may be stored.

On the top of the casing is a cursor 50 having one or more hair-lines 51, and guideways 48 and 49 are provided on which the cursor may be shifted laterally in either direction.

The casing-part 17 contains a driving mechanism consisting of a crank 52, a bevel-wheel 53, and a bevel-wheel 57 which is made integral with the bevel-wheel 56 already mentioned. The crank 52 can be turned in clock-wise direction (which means: in the "additive" sense), as well as in the reverse direction (which means: in the "subtractive" sense). The first-mentioned direction is used for multiplications, the other for divisions, especially with uniform scales or graduations. Means may be

provided to restrict two directions of rotation of the crank to one in order to prevent mistakes; besides, in order to cause that only complete revolutions can be made with the crank (52), there is provided at its rear surface a pin 58 (Fig. 11), combined with a spring which can engage a notch provided in a small stationary disk 59. The spring can be disengaged from said notch by means of a small knob located on the upper side of the crank, the arrangement being such, that this disengagement must take place before the crank can be turned, and the rotation is stopped automatically when a rotation has been completed, the spring-end entering then said notch.

Supposing, the calculation 18.36×2.165 must be made; then the cursor 50 is adjusted to the number 1836 of the rotary prism and the slide is so shifted that its first line coincides with the hair-line of the cursor and is, therefore situated over that adjusted number. Now the cursor is shifted again so that its hair-line is located on the number 2165 of the slide, and then the adjusting wheel 35 is shifted on its square shaft 33 by means of the knob 37, to that scale or graduation of the slide where there stands the number 2165, which is the scale or graduation to which points the hand 40 in Fig. 9. When thereafter the crank 52 is turned one time in the "additive" sense, the result 39.75 can be read off the rotary prism, the number of the digits being, of course, considered. By the rotation of the crank 52 the rollers or cylinders 29 and 20 have been rotated, but the latter roller or cylinder has not become active as the appertaining adjusting wheel 36 was in its position of rest. The adjusting-wheel 35, however, is rotated by the transmitting members 53 57 54 55 31 29, and the rotation of the shaft 33 is transmitted further by the bevel-wheels 41 and 42 to the prism 19 which latter is rotated corresponding to the adjustment previously made.

Electric means may be provided for turning the transmission members mentioned (53 . . . 29), and known means may be used to cause the resetting of the adjusting wheel to its initial position.

Of the device for the automatic ascertainment of the number of the digits (18 in Fig. 11) only an example is shown in Fig. 11. A side-view of this device, partly, in section, is shown in Fig. 10 and drawn to an enlarged scale. The top-part of the casing 60 (Fig. 10) is omitted in Fig. 11. In the top-part is the sight slot or hole 61 (Fig. 10) through which the top-number of the disk 64 at the time being can be seen. This disk is connected with a cog-wheel 63 which is engaged at every revolution of the cog-wheel 23 (Fig. 11) by a pin or other projection provided at a disk 62 connected with this cog-wheel. The cog-wheel 63 is checked in every position by a spring 89 (Fig. 10) secured to the casing 60. The wheel 62 rigidly mounted on the shaft of the rotary body 19 and provided in this case with only one tooth or projection engages, after it has made a complete revolution, with the toothed wheel 63 which has, in the present case, ten teeth, for example, and is mounted on a shaft and rigidly connected to a toothed wheel 64. The blade spring 89 engages a gap between two teeth of the wheel 63 and compels it to advance only by one tooth or one number. The casing 60 is attached to the main casing by means of a lug 65 (Fig. 11) provided at the front-wall of the main casing and engaging a sleeve-like member 66 forming a part of the casing 60, the members 65 and 66 being normally held in engagement with each other by a spring (not shown). At the disk 64 is provided a hollow branch-like projection 67 which is intended to serve as a handle and with the aid of which the members 65 and 66 can be disengaged so as to enable the operator to remove the casing 60 with the parts it carries from the main casing. Said member 67 may, however, also be used for turning, i. e., adjusting, the disk 64 to another digit or number.

Examples:

(1) $2.4 \div 0.062$; $E = +1$; $S = +2$; result 38.7.

(2) $\frac{32.1}{9.1} \times 0.0234$; $E = 0$; $S = -1$; result 0.0833.

(3) 2^{10}; $E = 1$; $S = 4$; result 1024.

The counting-disk may be replaced by a rack.

The apparatus may be employed also for making additions and subtractions, if, for instance, the slide 25 or another slide suited as equivalent for it, and on a suitably devised and arranged rotatory body, such as a prism or the like, scales of graduations with uniform division, are provided. With a unit of measure of 5 m. for the scales or graduations it is possible to reckon accurately, without any estimation, up to 99999. The above-described device for ascertaining the number of the digits is now used for stating the ten thousands; it is preferably provided at the left side of the apparatus. The range of the calculations can be extended to more digits by enlarging the apparatus similarly to the manner known with calculating machines. The device for ascertaining the number of the digits may be used in a corresponding manner also with calculating rollers and other calculating devices.

The apparatus is a combination of a calculating machine with a slide-rule and is distinguished by its affording the advantages of both machines and said rules. Apart from the great speed with which the result

is obtained, it offers, as regards continuous calculations, the further advantage that superfluous digits are suppressed with it.

In Figures 3–8, two more modifications are illustrated, one of them being shown in Figs. 3 and 4, the other in Figs. 5–8.

Referring to Figs. 3 and 4, this device consists of two pairs of wheels, viz, 68 and 73 on the left side and 69 and 74 on the right side, and of two endless bands 70 and 71 having each a row or plurality of holes 72. The distance between the holes of each band agrees with the distance between the scales or graduations, and said holes are engaged by pins provided around the circumference of the wheels 73 and 74. These wheels are affixed to the ends of the axle of the rotatory body 2, and the entire movable system (70 71 68 73 69 74) is actuated by putting a pin into any one of the holes 72 having a suitable position at the time being, and by moving the respective band in one or the other direction. 75 and 76 are abutments. In the case of a multiplication the pin is inserted into that hole 72 which is located at the side of the scale or graduation concerned, and is moved in the direction to the abutment (75 or 76) pertaining to the respective side of the device. In the case of a division the pin is inserted into one or the other band at the appertaining abutment and is then moved, with the band, to the scale or graduation concerned, that is to that scale or graduation which bears the number concerned. Whether the lefthand band etc. or the righthand band etc. is to be used is determined automatically by the number concerned, as the length of the slide located above the scales or graduations is such that the two bands are never accessible at a time, always only one thereof, either the left or the right. But both bands are covered when the slide is in its position of rest in which the casing of the device is closed. The slide is omitted in Figs. 3 and 4 for the sake of distinctness. The plate 28 visible in Figs. 3 and 4 is an equivalent to the stationary plate 28 in Figs. 11 and 12, and it bears also in this case (Figs. 3 and 4) the lead-number and the limit-numbers at its lefthand and righthand rim.

Example: $2.75 \times 4.4 = 12.1$.

The index line on the right side is adjusted to the quantity or magnitude 2.75 of the respective scale or graduation of the rotatory prism, and the cursor is so adjusted that its line coincides with the quantity or magnitude 4.4 of the slide. Then the pin is put into that hole of the band 71 which lies at the side of the end-number 464, whereafter the band is moved by the pin until this latter contacts with the abutment 76. The result 12.1 can be read off at once on that scale or graduation of the body 2 which is on the top at the time being.

Referring now to Figs. 5–8, there are, in this modification, the endless bands, (70, 71, Figs. 3 and 4) replaced by racks 80. It must be understood that two devices of the kind shown in these figures are combined with the slide and plate etc. as in Figs. 3 and 4, one device being on the left, the other on the right of said other member of the apparatus. There is, therefore, of course, also a rotatory body such as 2, Fig. 3 and each of the projecting ends of the axle of this carries a sleeve 77 which is rotated with the axle and is shiftable on the respective axle-end. Each of the two sleeves is provided with two cog-wheels 78 and 79 (Figs. 6 and 8). There is also in this case an abutment (81, Figs. 5 and 7) for the pin by which one or the other rack 80 is shifted in the direction to the respective abutment. Each rack 80 is connected with two racks 82 and 83 (Fig. 6) which mesh with the before-mentioned cog-wheels 78 and 79 and are connected with tension springs 84 and 85 by which they are withdrawn into their former position. But as the sleeve 77 with the cog-wheels 78 and 79 is shiftable on the appertaining axle-end, as already described, and as the distance between these wheels is less than the distance between the racks 82 and 83, either one or the other of these cog-wheels meshes with the rack pertaining to it, the arrangement being such that one of the racks in question (82 83) serves for turning the body 2 in one direction and the other serves for turning it in the other direction, but the movement of the rack moving in the direction to the body 2 is effected by the pin or the like (Fig. 5) and the movement in the reverse is effected by the springs 84 and 85. The racks 82 83 and the cog-wheels 78 and 79 are provided with ratchet-teeth, and the teeth of the rack 82 and the wheel 78 are directed reversely to those of the rack 83 and the wheel 79, and an elastic pawl 86 (Fig. 5) is provided which co-operates with the wheel 78 and prevents it from being rotated in the wrong direction. A similar pawl or, may be, a spring is provided also for the wheel 79.

The sleeve 77 with the two wheels in question is shifted in one or the other direction by means of the members 87 and 88 in Fig. 8. If the parts are shifted to the right, the driving gear is adjusted for the performing of divisions, and if they are shifted to the left, the driving gear is adjusted for making multiplications. In both cases the gear is operated by shifting the rack 80 in the same direction, viz, in the direction to the abutment 81 where the path of the pin ends. In all other respects the manner in which the calculation is carried through is practically the same as has been described with reference to the other forms shown.

I claim:

1. A calculating device, comprising, in combination, an oblong casing; a rotary body arranged longitudinally below an inspection slot provided in the oblong casing, and bearing a plurality of scales also extending longitudinally; a longitudinally shiftable plate arranged in said casing parallel to said rotary body and bearing also a plurality of scales extending longitudinally thereon; a cursor so arranged as to be adapted to be moved transverely over said plate and said slot; and means supporting elastically the said rotary body at the ends of its axle, substantially as described.

2. A calculating device, comprising, in combination, an oblong casing; a rotary body arranged longitudinally below an inspection slot provided in the oblong casing, and bearing a plurality of scales also extending longitudinally; a longitudinally shiftable plate arranged in said casing parallel to said rotary body and bearing also a plurality of scales extending longitudinally thereon; bevel-wheels meshing with said wheels; shafts of angular section connected with the other bevel-wheels; friction-disks arranged shiftably on said shafts, one on either thereof; members shifted together with these wheels; hands connected with these members, one with either thereof; and being arranged to point to the ends of the scales on the plate; friction-rollers arranged to contact with said friction-wheels and located below the said plate; and means for rotating said rollers simultaneously and uniformly substantially as set forth.

3. A calculating device, comprising, in combintion, an oblong casing; a rotary body arranged longitudinally below an inspection slot provided in the oblong casing, and bearing a plurality of scales also extending longitudinally; a longitudinally shiftable plate arranged in said casing parallel to said rotary body and bearing also a plurality of scales extending longitudinally thereon; and a device adapted to ascertain automatically the number of the digit, as set forth.

4. A calculating device, comprising, in combination, an oblong casing; a rotary body arranged longitudinally below an inspection slot provided in the oblong casing, and bearing a plurality of scales also extending longitudinally; a longitudinally shiftable plate arranged in said casing parallel to said rotary body and bearing also a plurality of scales extending longitudinally thereon; a device adapted to ascertain automatically the number of the digits, and comprising a disk connected rigidly with the said prismatic body; a projection on the circumference thereof; a cog-wheel arranged in the plane of said disk and adapted to be turned partly by said projection; a spring arranged to hold this cog-wheel in proper position relatively to said disk; another disk connected firmly with the cog-wheel and bearing on its circumference the numbers of the digits; a casing enclosing this device and having a sight-hole located over the digit-number disk, substantially as set forth.

In testimony whereof I affix my signature.

DR. PHILIPP LÖTZBEYER.