

J. L. KNIGHT.

Device for Calculating Percentage, &c.
No. 214,510. Patented April 22, 1879.

FIG. 2.

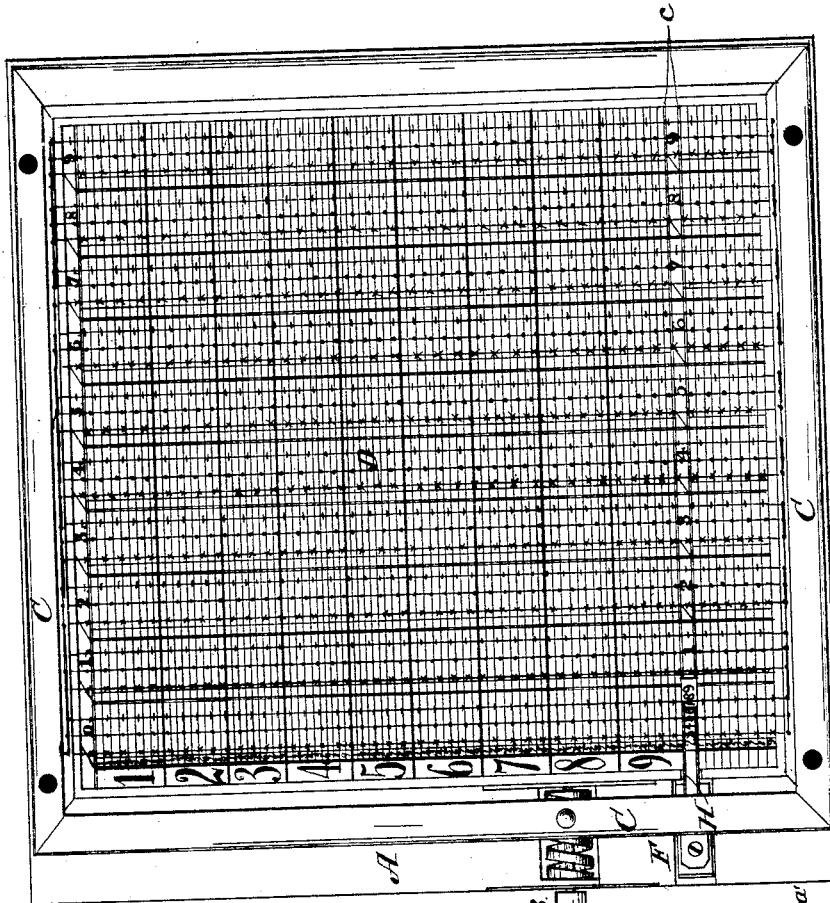
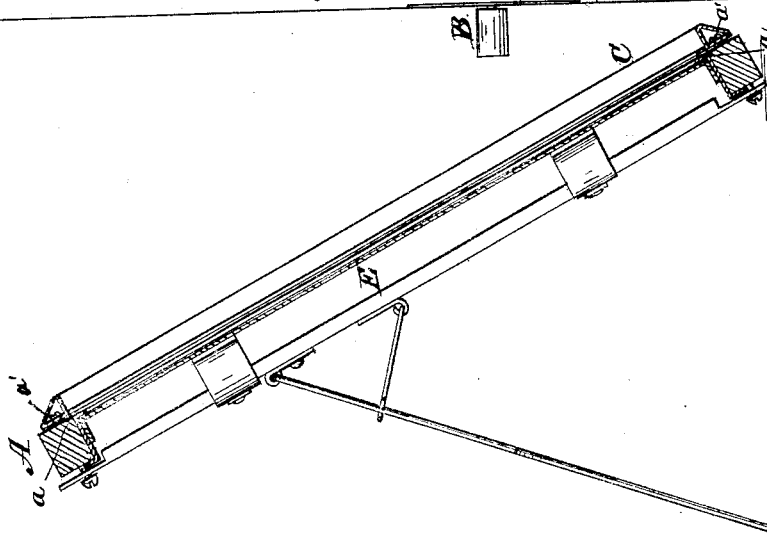


FIG. 1.



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FIG. 4.

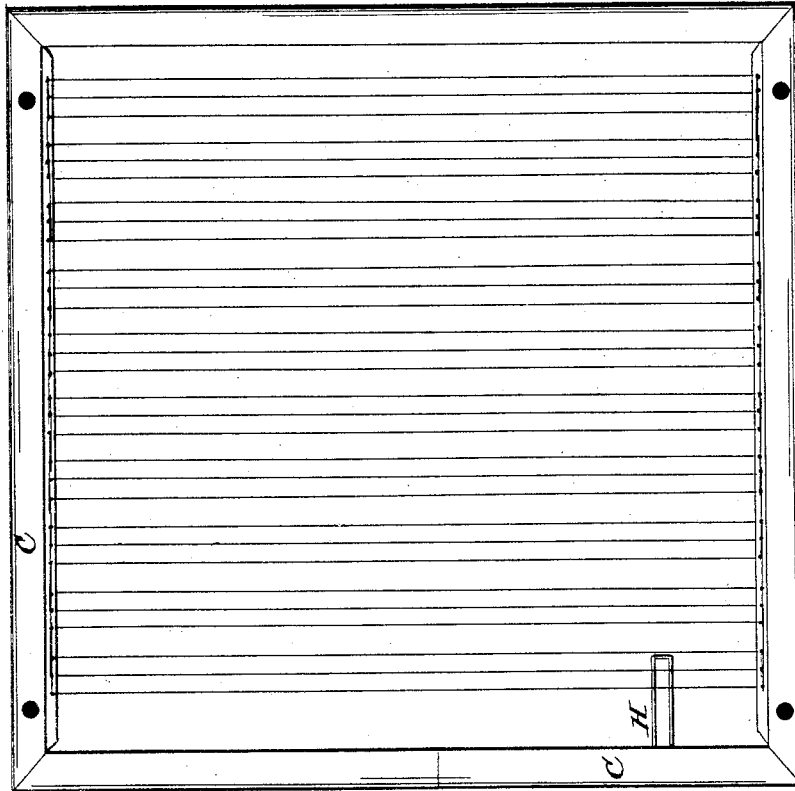


FIG. 3.

1	0	1	8	9	3	7	5	0	0	1	0	2	z
2	0	1	9	1	2	5	0	0	0	2	0	2	
3	0	1	9	3	1	2	5	0	0	3	0	2	
4	0	1	9	5	0	0	0	0	0	4	0	2	
5	0	1	9	6	8	7	5	0	0	5	0	2	
6	0	1	9	8	7	5	0	0	0	6	0	2	
7	0	2	0	0	6	2	5	0	0	7	0	2	
8	0	2	0	2	5	0	0	0	0	8	0	2	
9	0	2	0	4	3	7	5	0	0	9	0	2	
1	0	3	7	6	8	7	5	0	0	1			
2	0	3	7	8	7	5	0	0	0	2			
3	0	3	8	0	6	2	5	0	0	3			
4	0	3	8	2	5	0	0	0	0	4			
5	0	3	8	4									

FIG. 5.

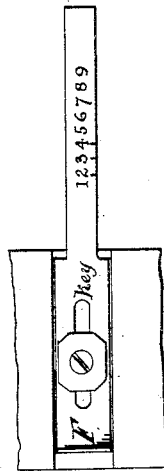
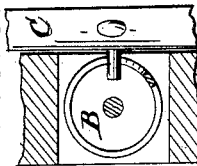


FIG. 6.



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FIG. 7.

	0.	1.	2.	3.	4.	5.	6.	7.	8.	9.
1	018937500	020913500	022697500	024382500	026067500	027752500	029437500	031122500	032807500	034492500
2	019132500	021108500	022892500	024577500	026262500	027947500	029632500	031317500	033002500	034687500
3	019327500	021303500	023087500	024772500	026457500	028142500	029827500	031512500	033197500	034882500
4	019522500	021498500	023282500	024967500	026652500	028337500	030022500	031707500	033392500	035077500
5	019717500	021703500	023487500	025172500	026857500	028542500	030227500	031912500	033597500	035282500
6	019912500	021908500	023692500	025377500	027062500	028747500	030432500	032117500	033802500	035487500
7	020107500	022113500	023907500	025592500	027277500	028962500	030647500	032332500	034017500	035702500
8	020302500	022308500	024102500	025787500	027472500	029157500	030842500	032527500	034212500	035897500
9	020497500	022493500	024287500	025972500	027657500	029342500	031027500	032712500	034397500	035282500
10	020692500	022688500	024482500	026167500	027852500	029537500	031222500	032907500	034592500	035487500
11	020887500	022883500	024677500	026362500	028047500	029732500	031417500	033102500	034787500	035682500
12	021082500	023078500	024872500	026557500	028242500	029927500	031612500	033307500	034992500	035877500
13	021277500	023273500	025067500	026752500	028437500	030122500	031817500	033512500	035207500	036072500
14	021472500	023468500	025262500	026947500	028632500	030317500	032012500	033707500	035402500	036267500
15	021667500	023663500	025457500	027142500	028827500	030512500	032207500	033902500	035597500	036462500
16	021862500	023858500	025652500	027337500	029022500	030707500	032402500	034097500	035792500	036657500
17	022057500	024053500	025847500	027532500	029217500	030902500	032597500	034292500	035987500	036852500
18	022252500	024248500	026042500	027727500	029412500	031097500	032792500	034487500	036182500	037047500
19	022447500	024443500	026237500	027922500	029607500	031292500	032987500	034682500	036377500	037242500
20	022642500	024638500	026432500	028117500	029802500	031487500	033182500	034877500	036572500	037437500
21	022837500	024833500	026627500	028312500	030002500	031682500	033377500	035072500	036767500	037632500
22	023032500	025028500	026822500	028507500	030197500	031877500	033572500	035267500	036962500	037827500
23	023227500	025223500	027017500	028702500	030392500	032072500	033767500	035462500	037157500	038022500
24	023422500	025418500	027212500	028897500	030587500	032267500	033962500	035657500	037352500	038217500
25	023617500	025613500	027407500	029092500	030782500	032462500	034157500	035852500	037547500	038412500
26	023812500	025808500	027602500	029287500	030977500	032657500	034352500	036047500	037742500	038607500
27	024007500	026003500	027797500	029482500	031172500	032852500	034547500	036242500	037937500	038802500
28	024202500	026198500	027992500	029677500	031367500	033047500	034742500	036437500	038132500	038997500
29	024397500	026393500	028187500	029872500	031562500	033242500	034937500	036632500	038327500	039192500
30	024592500	026588500	028382500	030067500	031757500	033437500	035132500	036827500	038522500	039387500
31	024787500	026783500	028577500	030262500	031952500	033632500	035327500	037022500	038717500	039582500
32	024982500	026978500	028772500	030457500	032147500	033827500	035522500	037217500	038912500	039777500
33	025177500	027173500	028967500	030652500	032342500	034022500	035717500	037412500	039107500	039972500
34	025372500	027368500	029162500	030847500	032537500	034217500	035912500	037607500	039302500	040167500
35	025567500	027563500	029357500	031042500	032732500	034412500	036107500	037802500	039497500	040362500
36	025762500	027758500	029552500	031237500	032927500	034607500	036302500	037997500	039692500	040557500
37	025957500	027953500	029747500	031432500	033122500	034802500	036497500	038192500	039887500	040752500
38	026152500	028148500	029942500	031627500	033317500	035002500	036692500	038387500	040082500	040947500
39	026347500	028343500	030137500	031822500	033512500	035197500	036887500	038582500	040277500	041142500
40	026542500	028538500	030332500	032017500	033707500	035392500	037082500	038777500	040472500	041337500
41	026737500	028733500	030527500	032212500	033902500	035587500	037277500	038972500	040667500	041532500
42	026932500	028928500	030722500	032407500	034097500	035782500	037472500	039167500	040862500	041727500
43	027127500	029123500	030917500	032602500	034292500	035977500	037667500	039362500	041057500	041922500
44	027322500	029318500	031112500	032797500	034487500	036172500	037862500	039557500	041252500	042117500
45	027517500	029513500	031307500	032992500	034682500	036367500	038057500	039752500	041447500	042312500
46	027712500	029708500	031502500	033187500	034877500	036562500	038252500	039947500	041642500	042507500
47	027907500	029903500	031697500	033382500	035072500	036757500	038447500	040142500	041837500	042702500
48	028102500	030098500	031892500	033577500	035267500	036952500	038642500	040337500	042032500	042897500
49	028297500	030293500	032087500	033772500	035462500	037147500	038837500	040532500	042227500	043092500
50	028492500	030488500	032282500	033967500	035657500	037342500	039032500	040727500	042422500	043287500
51	028687500	030683500	032477500	034162500	035852500	037537500	039227500	040922500	042617500	043482500
52	028882500	030878500	032672500	034357500	036047500	037732500	039422500	041117500	042812500	043677500
53	029077500	031073500	032867500	034552500	036242500	037927500	039617500	041312500	043007500	043872500
54	029272500	031268500	033062500	034747500	036437500	038122500	039812500	041507500	043202500	044067500
55	029467500	031463500	033257500	034942500	036632500	038317500	040007500	041702500	043397500	044262500
56	029662500	031658500	033452500	035137500	036827500	038512500	040202500	041897500	043592500	044457500
57	029857500	031853500	033647500	035332500	037022500	038707500	040397500	042092500	043787500	044652500
58	030052500	032048500	033842500	035527500	037217500	038902500	040592500	042287500	043982500	044847500
59	030247500	032243500	034037500	035722500	037412500	039097500	040787500	042482500	044177500	045042500
60	030442500	032438500	034232500	035917500	037607500	039292500	040982500	042677500	044372500	045237500
61	030637500	032633500	034427500	036112500	037802500	039487500	041177500	042872500	044567500	045432500
62	030832500	032828500	034622500	036307500	037997500	039682500	041372500	043067500	044762500	045627500
63	031027500	033023500	034817500	036502500	038192500	039877500	041567500	043262500	044957500	045822500
64	031222500	033218500	035012500	036697500	038387500	040072500	041762500	043457500	045152500	046017500
65	031417500	033413500	035207500	036892500	038582500	040267500	041957500	043652500	045347500	046212500
66	031612500	033608500	035402500	037087500	038777500	040462500	042152500	043847500	045542500	046407500
67	031807500	033803500	035597500	037282500	038972500	040657500	042347500	044042500	045737500	046602500
68	032002500	033998500	035792500	037477500	039167500	040852500	042542500	044237500	045932500	046797500
69	032197500	034193500	035987500	037672500	039362500	041047500	042737500	044432500	046127500	046992500
70	032392500	034388500	036182500	037867500	039557500	041242500	042932500	044627500	046322500	047187500
71	032587500	034583500	036377500	038062500	039752500	041437500	043127500	044822500	046517500	047382500
72	032782500	034778500	036572500	038257500	039947500	041632500	043322500	045017500	046712500	047577500
73	032977500	034973500	036767500	038452500	040142500	041827500	043517500	045212500	046907500	047772500
74	033172500	035168500	036962500	038647500	040337500	042022500	043712500	045407500	047102500	047967500
75	033367500	035363500	037157500	038842500	040532500	042217500	043907500	045602500	047297500	048162500
76	033562500	035558500	037352500	039037500	040727500	042412500	044102500	045797500	047492500	048357500
77	033757500	035753500	037547500	039232500	040922500	042607500	044297500	045992500	047687500	048552500
78	033952500	035948500	037742500	039427500	041117500	042802500	044492500	046187500	047882500	048747500
79	034147500	036143500	037937500	039622500	041312500	043007500	044687500	046382500	048077500	048942500
80	034342500	036338500	038132500	039817500	041507500	043202500	044882500	046577500	048272500	049137500
81	034537500	036533500	038327500	040012500	041702500	043397500	045077500	046772500	048467500	049332500
82	034732500	036728500	038522500	040207500	041897500	043592500				

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IMPROVEMENT IN DEVICES FOR CALCULATING PERCENTAGE, &c.

Specification forming part of Letters Patent No. **214,510**, dated April 22, 1879; application filed April 29, 1878.

To all whom it may concern:

Be it known that I, J. LEE KNIGHT, of Topeka, in the county of Shawnee and State of Kansas, have invented certain new and useful Improvements in Calculators; and I do hereby declare that the following is a full, clear, and exact description of the invention, which will enable others skilled in the art to which it pertains to make and use the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

In the drawings, Figure 1 is a vertical section. Fig. 2 is a plan. Fig. 4 is the carrying-shield and frame, with the fixed tables removed. Figs. 3, 5, and 6 are detail views; and Fig. 7 is a fixed table, showing the combination partially made up on the basis of 18 $\frac{3}{4}$ per cent., or cost, or duty, per article or piece, or tax per head, &c.

This invention, which is a 9x9 combination calculator, is a mechanical device for showing at a glance, or by the simple addition of two or three sums indicated by the mechanism, the exact results of percentage calculations which would otherwise require extended multiplications, involving the constant possibility of error.

The machine has been so designed as to be simple in construction, easily comprehended in its operation and the formation of the tables used, and absolutely accurate in the results attained by its use.

The device is composed of a deep rectangular frame, A, of suitable material and size, provided with an actuating-screw, B, for giving motion to a superposed rectangular frame or carrying-shield, C, supported thereon. The frame has also a projecting metal flange, *a*, around the inner front margin, to serve as a catch, against which the rectangular tables D may rest, and be retained in place flush with the front or face of said frame A. The frame A is also provided with a removable back, E, to facilitate changing the table of one rate for the table carrying a different rate, and is made deep enough for the thickness of the frame material to form a receptacle for a supply of extra tables to be stored and kept clean and straight when not in use. The frame A is also provided with an adjustable key-slip, F, of

metal or other suitable material, having the figures 1 to 9, inclusive, and the word "key" placed thereon.

The key-slip F is slotted and secured in position so that it may be moved back and forth and fixed at different distances as related to the permanent table, for the purpose of changing the rate carried by the same table, as will be hereinafter described.

To this principal frame A is attached another frame or carrying-shield, C, secured by screws *a'* or other suitable means, in such manner that it may be freely moved from side to side by means of a pin projecting from its under side into the open groove of the screw B. The carrying-shield is provided with ten groups of guides, stretched across from side to side, and composed of red, yellow, and blue silk-thread or other suitable material, there being three guides in each group, all being placed at fixed distances, corresponding with the lines of figures on the fixed table, to be hereinafter described. This carrying-shield is also provided with a wire-loop, H, placed at a point to correspond with the adjustable key-slip of the first-described frame, and on a line horizontally with the wide horizontal bar of division of the fixed table. This shield moves on anti-friction bearings affixed to the frame A.

The fixed tables D are made on a card or board cut to the proper size to fit snugly inside of the frame A and against the flanges *a*. They are divided by engraved or printed heavy vertical double lines *b* into ten equal vertical tiers or columns, *b'*, and again divided horizontally by one heavy or wide double line, *c*, near the lower end, into the parts or divisions I and K. The part I, above this wide dividing-line *c*, is again subdivided into nine equal horizontal spaces or tiers, *d*, by single lines *d'* drawn parallel to the wide double line *c*, and at right angles to the vertical columns *b*.

The nine horizontal spaces of the upper part, I, have at the left-hand end of each the figures from 1 to 9, respectively, and the ten vertical spaces between the wide vertical lines *b* have the ten digits 0 1 2 3 4 5 6 7 8 9 at the top of each, respectively.

On the wide double line or horizontal bar *c* are placed the figures from 1 to 9 in the lower ends of the vertical tiers *b'*, over which the

corresponding figures are placed at the top of the table.

By these general divisions it is found the tables are divided into one hundred rectangular blocks or spaces, ten being below the wide horizontal bar, and ninety above it. At the left-hand margin of the horizontal tiers of spaces *d* are placed, in consecutive order, the figures from 1 to 9, inclusive.

The space in the double line or horizontal bar *c* above the lower left-hand corner block in the division K is left blank, and over it is arranged the adjustable key-slip F. These several divisions, with their marginal indices, constitute the fixed table, to be used, in connection with the frame, with key-slip and carrying-shield with loop, for the purpose of readily and accurately indicating the results of calculations in percentage. These forms of division and marginal indices, as here arranged and described, constitute a permanent and useful combination of lines and figures to be used in connection with tables of changeable figures written on the board or card for the specific purposes hereinafter fully explained.

I will now explain the manner of forming the combinations of figures to be written or printed on the fixed tables, and also the manner of using the device when completed.

Each table is supplied with a set of combinations derived from a fixed rate or per cent. or a definite whole or fractional number.

For convenience of reference the rectangular block K', at the lower left-hand corner in the division K immediately below the key-slip, is termed the "key-block." The other nine blocks or spaces in said division are, for convenience, termed the "base-tier." The ninety blocks in the division I are termed the "upper group." For further convenience the nine combinations written or printed on the key-block are called "key combinations." The eighty-one combinations of the base-tier are called "derived combinations," and the nine hundred combinations of the upper group are called "detailed combinations."

The rate per cent. being given, which is to become the multiplier in solving the problems, is written decimally, and this decimal statement of the per cent. on one dollar at the given rate is the first key combination, from which all the others are formed. Its place in the table is at the top of the key-block, and directly to the right of and on a horizontal line with the small marginal index-figure 1 of the key-block. This key combination added to itself (or multiplied by two) gives the second key combination, to be written next below it, on a horizontal line with the marginal index-figure 2 of the key-block. The first key added to the second will give the third, the first added to the third will give the fourth, added to the fourth will give the fifth, and so on for the nine key combinations. If, now, we again add the first to the ninth, we shall have increased to tenfold, or the figures will be repeated, but located one space farther to the

left, this tenth addition giving the proof that all the others are correctly added.

The derived combinations of the base-tier are formed by adding a tenth of the first key to the first key for the first derived combination of the first or left-hand block of the base-tier. To this we again add a tenth of the first key for the first or upper derived combination of the second block. To the second we add a tenth of the first key for the third; add the same to the third and we get the fourth, and so on for the nine upper derived combinations, written opposite the several small index-figures 1 of the nine blocks of the base-tier. For the second horizontal line of derived combinations, to be written opposite the index-figures 2, we take the second key combination and add to it tenths of the first key in the same way. For the third line we take as a starting-point the third key, adding successively the tenth part of the first key, which is the constant increase, and for the fourth, fifth, &c., proceed in the same way by adding to the fourth, fifth, &c., key combinations. Having added one-tenth of the first key nine successive times to form the first series of nine derived combinations, if to the ninth one we again add the tenth of first key we shall have just doubled the first key, and if the additions have been correct the result should be equal to the second key, which was formed by adding the first key to itself. In like manner we find proof of all the additions by making a tenth addition at the end of each series of nine derived combinations, which will always give the key combination of the next series.

It is seen that the key combinations increase in a ratio or progression equal to the whole ratio, while the derived combinations increase by a ratio equal to but one-tenth of the rate or number, yet both have a fixed ratio derived from the first key—*i. e.*, the rate or number.

We now have to deal with combinations having a still different ratio of increase—*viz.*, one one-hundredth of the first key. These are the detailed combinations of the upper group. To form these we take the first key as a starting-point for the first series (of blocks) of combinations of the upper group—those occupying the space in the top subdivision which has the large figure 1 at the left-hand end—and by the addition of one one-hundredth of the first key to the first key get the first or upper combination of the block over which the large 0 stands at the upper left-hand corner of the table. To this first-detailed combination we again add the ratio of constant increase for the second combination of that block. To this another addition of the same ratio of increase will give the third, and so on for the nine combinations of that block. A proof of the several additions can be had by making a tenth addition; the result being equal to the first derived combination of the base-tier, that being first key plus one-tenth of itself, and in

this case being first key plus ten-one-hundredths of first key. For the second block of first series (horizontally) we take the first derived combination of the base-tier, and to it add successively the constant ratio nine times, which will give the nine combinations of the second block, a tenth addition proving the work, as before, by giving the second derived combination of the base-tier, for the reason that here we have added twenty one-hundredths, while in the base-tier we added two-tenths. The third block is in like manner formed by successive additions to the second derived combination, the fourth block by additions to the third of the base-tier, and so on for the ten blocks of the first series, the work being proved at the end of each block by a tenth addition of the ratio of increase.

For the second series (of blocks) of combinations, on the space at the left-hand end of which the large figure 2 stands, we proceed by the same ratio of constant increase, but take the second key combination as an initial point, and, after forming the combinations for the first block of that series, prove, as before, by a tenth addition, which gives the same figures as the first derived combination of the second series in the base-tier, which, in like manner, is the starting-point or number to which an addition of the ratio of increase will give the first combination of the second block. The ratio being again added to this will give the second, and so on for the nine combinations of that block.

The tenth addition proves the work by giving the second derived combination of the second series in the base-tier, which is also the starting-point from which in the same way the combinations of the third block are formed, and so on for all the blocks of the second series.

For the third, fourth, fifth, &c., series of the upper group we take the corresponding key combination, and in regular order its derived combinations, and by successive additions of the ratio of increase form all the detailed combinations of the upper group, proving the work at every tenth step by the derived combinations of the base-tier, which were also proven at every tenth step by their key combinations, and these again were proven at the tenth step, as previously shown, by the formation of a "repetend."

We find, then, that we have combinations of three kinds—that is, formed from three different ratios of increase—viz., key combinations, increasing by a ratio equal to unity of the rate; derived combinations, formed by a constant increase equal to one-tenth the rate; and detailed combinations, in which the ratio is equal to one one-hundredth of the rate.

This system of decimal logarithmic combinations being formed and arranged on the table as here described, may now be used in connection with the guides of the carrying-shield to give the results of all multiplications by the given rate or number on any sum less

than one thousand millions—that is to say, any sum or amount that can be represented by nine figures, which comes within a single unit of a thousand millions, viz., 999999999, and this by the simple addition of three sums indicated by the several marginal indices, and divided by the red, yellow, and blue guides.

Having explained the form of my device, and the manner of adjusting it to any rate or multiplier, I will give some examples of its use, as illustrated by the partially-formed combinations on the model.

The first and second key combinations as written on the model, and their corollary derived and detailed combinations, are from the fractional multiplier $18\frac{3}{4}$, and may be used to give results of percentage calculations at $1\frac{7}{8}$ mills per cent., $18\frac{3}{4}$ per cent. mills, or $18\frac{3}{4}$ per cent. cents, or for determining the value of any given number of pounds, yards, parcels, or things at either of those prices per yard, pound, &c.

EXAMPLES AND RULES.

Adjustment of the key-slip.—The key-slip, in addition to the nine significant figures, has three check-marks on the lower edge. For multiplying by $1\frac{7}{8}$ as mills, adjust the key-slip so the left-hand check-mark coincides with the right-hand line of the vertical column—i. e., the line separating the small marginal indices of the key-block from the key combinations. If it be desired to multiply by $18\frac{3}{4}$ as mills, set the slip so the middle one of the three check-marks coincides with the above-named line; and if the multiplier is to be $18\frac{3}{4}$ as cents, set the key-slip so the right-hand check-mark falls at the same point of the permanent table.

In the examples given, a rate of tax or duty is assumed at $18\frac{3}{4}$ mills on the dollar, and the key-slip set, as in model, at the center check-mark. This key-slip simply fixes the initial decimal-point or base from which the guides count, and the different guides serve to fix the decimal-points of the several combinations, whereby the addition of three combinations will give the results of calculations on sums composed of seven, eight, or nine significant figures; the addition of two combinations will give the result of multiplying any number composed of four, five, or six significant figures; and the result of multiplying any sum composed of three figures will be shown in full without addition.

I will now give several examples illustrative of the manner of using this table.

First example.—What is the tax or duty on \$1 at $18\frac{3}{4}$ mills per cent.? This we term a prime problem of the first class. Prime, because it needs no addition to get the result; of the first class, because it has but a single significant figure.

Rule 1.—Set the carrying-shield so the wire loop will inclose as many figures as there are figures from left to right in the sum being multiplied. In this example there is but one figure from left to right, and applying the

rule we set the shield so that the figure 1 of the key-slip falls inside the wire-loop.

Theorem 1.—All problems of a single significant figure are answered in the key-block, and the decimal-point is marked by the red or right-hand guide, the left hand or significant figure of the problem being the index to the combination which forms the answer.

Applying the theorem, we find opposite the small index-figure 1 of the key-block the first key combination divided by the red guide thus: .01875, or one cent, eight mills, and seventy-five hundredths, as the answer.

Second example.—Required the tax or duty on \$20—a prime problem of first class. Apply rule 1 by setting the shield to include the figure 2 of the key-slip. Apply theorem 1 and we find the second key combination divided by the red guide thus—.375, or thirty-seven cents and five mills as the answer.

Example.—Required the tax on \$18, prime problem, second class—second, because having two significant figures. Rule 1 sets the shield to include the figure 2 of the key-slip.

Theorem 2.—Problems having two significant figures in succession from the left are answered in the combinations of the base-tier as divided by red guide, the left-hand figure being the horizontal index, or index to series to be found on margin of block, and the second figure being the vertical or cross index to be found over top of block on the wide horizontal bar. Apply theorem 2, and we find in first series, eighth block of base-tier .03375 as the answer.

Third example.—Required the tax on \$197, prime problem, third class—third, because having three significant figures. Rule 1 sets the shield to include 3 of the key slip inside the loop.

Theorem 3.—Problems having three significant figures in succession from the left, or two significant figures separated by a single cipher, are answered in the detailed combinations of the upper group as divided by the red guide, the left-hand figure of the problem being the horizontal index to series of blocks, the second figure or cipher being cross or vertical index to block of the series, and the third figure of the problem from the left, the detail or block-index to the combination which is the answer. Apply theorem 3 and we find 03.693 as the answer.

Fourth example.—Required the tax or duty on \$2,182. This a complex problem, embodying a prime problem of the third class and an auxiliary problem of the first class—complex, because composed of more than one period of three figures; embodies an auxiliary problem, because requiring one addition to solve it.

Rule 2.—To get the result of a complex problem, divide the sum into periods of three figures, counting from the left. To the answer to first period as divided by the red guide add the answer to the second period as divided by the yellow guide; and if there be three periods, to the sum of the two, as above, add the an-

swer to the third period as divided by the blue guide. Apply rule 1, which sets the shield so the wire loop includes the figure 4 of the key-slip. Theorem 3 gives 40.875 as answer to first period, and theorem 1 gives .0375 as answer to second period. Add auxiliary to prime answer, and we have $40.875 + .0375 = 40.9125$ as complete answer.

NOTE.—Had the problem contained five significant figures the answer to second period would have been found by theorem 2 in base-tier, and added as above; if of six significant figures, or six figures, with significant figure in the units place, theorem 3 would have indicated the answers to both periods in the upper group, and these added together as above would have given the true answer.

Example.—Required the tax or duty on \$209219.13. Complex problem, composed of prime problem of third class; auxiliary problem of third class, and sub-auxiliary problem of second class. Rule 1 sets the shield to bring the figure 8 of the key-slip inside the loop. Theorem 3 gives 391875.00, red guide, as answer to first period; also, 410.625, yellow guide, as answer to second period, and theorem 2 gives .243+, blue guide, as answer to third period; therefore, $391875.00 + 410.625 + .243 = 392285.86$ as the answer. But this is manifestly an error if we are reckoning percentage, as the percentage of 18½ mills gives a sum greater than the original amount. The anomaly is readily explained when we recall the fact that the original sum had a decimal point two spaces from the right; or, in other words, it was cents instead of dollars; or, more properly, dollars and cents both; but we have dealt with it as dollars only, taking no account of the decimal point, which, by its place, really divided the sum by one hundred. If, however, we divide our answer by one hundred by removing the decimal point two places farther to the left we shall have corrected the seeming error, and our true answer 3922.85+.

NOTE.—If a sum is composed of dollars only, we read the answers dollars and cents as divided by the guides. If the sum is composed of dollars and cents both, we should read the answer cents and mills, as divided by the guides, and fix final decimal-points accordingly.

Let us now readjust the key-slip and make the multiplier 1½ mills instead of 18½ mills.

Example.—What commission is due from negotiating 209,219.13 of business at 1½ mills per cent.? The calculation is precisely the same as before, except that the decimal point will be found marked one space farther to the left in each case, and hence the answer will be \$402.28+; or, in other words, the adjustment of the slip serves to divide each answer, and hence the total, by ten.

Fifth example.—What is the cost of 20,921,913 yards of muslin at 18½ cents per yard? We readjust the key-slip so that the left-hand check-mark coincides with the line at right hand of small marginal-block index-

figures. Having so adjusted the key, we set the shield to bring the figure 8 inside the loop, and then find the answer to first and second periods of three figures from the left in upper group as before, the answer to third period in base-tier, and by adding the three together, as in the first example, where these same figures represented dollars and cents, and we now find the product represented by the three added combinations or answers, as severally divided by the red, yellow, and blue guides, to be 4022858.65+.

A comparison of this result with the former shows that our principal here, or multiplier, not only had no decimal-point, as in the former case, hence was not divided by a hundred, but that, by changing the key-slip, we have multiplied it by ten to start with.

The fourth, fifth, and sixth key combinations, and their corollary derived and detailed combinations, are based upon the following numbers, viz: the fourth equals 27693, the fifth equals 18475, and the sixth equals 53832, their aggregate being 100000. These numbers, if representing .27+ per cent., .18+ per cent., and .53+ per cent., would jointly make 100 per cent., or gross amount. Each would be completed for an entire table for use in distributing railroad earnings, &c., in combined machine, as hereinafter explained. They are given on the model, that examples may be tested by them, if thought desirable.

The above and foregoing examples illustrate the power of the machine and the uses of its various parts in accomplishing the results.

It is obvious that problems of any number of figures can be solved by finding answers to first nine figures from the left, suffixing to the result as many ciphers as there are figures more than nine in the problem, and removing the decimal-point in the answer an equal number of places farther to the right; then finding answers, as before, for the next general group of nine figures, or less, as the case may be, and adding the results together.

Two, four, six, eight, nine, or more of these tables and frames may be combined in one large frame, all the sliding shields being operated by the same swivel and pin, and thus be used to give at one motion the results of calculations at two, four, or more rates at the same time; or, each of the series of blocks of the upper group may be treated separately, having the first block from the left as a key-block, and the others in same series for derived combinations similar to base-tier. Each series could, in that case, carry a different rate.

This arrangement, by placing the guides two figures' spaces apart instead of three spaces, as in model, would give a machine carrying ten different rates, or, for tax calculations, nine different levies, and their total, and

would by a single setting give results by periods of two figures, by one addition giving answers on all sums less than 10000—viz., 9999; and by two additions, on any sum less than 100000—viz., 999999; and by the addition of a fourth guide, by adding four sums, carry eight figures.

This form would probably be preferable for most purposes, and was the original form contemplated; but the form shown in the model has so many advantages, and is, moreover, so much more complete as a symmetrical device, that I submit it as being the greater, which includes the less. The device, in one or the other form, would have many uses where rapid and accurate results are required.

Having described my invention, what I claim, and desire to secure by Letters Patent, is—

1. The combination, with the frame A and the rectangular table D, divided into nine vertical and horizontal tiers of spaces or blocks, with a lower or marginal horizontal tier, all provided with combinations of figures and marginal indices, as stated, of the rectangular adjustable frame C and the series of groups of differently-colored parallel guide-cords stretched across the face of the table D, and having their ends secured to opposite sides of said frame C, and arranged to mark the different columns of figures, substantially as set forth.

2. The combination, with the frame A, rectangular table D, divided into nine vertical and horizontal tiers of spaces or blocks, with a lower or marginal tier, all provided with combinations of figures and marginal indices, as described, the rectangular adjustable frame C, and the series of groups of differently-colored parallel guide-cords stretched across the face of the table D, and carried and adjusted by the movement of the frame C, of the key-slip F, secured on the frame A so that it can be adjusted laterally, and key-loop H fixed to adjustable frame C and arranged over the key-loop F, substantially as and for the purposes set forth.

3. The combination of the rectangular frame A, having the guide-pins *a'* and inner flange, *a*, the adjustable key-slip F, secured to the frame A, the rectangular frame C, sliding laterally and horizontally on the pins *a'*, and having the key-loop H, and the fixed rectangular table D, all arranged substantially as and for the purposes set forth.

In testimony that I claim the foregoing as my own I affix my signature in presence of two witnesses.

J. LEE KNIGHT.

Witnesses:

C. THOMAS, Jr.,
THOS. M. JAMES.