No. 768,971. PATENTED AUG. 30, 1904.

F. J. ANDERSON.

SLIDE RULE.

APPLICATION FILED DEC. 12, 1903.

NO MODEL. 5 SHEETS—SHEET 1.

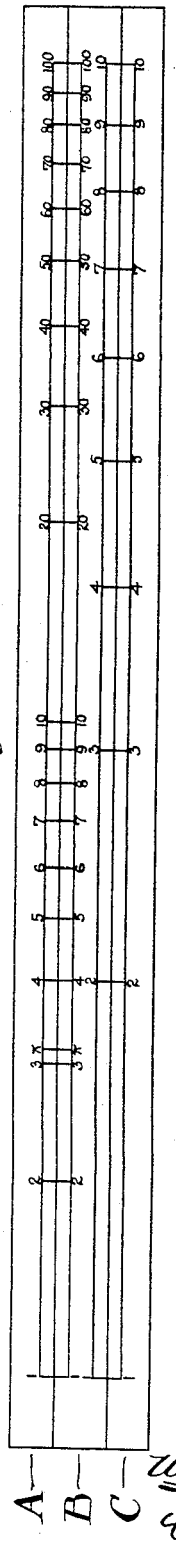

Fig. 1.

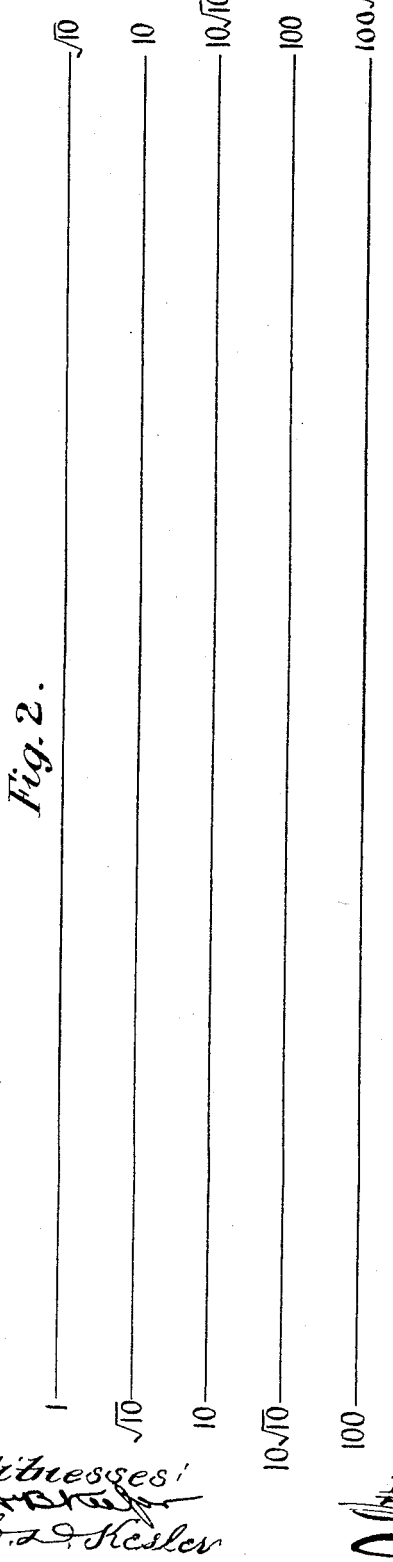

Fig. 2.

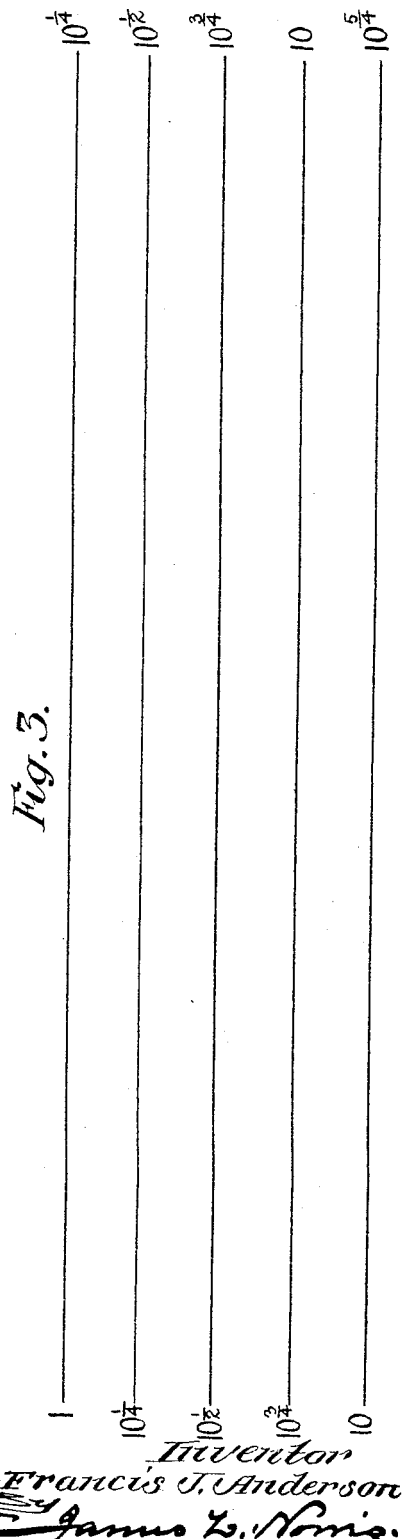

Fig. 3.

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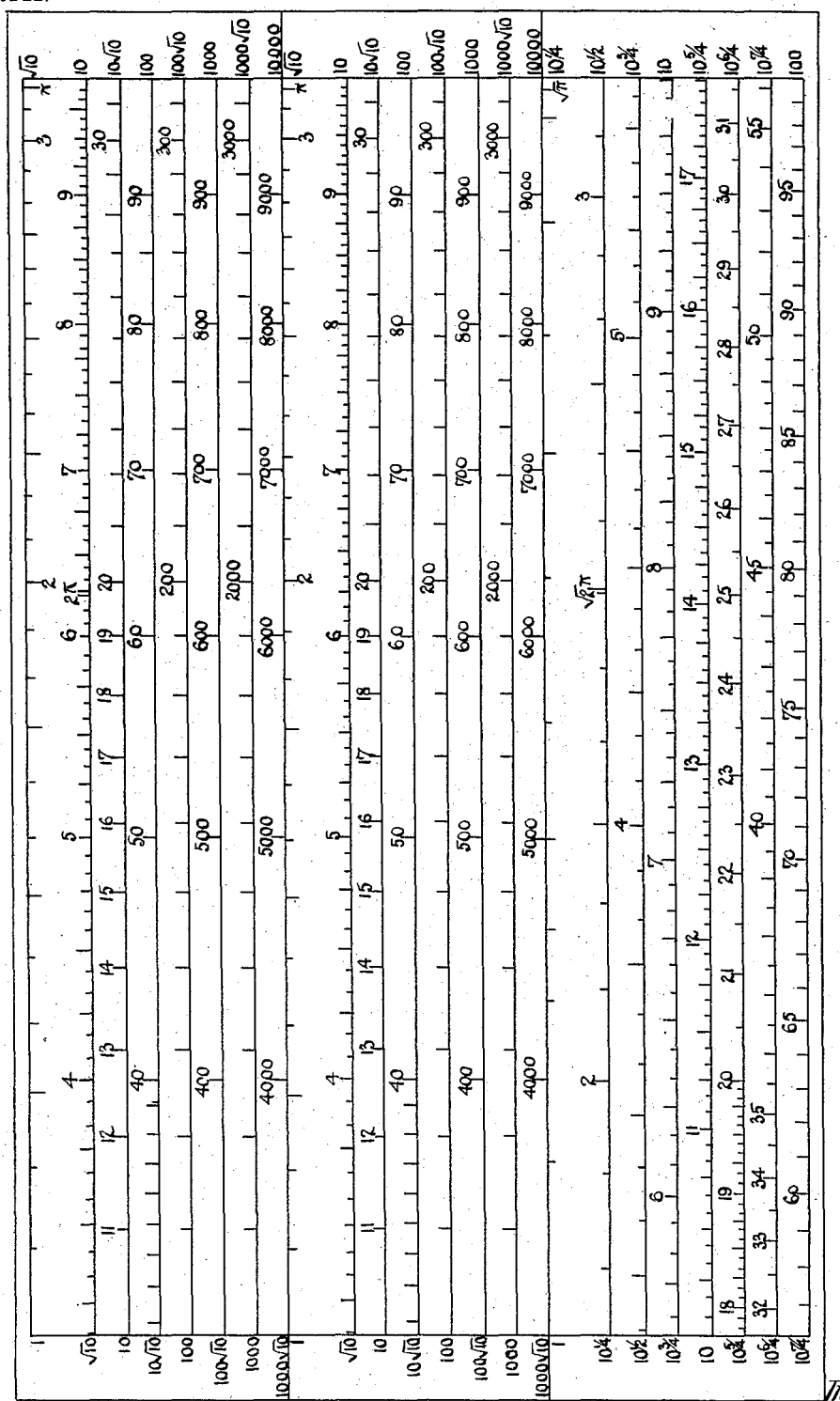
NO MODEL. 5 SHEETS—SHEET 2.

Fig. 4.



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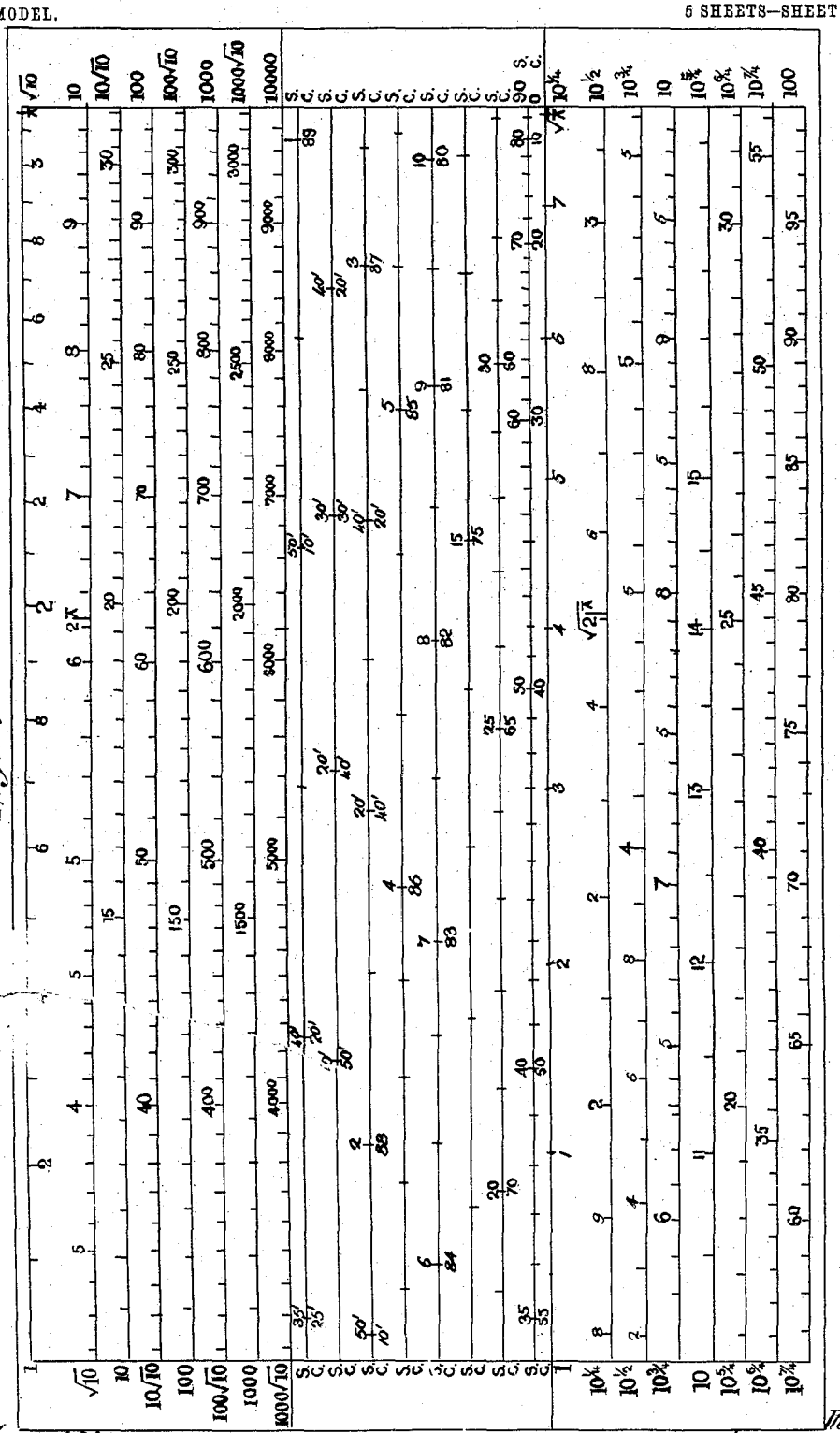
NO MODEL. 5 SHEETS—SHEET 3.

Fig. 3.



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NO MODEL. 5 SHEETS—SHEET 4.

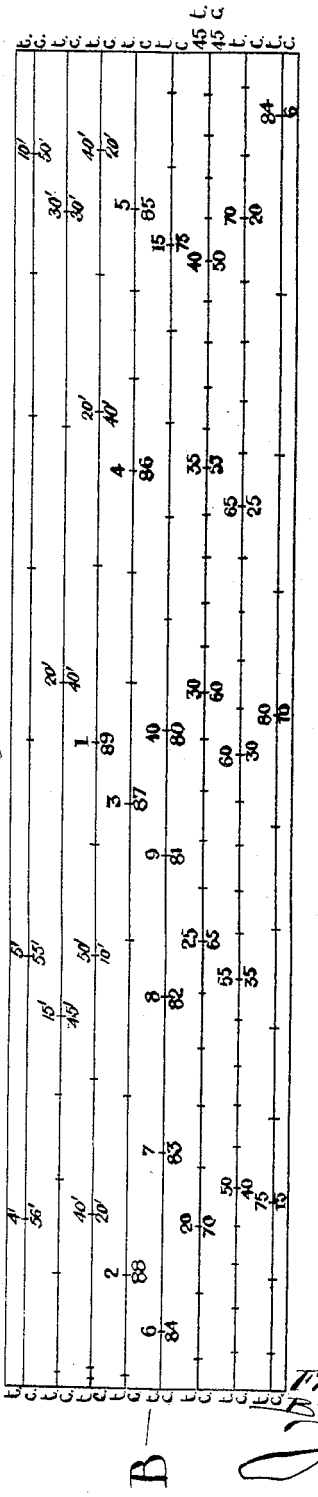

Fig. 6.

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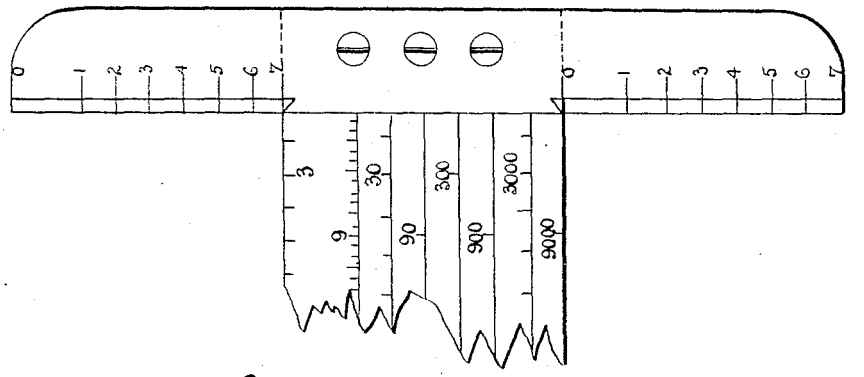
NO MODEL. 5 SHEETS—SHEET 5.

Fig. 9.



B

Fig. 8.

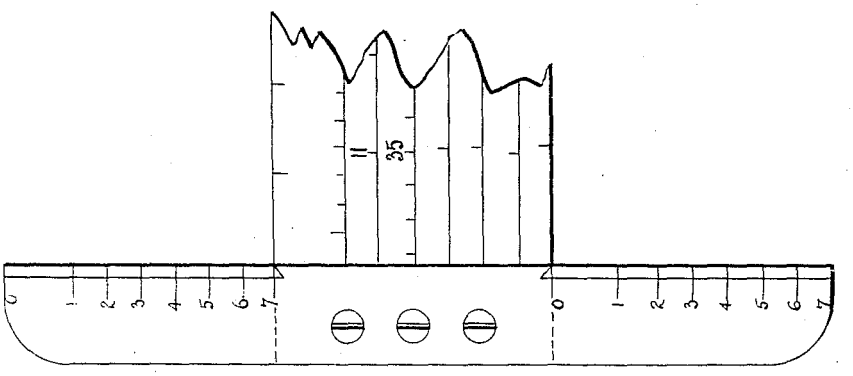
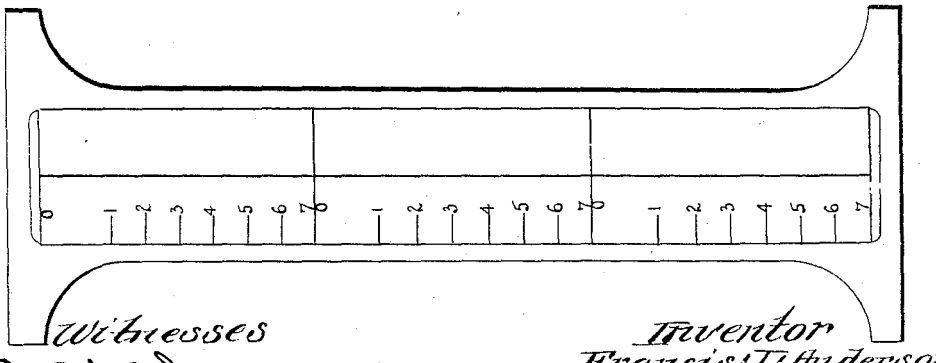


Fig. 7.



Witnesses

C. D. Kesler

Inventor

Francis J. Anderson

By James L. Norris

Atty.

No. 768,971. Patented August 30, 1904.

UNITED STATES PATENT OFFICE.

FRANCIS JAMES ANDERSON, OF WATERFORD, IRELAND.

SLIDE-RULE.

SPECIFICATION forming part of Letters Patent No. 768,971, dated August 30, 1904.

Application filed December 12, 1903. Serial No. 184,937. (No model.)

To all whom it may concern:

Be it known that I, FRANCIS JAMES ANDERSON, R. E., reconstruction officer, a subject of the King of Great Britain, residing at The Barracks, Waterford, in the county of Waterford, Ireland, have invented certain new and useful Improvements in Slide-Rules, of which the following is a specification.

This invention has reference to mathematical calculating devices and is founded on the principle of the well-known slide-rule.

The object of the invention is threefold—(*a*) to increase the accuracy and capacity of the ordinary decimally-divided slide-rule without any corresponding increase in the length of the instrument; (*b*) to do away with the necessity of the mental or mechanical calculation heretofore necessary to obviate ambiguity as to the position of the decimal point by giving each graduation on the scales a definite or absolute value that never varies; (*c*) to render it possible, if desired, to subdivide units on the slide-rule into other parts than tenths—such as twelfths or sixteenths, for example—thereby making it available for quantity surveyors, mechanical engineers, accountants, freight clerks, and others to whose work it is not at present applicable.

The ordinary rule is graduated on the face with two scales, one on each limb, which are duplicated on the slide. According to my said invention, however, each of the scales (instead of being in a continuous line) is split up into a series of equal parallel lines, the figures on each line being in geometrical progression with those of the adjacent lines immediately above or below them, from which they are separated by a "common ratio" of ten or of some root of ten. The number of lines in each scale may be increased in one direction as necessary, according to the height to which calculations are to be carried, and in the other direction, if desired, to read numbers less than unity to any required degree of accuracy.

The apparatus embodying the features of my invention comprises a slide-rule graduated as above indicated and provided with a slide having transverse end pieces or lateral extensions that extend across the face of the rule and with a traveler carrying a hair or other line that extends across all the scales to give the alinement of the various readings. The said lateral extensions of the slide and the traveler are adapted to distinguish by any appropriate means, such as markings, the various lines or similar parts of the scales.

In order that my invention may be clearly understood and readily carried into effect, I will now describe the same more fully with reference to the accompanying drawings, in which—

Figure 1 illustrates the manner in which the scales have been distributed on slide-rules of the type heretofore ordinarily employed. Figs. 2 and 3 illustrate in a simple form the manner in which I propose to distribute the scales on the limbs of the rule, Fig. 2 representing the upper and Fig. 3 the lower limb. Figs. 4 and 5 give two more complete examples of scales distributed in accordance with my present practice, Fig. 5 also exemplifying a somewhat modified form of the apparatus. Fig. 6 shows separately another scale useful for the slide. Fig. 7 is a view showing the traveler by itself. Figs. 8 and 9 are views, partly broken away, showing separately the opposite ends of the slide.

A represents the body of the rule, B the slide, and C the traveler.

The ordinary slide-rule has each of its limbs graduated with a scale, Fig. 1, which is comprised in a single or continuous line and which is repeated on the slide, and it has for its graduations values that are only relative. The scales shown in Figs. 2 and 3, however, are each split up into five portions or lines, between which are common ratios. If, for example, the geometrical ratio of $\sqrt{10}$ is selected, the upper scale would be graduated as shown in Fig. 2 and the lower scale as shown in Fig. 3, (omitting subdivisions,) the common ratio between lines in the upper being $\sqrt{10}$ and in the lower $\sqrt[4]{10}$.

The face of the instrument may be graduated as shown in Fig. 4, in which A and C are the upper and lower limbs, respectively, and B is the slide, and it is evident that the accuracy and capacity of the ordinary slide-rule has here been increased fourfold without any increase in the length of the instru-

ment, practically the only limit to this increase of accuracy and capacity being the number of lines which can be graduated on a limb or slide of a given width.

It will be noticed in the example shown in the drawings that the units are subdivided to twelfths for part of the scale by way of illustration; but they may be equally well subdivided to eighths, tenths, sixteenths, or any desired fraction, and the larger subdivisions (on the upper lines) may be again subdivided to forty-eighths, hundredths, sixteenths, or any desired parts within the compass of the instrument.

In the above example the slide bears on its face the same scale as the upper limb; but an interchangeable slide may be provided having trigonometrical and other scales, as hereinafter described.

Fig. 5 of the drawings illustrates a decimally-subdivided rule with a scale of natural sines and cosines (multiplied by one hundred) on the face of, and Fig. 6 a similar scale of tangents and cotangents (multiplied by one thousand) on the back of the interchangeable slide. "Gage-points" can be used at pleasure on all scales.

The instrument may be of any convenient size according to the purpose for which it is required and also of any appropriate material—such as wood, brass, celluloid, vulcanite, or other suitable material or materials, alone or in combination—and it is, with the important exceptions noted above, similar in construction to the ordinary slide-rule, having a body with upper and lower limbs between which works a slide, said limbs and slide being graduated as above described.

Over all and overlooking all scales is the traveler working in grooves on the sides of the body of the instrument and having a glazed surface provided with the aforesaid cross-bar or cross-line. Said glazed surface may be wholly or partially of magnifying-glass or may have a traveling magnifying-glass attached to it to insure finer readings and may also have auxiliary lines parallel to the cross-bar or cross-line to serve as a guide to the eye in estimating unmarked divisions.

Numbered cross-lines on the traveler indicate the positions of the various graduated lines on the rule and slide. Fig. 7 illustrates the general arrangement, the lines of the upper and lower edges of the body of the instrument being indicated, respectively, by the letters A and D and the upper and lower edges of the slide by the letters B and C, respectively.

In graduating the instrument units may be numbered in different colors from those of subdivisions as a guide to ready identification.

The slide has at each end and in such a position as not to interfere with the lengthwise movement a lateral extension comprising a beveled metal arm corresponding with the index-line and extending upward and downward to the full width of the rule. These arms have marked on them the line numbers of the scales on the upper and lower limbs. By their help the indices can be set without the necessity of using the traveler. Figs. 8 and 9 show the arrangement. The said arms may be so arranged as to be detachable and are capable of being refixed on the reverse side of the slide when the latter is in use.

The method of using the instrument is simple in the extreme. The left side of the slide, which has the numbers "1, $\sqrt{10}$, 10," and so on vertically over one another in the sketches, may be called the "left" index, while the right side, bearing the numbers "$\sqrt{10}$, 10, 10, $\sqrt{10}$" may be called the "right" index. Similarly the left and right sides of both the upper and lower limbs may be known as "left" and "right" indices. The traveler is used to indicate the alinement of the scales and to show by its numbered cross-lines the line of the scale on which the answer will be found. A few simple examples will best illustrate this.

Multiplication.—To obtain the results of multiplication, (*a*) set the index of slide (by means of its arm) (*b*) to first factor on upper limb, (*c*) above second factor on slide; (*d*) read answer on the line (of the upper limb) whose number is the total of the three numbers of the lines in (*a*), (*b*), and (*c*).

I. Thus to multiply one and six-twelfths by two and one-twelfth, on slide (*a*) set left index (line No. 0) (*c*) over "$2\frac{1}{12}$," (line No. 0;) on upper limb (*b*) to "$1\frac{6}{12}$," (line No. 0;) (*d*) read answer "$3\frac{6}{48}$," (line No. 0.) The answer is read on the 0 line of the limb, because the sum of the various lines used in the operations (*a*), (*b*), and (*c*) is 0+0+0=0.

II. To multiply fifty and one-twelfth by six, on slide (*a*) set left index (line No. 0) (*c*) over "6," (line No. 1;) on upper limb (*b*) to "$50\frac{1}{12}$," (line No. 3;) (*d*) read answer "$300\frac{1}{2}$," (line No. 4,) since 0+3+1=4.

III. To multiply two by seven. On setting the left index of slide to "2" on the upper limb it is found that the "7" on slide has traveled beyond the limb, and thus has no reading over it. Recourse is therefore had to the right index of slide (vertical line $\sqrt{10}$, 10, 10, $\sqrt{10}$, &c.,) which is set to "2" on the limb; but "1" is added to the number of its line (calling it "1" instead of "0.") The setting is then as follows: On slide (*a*) set right index (line No. 1) (*c*) over "7," (line No. 1;) on limb (*b*) to "2" (line No. 1;) (*d*) read answer "14," (line No. 2,) since 1+0+1=2.

Division.—This operation is the exact converse of multiplication, and therefore the line-number of the divisor (on slide) is called — (minus) and that of the dividend (on limb) + (plus), increasing the former by one in every

case where recourse is taken to the right index—*i. e.*, calling the right index "—1," (the left index being always "0.")

IV. Thus to divide seventy-two by six, on slide (*a*) set "6" (line No. 1) (*c*) over left index (line No. 0;) on limb (*b*) to "72" (line No. 3;) (*d*) read answer "12," (line No. 2,) since 3—1=2.

V. To divide twenty-four by eight, on slide (*a*) set "8" (line No. 1) (*c*) over right index (line No. 1;) on limb (*b*) to "24" (line No. 2;) (*d*) read answer "3," (line No. 0,) since 2—1—1=0.

The above rule can be expressed differently thus: To obtain line-number of answer on limb, (*a*) when left index is used deduct line-number of divisor from line-number of dividend, (*b*) when right index is used deduct line-number of divisor increased by one from line-number of dividend.

Squares and square roots.—Squares and square roots are obtained by inspection, as the numbers on the slide are the squares of the corresponding numbers (on the same lines) on the lower limb, while conversely the numbers on the lower limb are the square roots of those in a corresponding position on the slide. By setting the slide immediately over the lower limb there is thus formed a table of squares and square roots.

Cubes.—VI. Cube 4. On slide (*a*) set left index (line No. 0) (*c*) over "4" on slide, (line No. 1;) on lower limb (*b*) to "4," (line No. 2;) (*d*) read answer on upper limb, "64," (line No. 3,) since 0+2+1=3.

The rule is: If left index be used, the sum of the line-numbers in (*a*), (*b*), and (*c*) gives the number of the line in which the answer is to be read; but if the right index be used it most be called "+1," as in Example VII.

VII. Cube 7. On slide (*a*) set right index (line No. +1) (*c*) over "7" on slide, (line No. 1;) on lower limb (*b*) to "7," (line No. 3;) (*d*) read answer "343," (line No. 5,) since 1+1+3=5.

Cube roots.—In extracting cube roots the rule is to move the slide to the right or left (as may be required) until the same number on the slide appears under the number whose cube root is to be extracted on the upper limb, as appears on the lower limb under the index of the slide. If the left index be used, the line-number of the upper limb less the line-number of the slide gives the line-number of the lower limb where the answer will be found; but if the right index be used one must be deducted from the resulting line-number.

VIII. Thus if the cube root of twenty-seven is required, the slide is moved to the left until the same number (in this case "3") appears on the slide under "27" on the upper limb and on the lower limb under the right index of the slide. The setting stands thus: on upper limb (*a*) to "27," (line No. 2;) on slide (*b*) set "3," (line No. 0;) (*c*) under right index (line No. 1;) on lower limb (*d*) read answer "3," (line No. 1,) since 2—0—1=1.

IX. To find the cube root of thirteen hundred and thirty-one: On upper limb (*a*) to "1331," (line No. 6;) on slide (*b*) set "11," (line No. 2;) (left index (line No. 0;) on lower line (*d*) read answer "11," (line No. 4.)

Areas of circles.—Set "π" on the slide to either the right or left index of the upper ring, as may be necessary, calling the line-number "0" if to the left index and "+1" if to the right index. Then above the radius on the lower limb read the area of the circle on the slide in the line indicated by the sum of the line-numbers. Thus:

X. Radius forty-nine feet. Find area. On slide (*a*) set "π," (line No. 0;) on upper limb (*b*) to right index, (line No. 1;) on lower limb (*c*) over "49" (line No. 6;) on slide (*d*) read answer, area "7543" square feet, (line No. 7,) since 0+1+6=7.

XI. Radius 31.65 feet. Find area. On slide (*a*) set π, (line No. 0;) on upper limb (*b*) to left index, (line No. 0;) on lower limb (*c*) over "31.65," (line No. 6;) on slide (*d*) read answer, area "3147," (line No. 6,) since 0+0+6=6.

Note: By setting "π" on slide to the indices of the upper (instead of the lower) limb the necessity for using the traveler to give the alinement is avoided. Owing to the proximity of "π" to the right index it will rarely be necessary to set the slide to the left index of the upper limb. The value of the line-numbers to be assigned to the indices for the various operations may therefore be expressed thus: Left index: "± 0" in all operations. Right index: "+1" in all operations involving multiplication, including, therefore, cubing and areas of circles, and "—1" in all operations involving division, including cube roots.

Trigonometrical functions.—The interchangeable slide may have any useful scales on its face or back, as illustrated in Figs. 5 and 6, where the face bears a scale of sines ranging from "35′" to "90°" and of cosines ranging from "0°" to "89° 25′." The corresponding figures (on the same lines) on the scale of the lower limb give the values of the natural sines and cosines, (multiplied by one hundred,) while the scale on the upper limb similarly gives the values of their squares, (multiplied by ten thousand.) The back of the slide, as shown in Fig. 6, has a similar scale of tangents from "4′" to "84° 17′" and of cotangents ranging from "43′" to "89° 56′." Above them on the upper limb can be read their values, (multiplied by one thousand.) This slide has no indices.

What I claim, and desire to secure by Letters Patent of the United States, is—

1. In a slide-rule the combination of limbs, each of which carries a progressive series of longitudinal lines graduated with scales, a slide, and lateral extensions on said slide hav-

ing marks adapted to identify or distinguish the various scale-lines on the limbs.

2. In a slide-rule the combination of limbs each bearing a scale graduated on a progressive series of longitudinal lines, a slide also bearing a scale graduated on progressive series of longitudinal lines, and lateral extensions on said slide serving to distinguish or identify the various scale-lines on the limbs.

3. In a slide-rule the combination of limbs each bearing a scale graduated on a progressive series of longitudinall ines, a reversible slide having its opposite sides different from each other and both graduated, and removable lateral extensions on said slide serving to distinguish or identify the various scale-lines on the limbs.

4. In a slide-rule the combination of limbs and a slide each bearing a scale graduated on a progressive series of parallel longitudinal lines, indices on said slide extending across the scales upon the limbs and serving to distinguish the various lines thereof, and a traveler bearing a line extending completely across the three aforesaid scales to aline the readings.

5. In a slide-rule the combination of limbs and a slide each bearing a scale graduated on a progressive series of parallel longitudinal lines, indices carried by said slide and extending across the scales on the limbs to distinguish the individual scale-lines thereof, and means for distinguishing or identifying the individual lines of all the scales.

In testimony whereof I have hereunto set my hand, in presence of two subscribing witnesses, this 4th day of November, 1903.

FRANCIS JAMES ANDERSON.

Witnesses:

FRANK FLANAGAN,

GEORGE FREDERICK FRANCIS LONG.