PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements in Slide Rules and like Calculating Apparatus.

Communication from GEBR. WICHMANN M.B.H., of 13, Harlstrasse, Berlin, Germany, a German firm.

I, HENRY FAIRBROTHER, a British subject, of 30 and 32, Ludgate Hill, London, E.C. 4, 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 invention relates to a calculating device of the kind in which a rotary body, or more than one, is disposed in a casing the peripheral surfaces of said body being provided with scales and its axis set parallel to the longitudinal axis of the casing which carries scale-bearing movable plates or slides.

According to the invention the construction is such that one only of the surfaces or scales of the rotary body is visible in an inspection opening in the casing, whilst a common cursor is arranged on the casing above the rotary body and the slides. 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 on line A—B of Fig. 1, seen from right to left; Figure 3 is a plan showing mechanism for the simplified adjusting of a rotary body forming part of a modified construction to expose the result of the calculation; Figure 4 is a section on the line G—H of Fig. 3, seen from left to right; Figures 5, 6, 7, 8 show a modified adjusting mechanism for the rotary body, Fig. 8 being a section on line E—F of Fig. 6, seen from above; Figures 9 and 10 are details respectively of an adjusting device and a counter which are shown in Fig. 11. Fig. 11 is a plan, partly broken away, showing a modification with certain mechanism for rotating the rotary body to the necessary extent to expose the scale section containing the result, and Figure 12 is a section on line C—D of Fig. 11, seen from left to right.

Referring to Figs. 1 and 2, in a casing 1 is arranged a regular prism 2 of hexagonal cross-section showing on its six surfaces corresponding portions of the logarithmic numerical scale from 1—10 having a base of 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 guideways provided at the sides of the casing where they are supported by small springs 3 and 4 in order to enable the prism to yield when rotated and to hold it as closely as possible against the covering-plate of the casing. The prism can be turned by means of a knob 5, but in connection with the index-numbers mentioned later on, it may be rotated mechanically for setting by means of cogwheels and endless steel bands or other forms of gearing as will be more fully described hereinafter.

The prism axle which projects at its right hand end beyond the side wall of the casing carries a numbered wheel 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 against the action of spring 7 so as to get uncoupled from the knob.

Parallelly to the prism 2 extends the scale chamber in which superposed slides 8, 9, 10 can be shifted in guideways 11, 12, 13. Each slide is provided with a scale on both faces. The slides are shown in their normal positions. Above the three slides and the prism is

arranged a slide 14 which consists of glass and is provided on its under surface with a line (not shown).

In this way slide-rules having, for instance, a base of 50 cm. (length 53 cm., width 4.3 cm., depth 1.3 cm.) can be brought to a length of from 11 to 11.5 cm., a width of 5.2 cm, and a depth 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 cardinal numbers and at its rear with the logarithmic scale of the reciprocal numbers (inverse scale); the slide 9 is provided at its front with the logarithmic scale of squares and at its rear with that of cubes; and the slide 10 is provided at its front with the log. sine scale and at its rear with the log. tangent scale; each scale is divided up into six equal parts. It is possible to add in a convenient manner other scales, and if, as occurs often times, the computation passes from one scale section to another scale section the slide-rule may be double the length.

The manner of use of this slide-rule is practically the same as with the usual slide-rule; however, a few particular points must be observed, *viz.*,

The portions of the scales on the slides show on the left-hand side the index numbers from 0 to 5, and on the right-hand side the index numbers from 1 to 6, these numbers being arranged on differently coloured fields, if desired, so as to avoid confusion. The index numbers on the left side apply only for adjustments when the left hand index line (1) is used, and the index numbers on the right side apply only for adjustments when the right hand index line (10) is used.

EXAMPLE I: 1.5×4.

The rotary prism is turned until the scale-section showing the quantity or magnitude 1.5 appears. Then by means of the cursor line on the glass slide 14 the slide 8 is adjusted correspondingly in the same manner as in an ordinary slide-rule. Now the cursor line is moved to the number 4 on the slide and the prism is turned further by 3 steps in conformity with the index-number 3 on the left side. In order to obviate mistakes the counting disk 6 is used for this 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: $6.5 \div 5$.

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

It does not seem necessary to give further examples. But it is desirable 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 index numbers of the scale sections of the slide and of the prism 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 devices for turning the prism operated in connection with the index numbers.

Referring to Figs. 3 and 4 which show a mechanical means for adjusting the rotary body in a slide rule similar to that shown in Figs. 1 and 2 but having a stationary plate 28 engraved at its ends with numbers denoting the limits of the respective scale sections. The mechanical means 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 scale sections, 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 section scale 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 section concerned, that is, to that scale section which bears the number concerned. Whether the pin is to be inserted into the left hand band, *etc.*, or the right hand

band, *etc.*, is determined automatically, as only the band required for the result is accessible, the other band being covered by the slide. Both bands are covered when the slide is in its position of rest. 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 index or limit-numbers at its left hand and right hand margins.

EXAMPLE: $2.75 \times 4.4 = 12.1$.

The index line on the right of the slide is adjusted to the quantity of magnitude 2.75 of the respective scale 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 limit number 464 on the right, 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 of the body 2 which is now uppermost.

Referring now to Figs. 5—8, in this modification the endless bands (70, 71, Figs. 3 and 4) are 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 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 of 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 towards the body 2 is effected by the setting pin or the like (Fig. 5), and the movement in the reverse direction 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 spring pawl 86 (Fig. 5) is provided which cooperates 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 78 and 79 is shifted to the right or left by the relative movement of the members 87 and 88 in Fig. 8. Part 87 is the stationary casing and 88 is a slide inscribed with letters D, M to be visible alternatively through an opening in the fixed part 87. One such gear shifting device is provided at each end of the apparatus. 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 towards 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 form shown in Figs. 3 and 4.

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 has means for automatically turning the prism combined with an automatic device for ascertaining the value of the whole numbers.

In the example shown in Fig. 11 the device is intended for a comparatively large number, the device being shown in its entirety.

The casing is divided into three parts 15. 16, 17; at the right-hand lower corner is provided a small off-set chamber 18 in which are housed the means for ascertaining the value of the whole numbers; the cover of the casing is shown broken away over this chamber, as well as at the upper left-hand corner of the main casing.

In the casing part 15 is located the rotatory body or polygonal prism 19 having an operating crank as seen in Fig. 11. On the surfaces of prism 19 the scale-sections of a logarithmic scale

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 holding its reading face as close as possible to the reading aperture, 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 24, 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 guide-ways 26 and 27 and bears the scale-sections of a logarithmic scale like that of the prism 19. Below the slide 25 is located a plate 28 bearing on its ends the index-numbers or limit numbers, *i.e.* numbers denoting the limits of the perspective scale-sections; 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. These rollers 29, 30 are furnished with teeth of increasing length like the stepped rollers used in Thomas multiplying machines, in order that the setting of the wheels 35, 36 may subsequently produce corresponding degrees of rotation of the prism.

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-section 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.

On the right of the cylinder 29 is located a cog-wheel 43 (Fig. 11); another such wheel is located on the left of the cylinder 30; one is covered by the cover of the casing and not visible for this reason. Both these cog-wheels mesh with a rack provided on 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 bent ends 48 and 49, the latter engaging with grooves provided in the casing so that 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. Means may be provided to restrict the rotation of the crank to one rotation only in order to prevent mistakes; in order to effect this there is provided on the rear surface of the crank 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 is to 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 and so that its hair-line gets 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 of the slide where there stands the number 2165, which is the scale to which points the hand 40 in Fig. 9. When thereafter the crank 52 is turned once in the "additive" sense, the result 39.75 can be read off the rotatory prism, the number of whole numbers being, of course, considered. By the rotation of the crank 52 the rollers or cylinders 29 and 30 are rotated, but the latter roller or cylinder has not become active, as the appertain-

ing 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 22 to the prism 19, which latter is rotated corresponding to the adjustment of the wheel 35.

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

Of the device 18 (in Fig. 11) for the automatic ascertainment of the number of the whole numbers 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 wheel 64 at the time being can be seen. This wheel 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 on a disk 62 connected with this cog-wheel. The wheel 62, rigidly mounted on the shaft of the rotary body 19, in this case only provided with one tooth or projection, engages, after it has made a complete revolution, with the toothed wheel 63 which in the present case has 10 teeth, for example, and is mounted on a shaft and rigidly connected to a toothed wheel 64. A blade spring, not shown in Fig. 11, engages with a tooth space of 63 and compels the toothed wheel 63, together with the toothed wheel 64 which, for obtaining the place numbers, carries the numbers 0, +1, +2, +3, +4, +5 and −1, −2, −3, −4, always to advance only by one tooth or one number. The device is secured to the machine by a projection 65 which is inserted in the sleeve 66 on the front wall of the partial casing 15 and held by a spring. The toothed wheel 64 is connected to a hub 67 and can be released thereby from its engagement with the toothed wheel 62, the projection 65 being, if necessary, drawn a short distance out of the sleeve 66, and can be adjusted to exhibit any one of the numbers provided on the periphery.

As to the digit or number to be adjusted below the sight-hole (Fig. 10) at the commencement of every calculation, there is only one rule for all numerical quantities or magnitudes to be found by multiplication or by division or by raising to a higher power (involution). Supposing S_z denotes the number of the whole numbers of the numerator, S_n the number of the whole numbers of the denominator, and U the difference between the number of multiplications and divisions, then the number to be set will always be

$$E = (S_z - S_n) - U.$$

The formula is obtained in that with a complete revolution of the rotary body in the forward direction there is an increase of one and by a rotation in the opposite direction, when passing beyond the 0 position (starting position) the characteristic is reduced by 1. An example for multiplication is: 2.5×12; the place number S_z is 3; $S_n = 0$; $U = 1$; therefore $E = 3 - 1 = 2$. This figure 2 is set by hand by means of the button 67 so that the figure 2 is visible in the window 61. Example for powers. 2^{10}; $S_z = 10$; $S_n = 0$. Here nine multiplications are to be made, therefore $U = 9$. Thus $E = 10 - 9 = 1$.

Concerning calculations to be made according to the "rule of three," the number to be set is always simply $E = S_z - S_n - U$. When this number E has been set in the sight-hole, the counting wheel will show automatically the right number S of the whole numbers. This is due to the fact that 64 is connected directly with 63 (Fig. 10) so that when the rotary body or prism has completed a complete revolution the wheel 64 is turned forwards or backwards through one tooth or one unit. Further examples:

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

(2) $\frac{32.4}{9.1} \times 0.0234$; $E = 0$; $S = -1$; result 0.0833.

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

The counting wheel may be replaced by a rack.

The apparatus may be employed also for making additions and subtractions if, for instance, on the slide 25 and on a rotatory body, such as a prism or the like, scales of graduations with uniform division are provided. With a unit of measure of 5m. for the scales it is possible to reckon accurately, without any estimation, up to 99999. The above-described device for ascertaining the number of the whole numbers is now used for indicating the hundred thousands; for this purpose it is preferably provided at the left side of the apparatus.

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.

The invention can be carried out in various manners within the scope of the following claims.

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. Calculating device in which one (or more) rotary bodies of suitable cross section disposed in a casing (1) the peripheral surfaces of which are provided with scales, whilst their axis or axes are parallel to the longitudinal axis of the casing, are arranged at the side of one (or more) movable plates or slides provided with scales, characterised by the fact that always only one of the scales of the rotary body (or bodies) is visible in one (or more) inspection opening or slot in the casing, and that a cursor to both the plate and the body is arranged over the scales of the plate (or plates) and the rotary body (or bodies).

2. A calculating device according to Claim 1, characterised in that the rotary body (or bodies) is supported resiliently in such a manner that the upwardly directed scale is always pressed closely against the inspection opening.

3. A device according to Claims 1 and 2, characterised by the fact that the casing (1) has underneath the plate one or more chambers with guides, in which further plates with scales may be disposed.

4. A device according to Claims 1 to 3, characterised by the fact that the rotary body (2) is extended at one or both ends to such an extent that space is provided at the ends of its side surfaces for index numbers which are arranged in relation to the index numbers at the ends of the partial scales of the plates (8, 9, 10) which numbers are adapted to assist in determining the rotation of the rotary body to expose the results of calculation.

5. A calculating device according to Claim 1, characterised by a mechanical adjusting means for the rotary body which means may be so constructed that on two rectangular shafts (33, 34, Fig. 11), carrying bevel wheels (41, 42) at their ends gearing with bevel wheels (22, 23) mounted on the shaft of the rotary body, are slidably mounted two adjusting wheels (35, 36) connected with pointers co-operating with the index or limit numbers on an intermediate plate (28), and that adjacent to the shafts (33, 34) are mounted rollers (29, 30) having projecting ribs of different lengths engaging therewith which can be rotated by bevel wheels (31, 32) geared to bevel wheels (55, 56) rotated by means of a shaft (54) and a crank (52).

6. A calculating device according to Claim 5, characterised by a device which is detachable or rigidly connected to the machine for automatically determining the number of whole numbers, which device may be so arranged that a small disc (62, Fig. 11) keyed to the shaft of the rotary body engages with a toothed wheel (63), held in the correct position by a blade spring, which wheel (63) is rigidly connected to a disc (64) mounted on the same shaft, which disc, after setting the necessary number at the commencement, indicates at the termination of the calculation in its inspection aperture, the correct number of whole numbers of the result automatically, the disc (64) together with the toothed wheel (63) being removable from the disc (62) to allow the setting adjustment of the disc.

7. A calculating device according to Claim 1, characterised by a device for adjusting the rotary body mechanically to the result of the calculation by means of toothed wheels and racks or alternatively by two toothed wheels (73, 74, Fig. 5) provided on the shaft of the rotary body each of which is connected with a small wheel (68, 69) by means of an endless band provided with holes, whereby the movement may be effected by means of a pin inserted into the holes.

8. A device according to Claim 7, characterised by the fact that on the intermediate plate (28, Fig. 3) there are provided at the ends adjacent the rotary body adjusting means limiting or index numbers, corresponding with the scale sections of the calculating plate, which is of such length that the limiting or index numbers not concerned in the calculation together with the corresponding adjusting means driving device are covered automatically.

9. Calculating devices substantially as described and illustrated.

Dated this 23rd day of June, 1924.

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30 & 32, Ludgate Hill, London.

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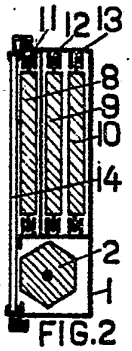


FIG.2

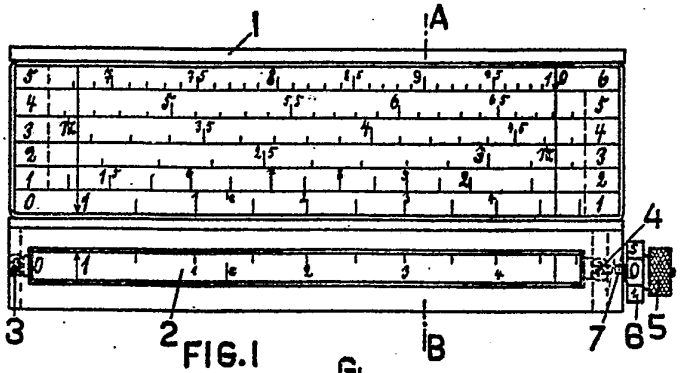
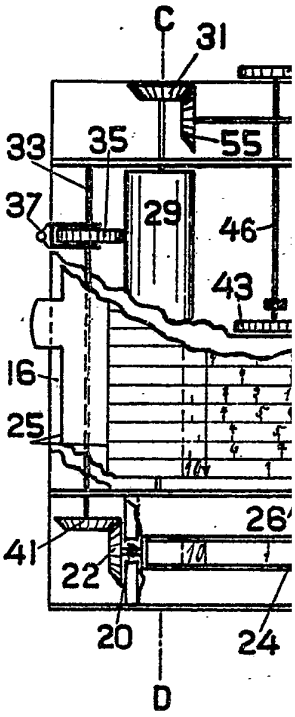


FIG.1



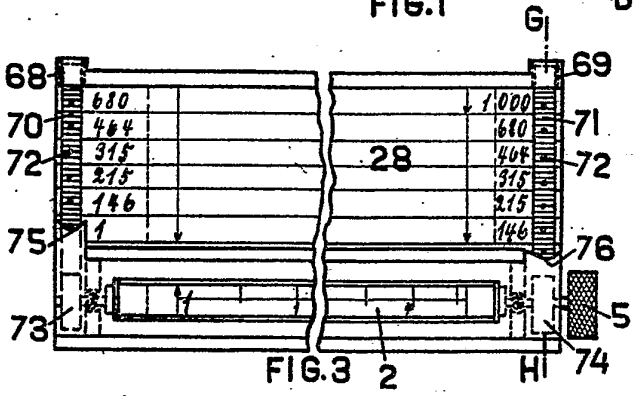


FIG.3

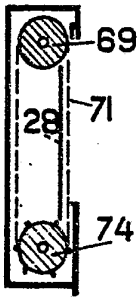


FIG.4

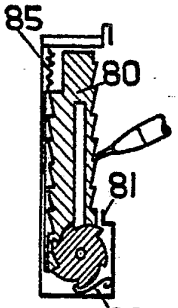


FIG.5

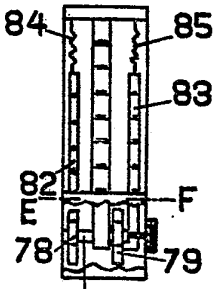


FIG.6

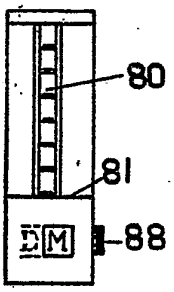


FIG.7

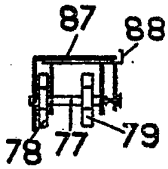


FIG.8

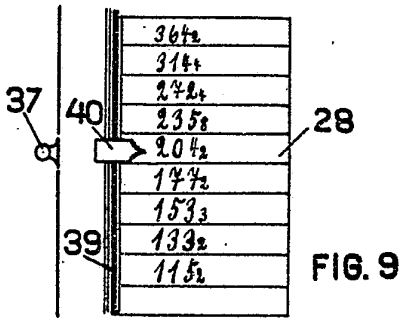


FIG.9

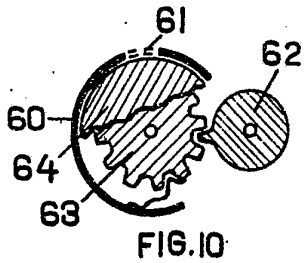


FIG.10

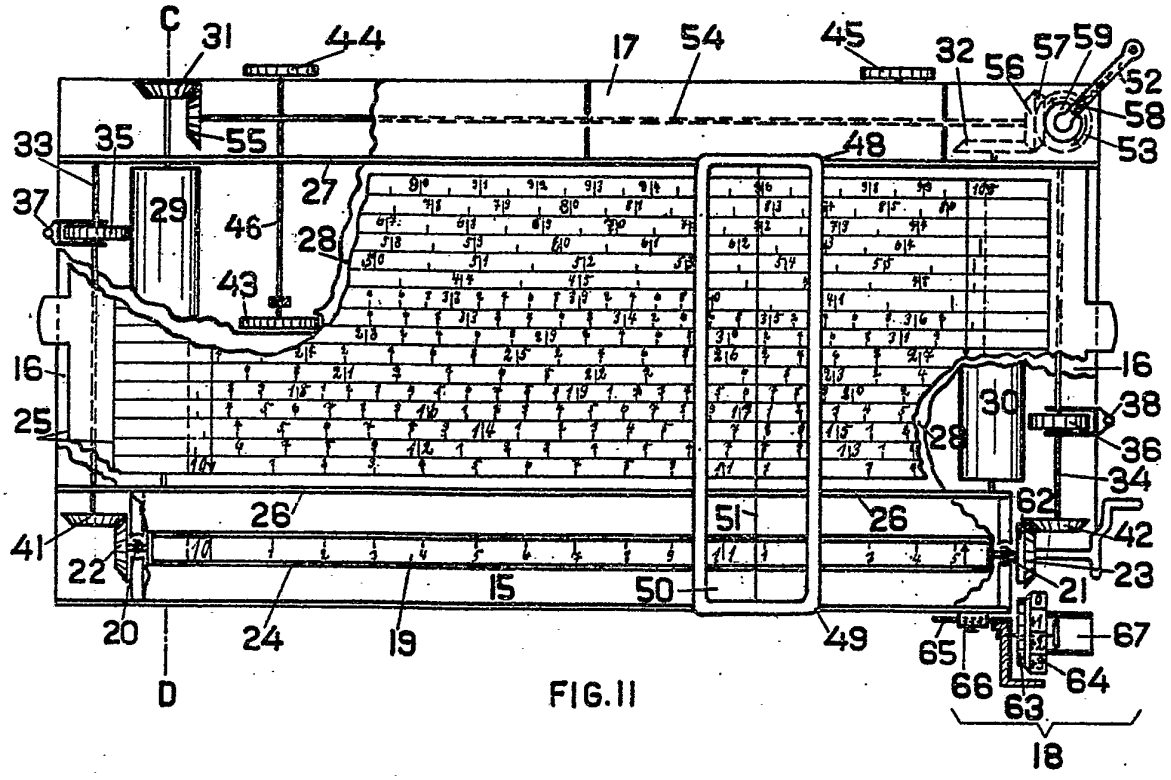


FIG. 11

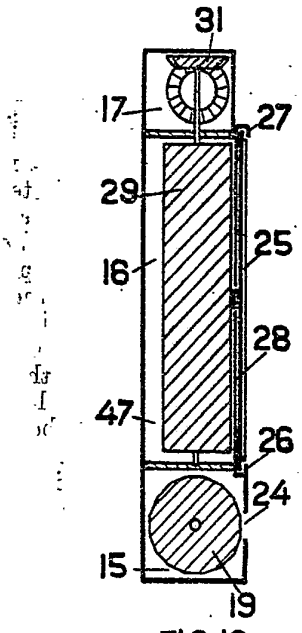
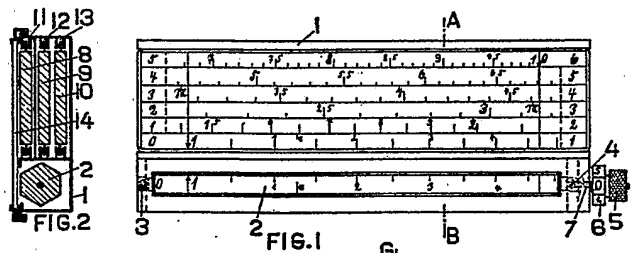
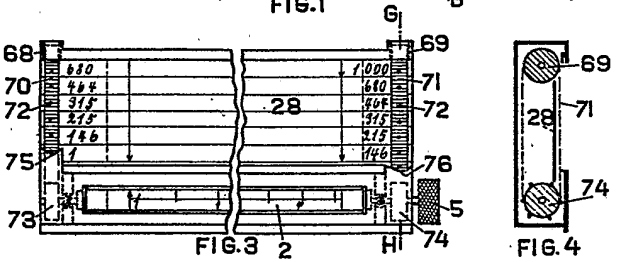
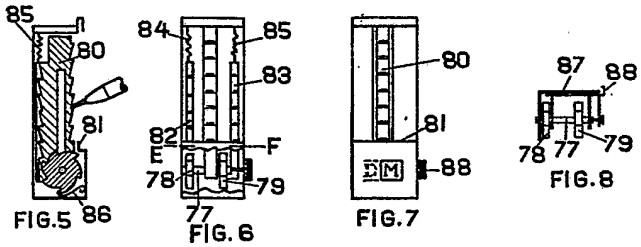


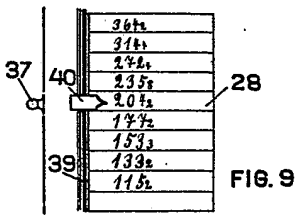
FIG. 12

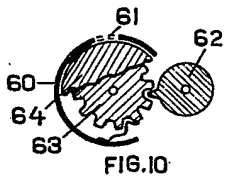
Malby & Sons, Photo-Litho

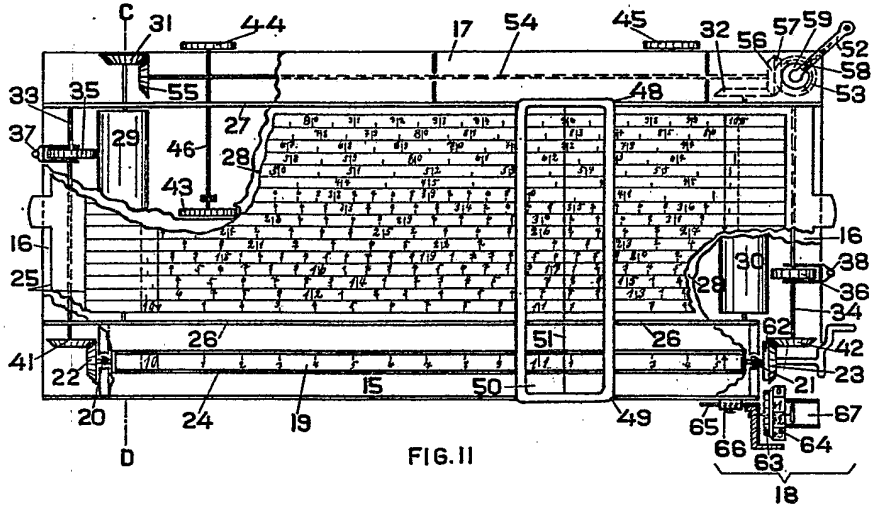


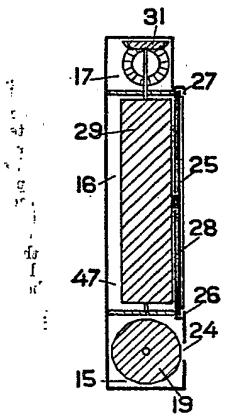












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