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COMPLETE SPECIFICATION.

Calculator.

We, ELIEZER ZUR, a citizen of the State of Israel, of Misra, Israel, and TECHEN ENTERPRISES LIMITED, a Company under the laws of the State of Israel, of Tel-Aviv, Israel, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a new calculating instrument working on principles similar to those of a slide rule. As is well known a slide rule, in principle, carries a logarithmic scale fixed to it and a similar logarithmic scale fixed to a "tongue" or "slide," both scales being equal and longitudinally displaceable against each other. The usual length of such slide rule is 25 cm on which the numbers 1 to 10 are arranged (once or twice) at the proper distances, with subdivisions between them. Obviously, it would be desirable, for the sake of accuracy, to spread the scale along a greater distance. But such spreading would require a far greater length of the instrument and would make it cumbersome. There exist, to be sure, already certain types of slide rules which, although bearing an enlarged scale, are of manageable dimensions. Such rules are usually cylindrical, with the scale either wound around to form a cylindrical helix or cut into strips and mounted parallel to each other. A scale shaped into a flat spiral may also be mentioned as a possibility.

We have now devised a new calculating instrument, which, although restricted in length, allows for a far greater accuracy than hitherto by extending the scale not in length but in width, thus creating a two-dimensional scale or "grid." An identical scale is provided on a slide, which slide, however, will be displaceable relative to the rule in two directions, perpendicular to each other, and preferably on top of the rule. In that case, said slide will be transparent or slotted so as not to obstruct visibility of the lower scale. A cursor or indicator will also be provided. Accordingly the new calculator comprises a base plate made from any suitable material, on said plate a logarithmic scale displayed consecutively on parallel and equidistant lines, said lines extending between opposite sides of a parallelogram and being inclined to the other two sides of the same in such a manner that an auxiliary line connecting the end of one of the parallel lines with the beginning of the next one will be parallel to the said two other sides, a sliding element for co-operation with said plate, on the sliding element at least four marks coinciding with the corners of the parallelogram, and means for pointing out on the sliding element any point within the said four marks.

The new calculator will now be described in detail with reference to the accompanying drawings which show in

Figs. 1 and 2 the principle of the pattern of the new scale;

Fig. 3 shows a practical embodiment of the new instrument in use;

Fig. 4 shows another practical embodiment of the new instrument;

Fig. 5 shows the cursor, seen in Fig. 4, in an exploded view;

Fig. 6 is a sectional view on line VI—VI of the assembled cursor of Fig. 5;

Fig. 7 shows a modification of the instrument shown in Fig. 4.

Before describing the construction of the new apparatus and its modifications, it will be advantageous to set out the underlying mathematical principle on which the new scale is based and which is shown in Fig. 1 of the drawings.

In the parallelogram A B C D (preferably as in the example shown, a rectangle) are two opposite sides, A B and C D, divided into equal, say ten, parts *a*.

Starting at A with the numeral 1, con-

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secutive points are consecutively numbered up to 10. Point B remains beyond the 10 and may be considered to be point 11.

Now points 1 to 10 are connected by straight lines to points on line C D so that 10 on line A B is connected with point C, and all other points on line A B by lines parallel to 10—C with points on line C D, with point D (as well as B) remaining outside the pattern. The two points B, D are of the greatest importance in the new device as will be seen later. In this way a grid comes into existence having a set of parallels S inclined to the direction of the sides A D and B C of the parallelogram. Now each part *a* on line A B can be considered to be a projection of the respective line S in the direction of A D (or B C) or the thin lines *p*. Therefore all the parts *a* from A to B will be the projection of all the lines S, and any subdivision carried out on a line S could be projected on to line A B and vice versa. All the lines S together present therefore an enlarged scale representation of the line A B on which enlarged scale all required subdivisions can be made with much greater accuracy than otherwise. Now the end of one S line and the beginning of the next one are connected by parallel lines *p* and, seen in the direction of these lines *p*, belong to the same point on the lines A B and C D. On the other hand, points A and B may be considered projections of the points D, C, respectively, if seen in the same direction, which means that their connections (the sides B—C and A—D) will be parallel to the lines *p*. This further means that points so connected have the same value i.e. each line begins at the value where the last one has ended. For further reference sides A—B, B—C, C—D, and D—A will be designated as sides H, O_1, H_1 and O respectively. Points A and D may both be considered to be starting points and B and C both end points. If now all S-lines are provided with a consecutive logarithmic scale beginning at A and ending at C the "grid" parallelogram will be suitable for calculating in the same way as other known devices which use logarithmic scales, e.g. a slide rule, but with much greater precision due to the great length of the scale. In the practical embodiment several such rectangles A B C D may be imprinted beside and/or above and below each other on the rule, as partly seen in thin lines in Fig. 1, thus further improving on its performance. Each rectangle, in this case, will represent one "cycle", say the numbers 1 to 10. The slide, however, need not carry the complete pattern as printed on the rule. In practice said "slide" will preferably comprise an exact image of the four points A, B, C, D only, rigidly interconnected and a movable pointer fixable at any point within and in relation to the said four points, the "slide" being displaceable on top of the rule in an irrotational movement.

Fig. 2 shows a slightly different grid parallelogram. Here lines S are perpendicular to lines H and H_1 of the basic parallelogram A B C D, the two other lines O, O_1 being inclined. Thus the pattern shown in Fig. 2 is distorted compared with that of Fig. 1 but otherwise similar and equally suited for the purpose in view.

In Fig. 3 the grid used is the same as that in Fig. 2, but turned clockwise through 90°. This is already a practical embodiment. Two identical plates M, N are placed on top of each other, M being the upper one and considered to be transparent. N, the base plate, is drawn in thin lines. Plate M carries a pointer or marker Y at the end of a linkage pivoted at T to plate M, near one of its edges. By means of said linkage marker Y can be placed above any desired point of plate M. Both plates carry identical parallelograms as described and have marked on the lines *p*. Therefore the logarithmic scale from 1 to 10 extending over all the *s*-lines from A to C. Line H is, as already stated, a projection of the *s*-lines in the direction of the lines *p*. Therefore the logartihmic scale spread on the *s*-lines could be displayed also, compressed, on the H-line or on a line parallel thereto; say on the edge of the plates M and N, and used for rough estimates of a result.

The use of the new device is similar to that of a slide rule; e.g. for multiplying two numbers the pointer of the slide is set on top of one number or figure of the scale of plate M, then this plate, (the slide) together with the pointer is moved without turning until point A of the slide coincides with the second number or figure on the scale on the base plate. Now the number or figure appearing below the pointer on the base plate will be the product sought. In case of the pointer marking a point outside of the parallelogram on the rule the slide has to be shifted so that instead of point A any other of the corner points of the slide will coincide with the said second number, in a manner similar to the shifting of the tongue of a slide rule to the left. This is shown by way of example in Fig. 3 which shows the multiplication of 6.5 by 3.5 Marker Y is placed on number 3.5 of plate M. Then plate M is so displaced in parallel relation to base plate N that point B of the grid of plate M is placed on top of number 6.5 of plate N. The number on base plate N underneath the marker Y gives the result which, in this case, is 22.75. Incidentally the two plates M, N in the position shown give also an example of the division of 2.6 by 4. With these two points superimposed the result 0.65 can be read at B. Calculating with two such plates is very simple.

Parallelism of the two unconnected plates is easily checked by the coincidence of the *s*-lines, no mechanical guiding means being needed. For practical purposes, i.e. for easier handling suitable guiding means known *per se* should be provided. Also, for better reading, it is advantageous to place the numbers in one plate above and in the other below the respective *s*-lines.

It is easily to be seen that in this arrangement the marker could be dispensed with, the means for indicating the required point being the point itself. On the other hand with a marker provided as shown the grid and scale on plate M could be partially or entirely dispensed with, retaining the four points A, B, C, D, only. In this case for performing e.g. the above multiplication plate M has first to be brought on top of plate N with the said four corner points coinciding with the respective corner points of the underlying plate N, then marker Y has to be placed in position on top of the number 3.5 of plate N. Now plate M together with the positioned marker is shifted as shown in Fig. 3 and the marker will point out the number 22.75 on plate N as the result in the same way as shown. But a mechanical guiding means will be provided for plate M in relation to plate N, as no *s*-line will be apparent on plate M for coincidence. The last arrangement has a wide range of practical possibilities. A series of plates N of equal outline may be provided, possibly simple printed paper sheets, carrying different scales, such as log., sine, tang., antilog, and even nomographic scales or diagrams, all sold as a set to be placed in a frame for use with a common "slide" plate M connected to said frame which "slide" plate, as set out, will carry only the four corner points and a marker. As the central portion of plate M does not carry any marks it could be cut out altogether.

Fig. 4 shows an arrangement where the two grids are placed beside each other, their correlation being achieved by means of a special cursor. Here a base plate M_1 has imprinted in its lower half a grid I. Its upper half serves as a guideway for a slide N_1 carrying a similar grid II. The slide is displaceable in one, the longitudinal, direction only, similar to a slide rule. The grids are in the shape of elongated rectangles, but otherwise like that of Fig. 1, i.e. with the *s*-lines inclined and the H-lines horizontal. On said H-lines could be provided scales as stated in connection with Fig. 3. For practical reasons such scales are provided on lines parallel to the H-lines, i.e. on the abutting edges of I and II which carry identical logarithmic scales from 1 to 10. The cursor as seen in Figs. 5 and 6 comprises a rectangular frame III slidingly held in appropriate longitudinal grooves provided in the parallel horizontal edges of plate M_1. The frame thus bridges both grids I and II and can be slid over the entire length of said grids. In the frame III is slidingly held a transparent slide IV, and within this slide and on top of it is, also slidingly, held a further slide V. Slides IV and V are slidable across both grids, i.e. in a direction perpendicular to that of frame III. Slide IV carries a marking comprising a centre line alpha extending in its longitudinal axis and in the direction of imaginary *p*-lines, and four short lines *b*, *c*, *d*, *e*, crossing said centre line at distances from each other equal to the width and distance apart of the grids I and II. Slide V carries a single cross line *f*, parallel to the short lines on slide IV. This calculator is used as follows: To find the product of the two factors A and B the cursor is shifted so that the centre line alpha lies over A on grid I. Then slide IV is shifted until cross line *b* (or *c*) lies also over A, which means that the crossing point of lines alpha and *b* (or *c*) lies exactly above point A. Now slide N_1 carrying grid II is shifted so that its end (in this case the left end) coincides with line alpha. After this the small slide V (with the other parts remaining in their places) is shifted upwards until its cross line *f* coincides with the H-line of grid II (see left hand position of the cursor in Fig. 4 in dotted lines). Now the cursor is shifted to the right until centre line alpha coincides with factor B on one of the *s*-lines of grid II. The crossing point of centre line alpha in this position with one of the *s*-lines on grid I gives the result. This, however, will not appear very accurately, due to the small angle between line alpha and the respective *s*-line. For the exact result slide IV together with slide V is shifted until the crossing point of lines alpha and *f* comes to lie exactly on top of factor B. The crossing point of alpha with line *b* (or line *c*, if this has been used at the beginning) gives now the exact result on the underlying *s*-line. If, by shifting slide N_1 as described, factor B would come to lie outside grid I, the right hand end of slide N_1 has to be brought into coincidence with line alpha, exactly similar to a slide rule.

Fig. 7 shows an arrangement which is different from that shown in Fig. 4 only in that the grids are turned through 90°. This means that the horizontal longitudinal lines are the O-lines and the short vertical ones the H-lines of a rectangle similar to that shown in Fig. 1, with the *s*-lines slightly inclined to the horizontal and downwards from left to right. A cursor to be provided will be similar to that shown in Figs. 4 to 6 and its use will also be similar.

The above examples refer to the grid as carrier of the logarithmic function. But it is obvious that such grid may carry other functions as well, e.g. the sine and tang. function etc. in a way similar to that known with the slide rule. It may also serve for nomographic purposes. The term "scale" includes also any suitable sequence of marks or numbers. The said grid may also be imprinted on the surface of a cylinder, with the "slide" being formed by a second, outer cylinder, said outer cylinder carrying the pointer, if any, and being transparent and turnable as well as axially displaceable on the first cylinder. Accordingly, whenever the term "plate" is used in this Specification and claims it is meant to include a cylindrical surface as well.

The pointer may be provided with a line or lines like a cursor or with a cross or any desired mark. It may carry a magnifying lens. A similar magnifying lens may be carried by the four corner points of the slide. The slide may be formed by a full size transparent table and, at the same time, the cursor be dispensed with. In that case any required point will be marked by a point made e.g. with a grease pencil on the transparent slide. As can be seen from Figs. 3, 4 and 7 the grids may greatly vary in shape and size according to special requirements. They may be nearly square or may be elongated so that the device will resemble more or less a slide rule. In all cases it may carry more than one "cycle" from 1—10.

It will have become clear from the foregoing that, as the grid is two-dimensional, each point will not only have magnitude but direction as well. Thus the device will be well suited also for vector analysis.

The surface of a cylinder, incidentally, offers two different possibilities for the arrangement of the grid thereon:—

(1) Both O-lines coincide and form a common generatrix. Then point A coincides with B, and C with D.

(2) Both H-lines coincide and form a common generatrix. Then all the *s*-lines form a continuous helix around the cylinder.

There exists even another possibility:— To bend such cylinder into a torus in which case all four corner points would coincide. This form also is intended to be included by the term "plate" used in this Specification and the claims.

What we claim is:—

1. Calculator comprising a base plate made from any suitable material, on said plate a logarithmic scale displayed consecutively on parallel and equidistant lines, said lines extending between opposite sides of a parallelogram and being inclined to the other two sides of the same in such a manner that an auxiliary line connecting the end of one of the parallel lines with the beginning of the next one will be parallel to the said two other sides, a sliding element for cooperation with said plate, on the sliding element at least four marks coinciding with the corners of the parallelogram, and means for pointing out on the sliding element any point within the said four marks.

2. Calculator as claimed in Claim 1, the base plate being constituted by a frame for the accommodation of a sheet carrying the said scale.

3. Calculator as claimed in Claim 1, the sliding element being a transparent plate carrying a scale identical with the scale on the base plate.

4. Calculator as claimed in Claim 1, the base plate and slide carrying identical scales and being arranged displaceably along each other, the slide being slidingly accommodated in suitable guideways provided in the base plate, a cursor being provided slidable in guideways provided in the base plate and parallel to the first mentioned guideways, said cursor extending across the width of both parallelograms and carrying adjustable markings.

5. Calculator as claimed in Claim 3, the transparent plate carrying pivotally connected thereto a marker or pointer.

6. Calculator as claimed in Claim 3, the transparent plate being accommodated on top of the base plate and movably connected thereto for irrotational displacement.

7. Calculator as claimed in Claim 1, 2, 3, 5, or 6, the sliding element being a frame carrying four marks coinciding with the corners of the parallelogram on the base plate and including a marker or pointer.

8. Calculators, substantially as hereinbefore described and shown in the annexed drawings.

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PROVISIONAL SPECIFICATION.

Calculator.

We, Eliezer Zur, a citizen of the State of Israel, of Misra, Israel, and Techen Enterprises Limited, a Company under the laws of the State of Israel, of Tel-Aviv, Israel, do hereby declare this invention to be described in the following statement:—

The present invention relates to a new calculating instrument working on principles similar to that of a slide rule. As is well known a slide rule, in principle, carries a logarithmic scale fixed to it and a similar logarithmic scale fixed to a "tongue" or "slide", both scales being equal and longitudinally displaceable against each other. The usual length of such slide rule is 25 cm. on which the numbers 1 to 10 are arranged (once or twice) at the proper distances, with subdivisions between them. Obviously, it would be desirable, for the sake of accuracy, to spread the scale along a greater distance. But such spreading would require a far greater length of the instrument and would make it cumbersome. There exist, to be sure, already certain types of slide rules which, although bearing an enlarged scale, are of manageable dimensions. Such rules are usually cylindrical, with the scale either wound around to form a cylindrical helix or cut into strips and mounted parallel to each other. A scale shaped into a flat spiral may also be mentioned.

The present invention provides a new calculating instrument, which although restricted in length, allows for a far greater accuracy than hitherto by extending the scale not in length but in width, thus creating a two-dimensional scale. An identical scale is provided on a slide, which slide, however, will be displaceable relative to the rule in two directions, perpendicular to each other, and preferably on top of the rule. Furthermore, said slide will be transparent so as not to obstruct visibility of the lower scale. A cursor will also be provided.

The new scale will be constructed on the following principle shown in the accompanying drawing.

In a parallelogram A B C D (preferably as in the example shown, a rectangle) are two opposite sides, A B and C D, divided into equal, say ten, parts.

Starting at A with the numeral 1, consecutive points are consecutively numbered up to 10. Point B remains beyond the 10 and may be considered to be point 11. Now points 1 to 10 are connected by straight lines to points on line C D so that 10 on line A B is connected with point C, and all other points on line A B by lines parallel to 10—C with points on line C D, with point D (as well as B) remaining outside the pattern. The two points B, D, are of the greatest importance in the new device as will be seen later. In this way a grid comes into existence having a set of parallels S inclined against the direction of the sides A D and B C of the parallelogram. Now each part on line A B can be considered as a projection of the respective lines S in the direction of A D (or B C). Therefore all the parts from A to B will be the projection of all the S, and any subdivision carried out on a line S could be projected onto line A B and vice versa. All the lines S together present therefore an enlarged scale of the line A B on which enlarged scale all required subdivisions can be made with much greater accuracy as otherwise. Now the end of one S line and the beginning of the next one belong to the same point on the lines A B and C D which means that their connections will be parallel to the sides B C and A D. This further means that such points have the same value i.e. each line begins at the value where the last one has ended. Similarly points A and D may both be considered to be starting points and B and C both end points. If now all S lines are provided with a consecutive logarithmic scale beginning at A and ending at C the parallelogram will be suitable for calculating in the same way as other known devices which use logarithmic scales, e.g. a slide rule, but with much greater precision due to the great length of the scale. In the practical embodiment several such rectangles A B C D will be imprinted beside each other on the rule, thus further improving on its performance. The slide need not carry the complete pattern as printed on the rule. In practice said "slide" will preferably comprise an exact image of the four points A B C D only, rigidly interconnected and a movable pointer fixable at any point within and in relation to the said four points, the "slide" being displaceable on top of the rule in an irrotational movement.

The use of the new device is similar to that of a slide rule, e.g. for multiplying two numbers the pointer of the slide is set on top of one number of the scale, then the slide together with the pointer is moved without turning until point A of the slide coincides with the second number on the scale. Now the number appearing below the pointer will be the product asked for. In case of the pointer marking a point outside of the parallelogram on the rule the slide has to be shifted so that instead of point A any other of the corner points will coincide with the said second number, in a manner similar to the shifting of the tongue of a slide rule to the left.

The above description refers to the "grid" as carrier of the logarithmic function. But it is obvious that such grid may carry other functions as well, e.g. the sine and tang. function etc. in a way similar to that known with the slide rule. It may also serve for nomographic purposes. The term "scale" includes also any suitable sequence of marks or numbers. The said grid may also be imprinted on the surface of a cylinder, with the "slide" being formed by a second, outer cylinder, said outer cylinder carrying the pointer and being transparent and turnable as well as axially displaceable on the first cylinder.

The pointer may be provided with a line or lines like a cursor or with a cross or any desired mark. It may carry a magnifying lens. A similar magnifying lens may be carried by the four corner points of the slide. The slide may be formed by a full size transparent table and the cursor be dispensed with. In that case any required point will be marked by a point made with a grease pencil.

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773,366 PROVISIONAL SPECIFICATION
I SHEET

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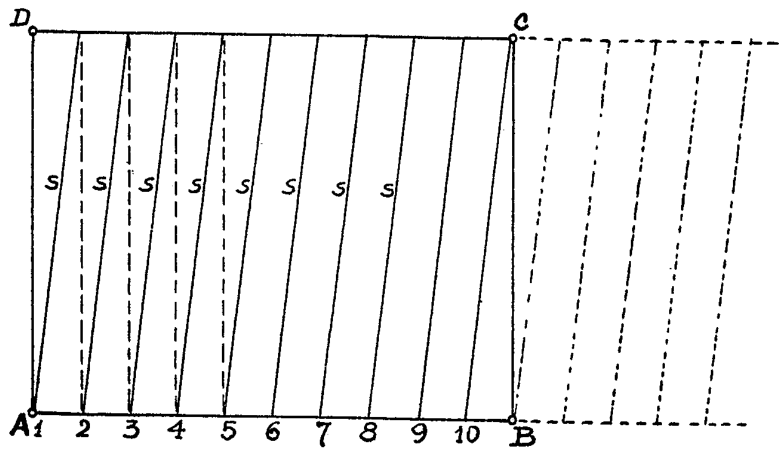


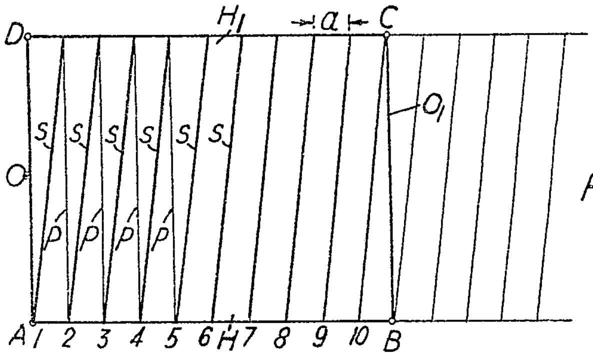


FIG. 1.

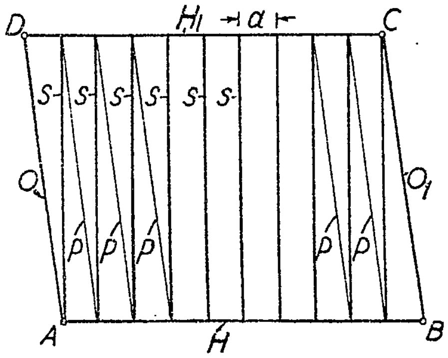
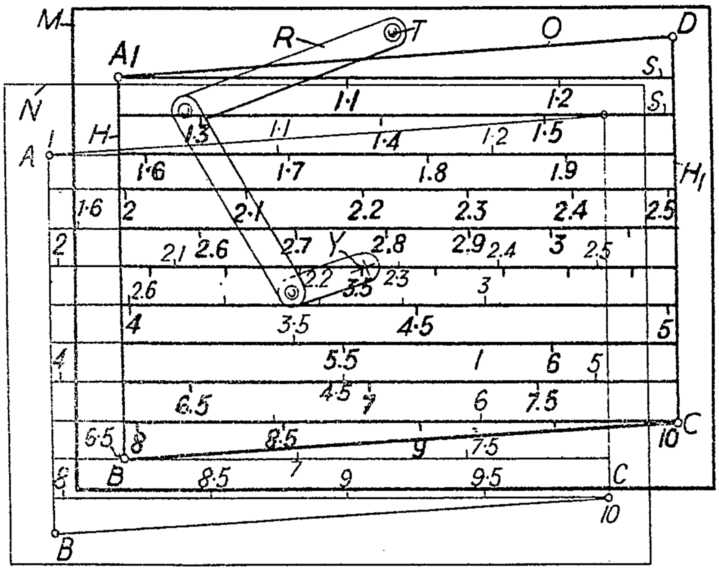


FIG. 2

FIG. 3.



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2 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEETS 1 & 2

FIG. 4.

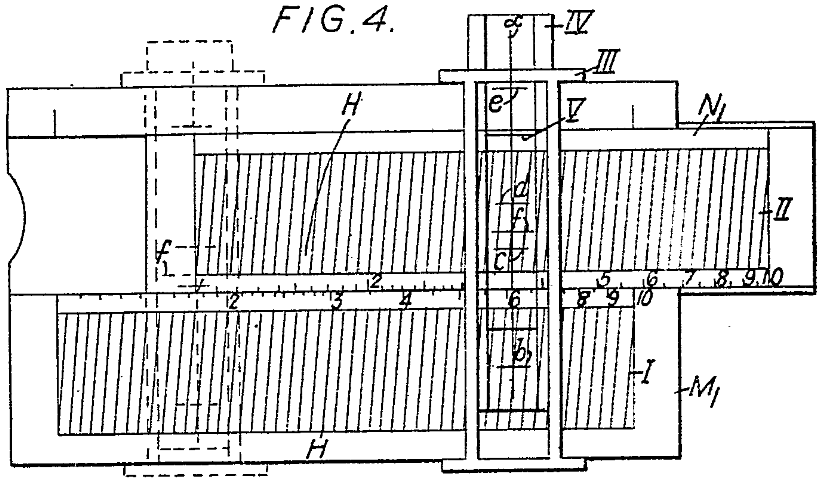
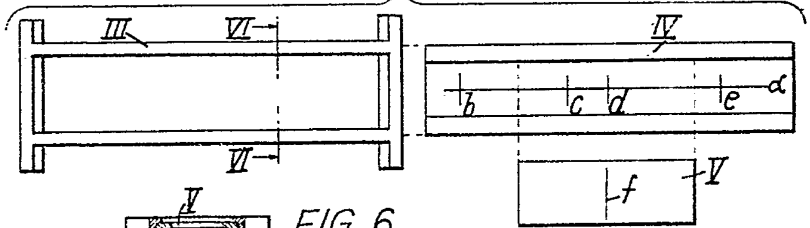


FIG. 5.



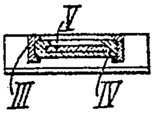
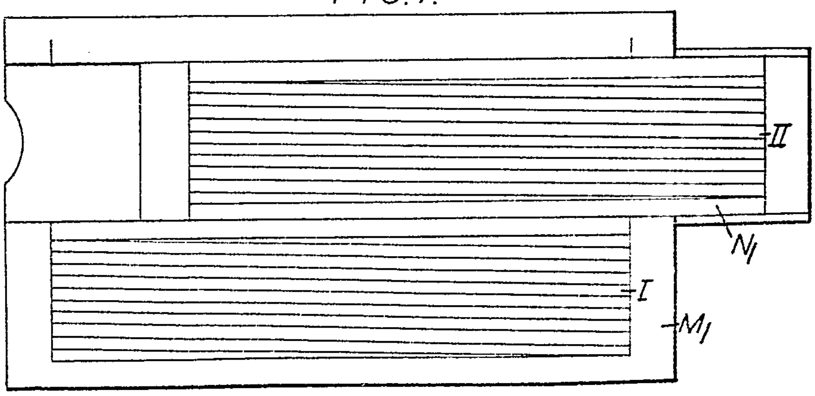


FIG. 6.

FIG. 7.



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2 SHEETS

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SHEETS 1 & 2

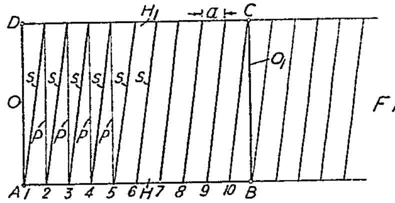


FIG. 1.

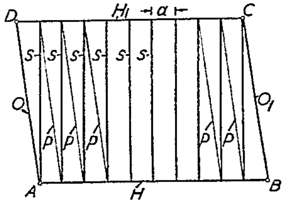


FIG. 2

FIG. 3.

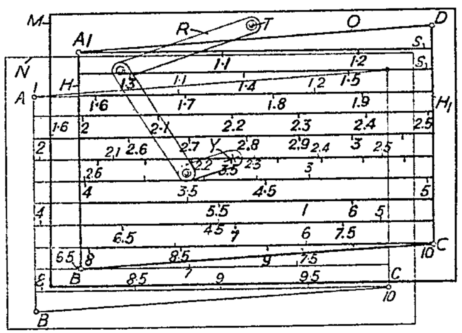


FIG. 4.

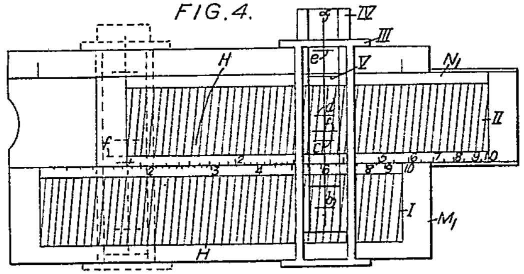
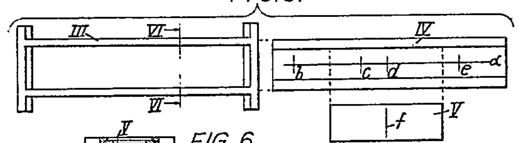


FIG. 5.



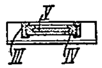


FIG. 6.

FIG. 7.