(No Model.)

2 Sheets—Sheet 1.

G. B. GRANT.

CALCULATING MACHINE.

No. 605,288. Patented June 7, 1898.

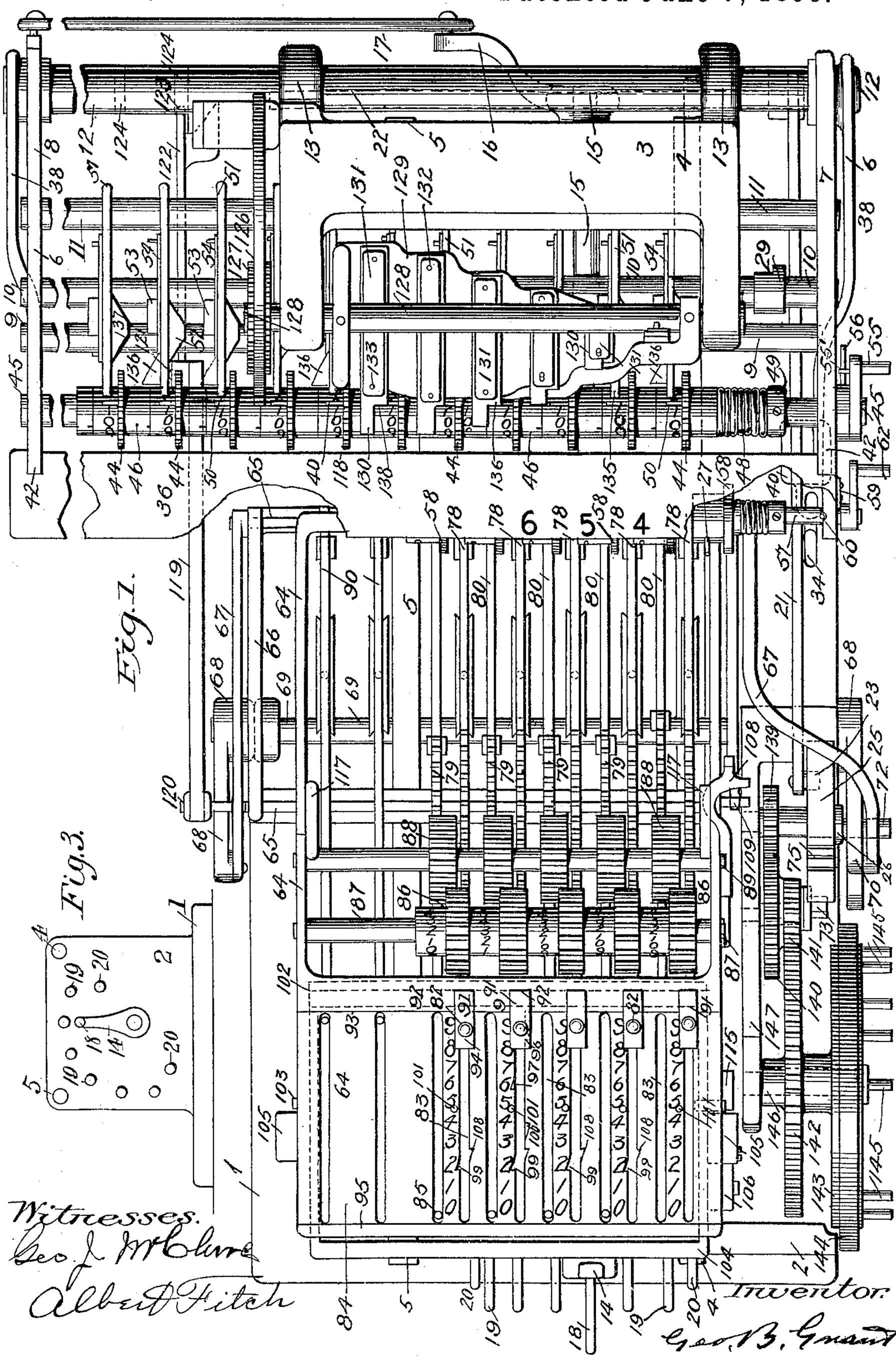

Fig. 1.

Fig. 3.

Witnesses.
Geo. L. McClure
Albert Fitch

Inventor.
Geo. B. Grant

(No Model.) 2 Sheets—Sheet 2.

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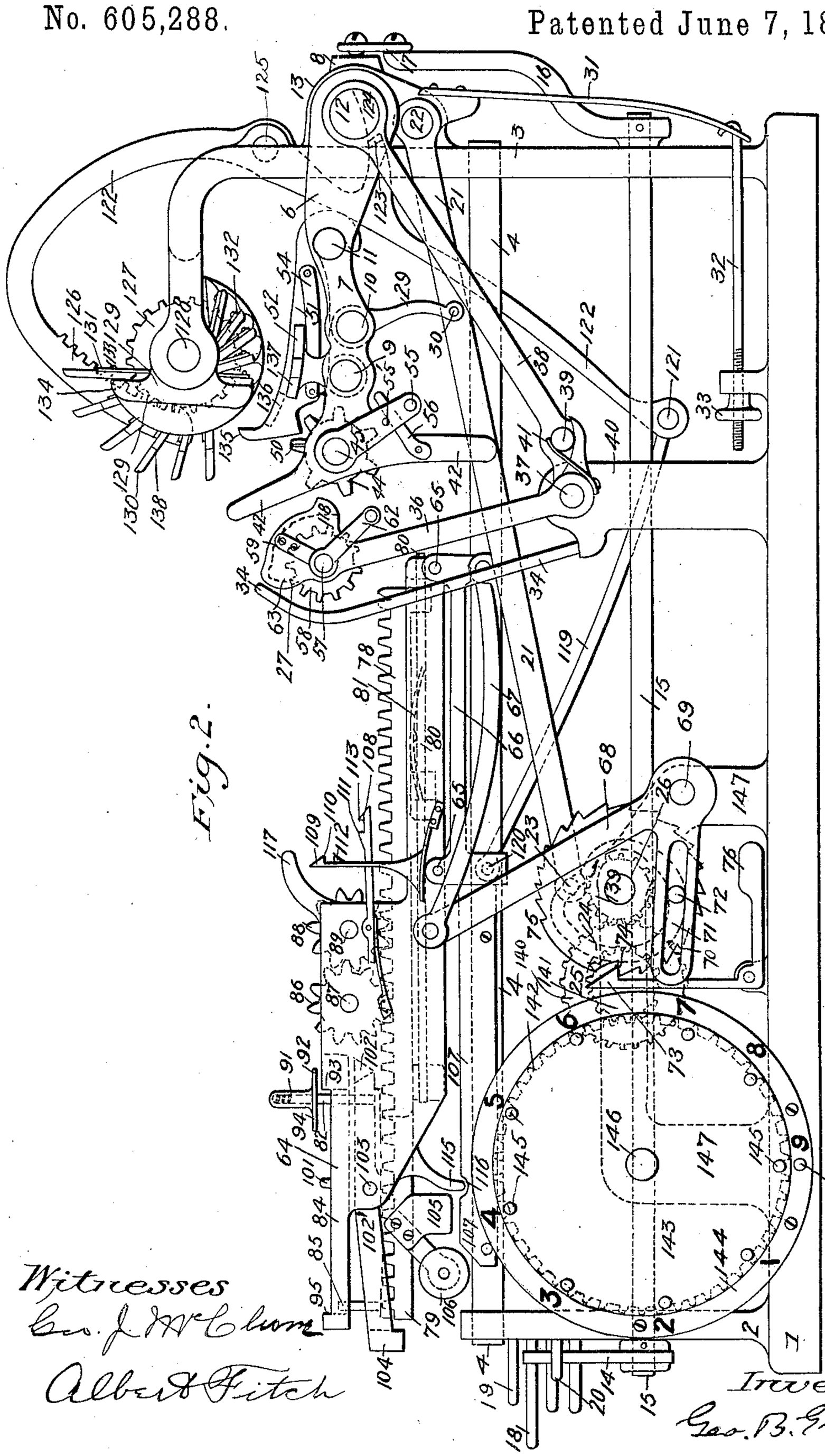

Fig. 2.

Witnesses
Geo. J. McClure
Albert G. Fitch

Inventor.
Geo. B. Grant

UNITED STATES PATENT OFFICE.

GEORGE B. GRANT, OF LEXINGTON, MASSACHUSETTS.

CALCULATING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 605,288, dated June 7, 1898.

Application filed February 20, 1895. Serial No. 539,162. (No model.)

To all whom it may concern:

Be it known that I, GEORGE B. GRANT, of Lexington, in the county of Middlesex and State of Massachusetts, have invented certain Improvements in Calculating-Machines, of which the following is a full specification.

This calculating-machine is for the purpose of solving problems in the four cardinal rules of arithmetic—addition, subtraction, multiplication, and division. It belongs to the class of instruments for that purpose that operate by definite mechanical motions and give complete and definite results as distinguished from the class that act by tabular or logarithmic devices.

The object of this invention is the general improvement and simplification of the mechanism.

In the drawings, Figure 1 is a plan of the whole machine. Fig. 2 is a side elevation of the same. Fig. 3 illustrates a detail of the mechanism.

Figs. 1 and 2 show a machine designed to make use of factors of five places and products or dividends of ten places.

On the base 1 are mounted two end frames 2 and 3, and the two tie-rods 4 and 5 are fixed in the frames. The numeral-carriage 6 consists of two frames 7 and 8, which are joined together by the tie-rods 9, 10, and 11 and the rock-shaft 12. The rock-shaft 12 slides in bearings in lugs 13 on the frame 3, permitting a shifting motion from side to side of the numeral-carriage parallel to that rod through a limited distance—here two and a half inches—and also permitting its oscillation a limited amount—here three-sixteenths of an inch—at the rod 9.

The shifting motion of the numeral-carriage 6 is most conveniently effected by means of the shifting handle 14 at the front end of the machine rather than by reaching over to it and moving it by hand. This handle is on a shaft 15, mounted in bearings in the frames 2 and 3. The shaft 15 carries a lever 16 at the back of the machine, from which lever a link 17 connects with the frame 8 of the numeral-carriage, so that by taking hold of the pin 18 on the handle 14 the numeral-carriage 6 may be set anywhere within the limits of its motion. It is necessary in the operation of the machine to move the numeral-carriage at will to either one of six positions—one at each end of its movement and one at each of four equidistant positions between—and this is accomplished with the assistance of the six pins 19, projecting from the front frame 2 over the handle 14 and close to the pin 18. The hand of the operator easily sets the pin 18 at either one of the pins 19 by touch, and thus places the numeral-carriage 6 in any one of its six positions; but four of these pins 19 are necessary, as the first and last positions of the handle 14 are fixed by its striking the two pins 20.

The oscillation of the numeral-carriage 6 is effected by the cam-lever 21, which is attached to the rock-shaft 22 in the lugs 13 on the frame 3. At its front end it carries a pin 23, working in a cam-groove 24 in the crank-wheel 25, that is rotated on a stud 26 in the post 147 from the base 1 by means of the operating-crank 72. This operating-crank is rotated to the left, and the lever 21 is thus oscillated a distance sufficient to oscillate the numeral-carriage 6 three-sixteenths of an inch at the tie-rod 9. The link 29 fits and slides freely on the tie-rod 10 and is joined to the lever 21 at the pivot-pin 30, being bent to permit adjustment of the numeral-carriage. The spring 31 is attached to the lever 21, and the link 32 draws on it, so as to balance the weight of it and the numeral-carriage, the tension of the spring being regulated by the nut 33.

The position of the numeral-carriage 6 is shown to the eye by the indicator-pin 34, which is set into any fixed part, such as the post 40 in the base 1, the six equidistant positions of the carriage being indicated by the numerals "1," "2," "3," "4," "5," and "6" on the upper surface of the indicator-bar 36, carrying the indicator-wheels 58, as hereinafter described.

The indicator-bar 36 can be oscillated about the tie-rod 37 as a center, and this tie-rod is held in bearings in the arms 38, which are connected by the tie-rod 39 and swing over the ends of the rock-shaft 12 that project from the frames 7 and 8 of the numeral-carriage. The tie-rod 37 slides in the post 40. By this means the indicator-bar 36 is shifted with the numeral-carriage, but does not oscillate with it, and can be given a small oscillation of its

own on the tie-rod 37 as a center, the spring 41 keeping it pressed to the front.

The numeral-carriage can be shifted by hand instead of by the handle 14, and to assist that operation the arms 42 are placed on the frames 7 and 8.

The numeral-wheels 44 (eleven in number and alike) rotate freely on the shaft 45 in bearings in the frames 7 and 8 of the numeral-carriage 6. They are separated by collars 46, which slide freely on the shaft 45, but are normally held from rotating upon it. A coil-spring 48, adjusted by an adjustable collar 49, presses on the end wheel of the series and holds them all under sufficient tension to prevent any accidental rotation. Each numeral-wheel 44 has ten teeth, and one of the teeth carries a carrying-pin 50. The flange of the wheel 44 is marked with the numerals "1," "2," "3," "4," "5," "6," "7," "8," "9," and "0." The tens-carrying levers 51, one to each numeral-wheel 44, oscillate on the tie-rod 11 and are held between the jaws 52 and 53 on the rod 9 by means of the flat friction-spring 54, so that they remain where placed unless purposely moved. The numerals on the flange of the numeral-wheel are so arranged that the figure "0" appears in view from the front of the machine over the indicator-bar 36 when the carry-pin 50 is against the carry-lever 51. The carry-lever 51 will yield and be swung up when the numeral-wheel 44 rotates to the left in the figure, but will not yield when the wheel is rotated backwardly, or to the right, so that if the shaft 45 be rotated once backwardly, or to the right, each wheel upon it will turn with it until the carry-pin 50 upon it strikes the carry-lever 51 and will be held there with the figure "0" appearing over the indicator-bar 36. The shaft 45 is rotated for this purpose by the zero-setting crank 55, which is held by the detent 56 and pin 55′. Therefore to bring all the wheels to read "0," press back the detent and turn the crank once around to the right, as shown in the drawings, until it catches on the detent again.

The indicator-shaft 57 rotates in bearings in the indicator-bar 36, and the six indicator-wheels 58 rotate upon it to count the number of reciprocating motions of the adding-carriage 64, and hence to show the multiplier that has been used or the quotient that has been obtained, said wheels 58 being separated by collars and held by a coil-spring and adjustable collar similar to the numeral-wheels 44 on the shaft 45. This indicator-shaft 57 can be shifted a little in its bearings to the left in Fig. 1 and is pressed toward the rear, or to the right as shown in Fig. 1, by the spring 59 and held from turning by the pin 60, which holds in a notch in the indicator-bar 36. The indicator-shaft can be rotated by the indicator zero-setting crank 62. Each indicator-wheel 58 has ten teeth, and on the flange of each are two rows of numerals, a row on the right printed in black and a row on the left printed in red, or the two rows may be distinguished by difference in size. The two rows of numerals are arranged in reverse order, the "0" of each row being together, the right-hand row increasing as the indicator-wheel is rotated to the left and the left-hand row increasing as the wheel is rotated to the right. The right-hand row indicates positive results, or results in addition and multiplication, and the left-hand row indicates negative results, or results in subtraction and division. On the flange of each wheel 58 is a pin 27, and on the indicator-bar 36 is a point 63. Ordinarily the pin and point pass each other; but when the shaft is pressed inward and rotated by the crank-handle 62 they will strike each other and the wheels will be brought to read "0." Therefore to bring all the indicator-wheels to read "0" press the shaft endwise and turn the crank once to the right.

The adding-carriage 64 is a frame that has a lateral motion through a small distance—here one-quarter of an inch—on guide-rods 65, held in a frame 66, that slides on the guide-rods 4 and 5 through a limited distance, here two and three-quarters inches. The frame 66 receives a regular backward-and-forward reciprocating motion by means of the links 67, one on each side, attached to arms 68, that are on the rock-shaft 69. The rock-shaft 69 is oscillated by the lever 70, having a slot 71, in which works the crank-pin 72 on the crank-wheel 25. Therefore when the crank-wheel 25 is rotated to the left the frame 66 and adding-carriage 64 are reciprocated, being thrown backward a definite distance and returned to their original position. The motion backward is quicker than the return in the proportion of about one to two, for the reason that the operation of carriage of tens performed during the return should be performed more slowly than the operation of addition carried on during the motion toward the rear. By reason of the structure last described the adding-carriage is quickly thrown back to the rear, brought to a gradual stop, then returned to the front slowly, and gradually stopped in the setting position, as shown by the figures.

The catch 73 holds on the tooth 74 or upon the teeth 75 on the crank-wheel 25, so that backward or right-hand motion of the crank-wheel is prevented except when the catch 73 is within a certain distance of the tooth 74, and left-hand motion is always permitted. It is desirable that the position at which the crank 72 is stopped should not be too closely fixed; but backward motion will be injurious except near that stopping position. Therefore the crank is left free for a certain distance over which backward motion is not injurious. The weighted arm 76 keeps the catch 73 in place, being preferable to a spring, for the latter would snap the catch on every tooth and be noisy, while the weight, having considerable momentum, will not hold the catch

down at the regular speed of the wheel, while it will take hold promptly when the wheel is stopped.

The cam-groove 24 is so shaped and placed with reference to the crank-pin 72 that the numeral-carriage 6 is held down until its motion to the rear is completed. Then when the adding-carriage has been brought to a stop the numeral-carriage is suddenly raised (the cam being assisted by the spring 31) and held up until the adding-carriage is nearly back to the left, when the numeral-carriage commences to drop and is half dropped, in the position of the figures of the drawings. The links 67 are bent so as to provide a means of readily adjusting the position of the adding-carriage by varying the amount of the bend.

The adding-carriage 64 carries ten adding-racks—five positive racks 78, a half-inch apart, and five negative racks 79, placed half-way between the positive ones. Each rack slides on a guide-rod 80, held by the carriage-frame at its ends, and a friction-spring 81 beneath each rack, pressing on the rod and rack, holds the rack from accidental motion. The front end of each positive rack has a setting-pin 82 running in and projecting up from a slot 83 in the setting-plate 84 and serving as a handle for adjusting the rack. The similar pins 85 on the negative racks 79 go into the slots far enough to be guided by them, but do not project, or the pins on the negative racks may project, while those on the positive racks do not. The positive rack 78 may be adjusted in ten different positions by the scale of numerals "0," "1," "2," "3," "4," "5," "6," "7," "8," and "9" on the setting-plate by the side of the slot.

The gears 86 rotate on the shaft 87, fixed at its ends in the frame of the adding-carriage 64, and mesh with the positive racks 78, the gears 88 run on the fixed shaft 89 and mesh with the negative racks 79, while all the gears 86 and 88 are wider than the racks and mesh together in the spaces between the racks. Therefore when a positive rack is adjusted by moving its pin 82 in a slot 83 it drives a gear 86, which in turn drives a gear 88, and that in turn drives a negative rack 79 in a direction opposite to the motion of the positive rack, but at the same speed. This device is so arranged that when the positive pin 82 is set to any numeral on the plate 84 beside the slot the corresponding negative pin 85 is set to the arithmetical complement of that numeral. The units negative rack—the one to the right in the machine—is set to the complement of ten and the others to the complement of nine.

Beyond the five pairs of adjustable racks, or to their left in the machine, are two leading racks 90, which are in the negative positions beyond the negative racks, a half-inch and a whole inch beyond the last one; but they have no corresponding positive racks and no scale of setting-numerals, but each rack has a pin.

The flange of the gear 86 is provided with the ten numerals as a setting-index, and they are so placed that the one seen over the end of the setting-plate 84 is the same as the one the corresponding pin 82 is set to at the slot. The pins are most easily set in position by means of the numerals at the sides of the slots; but the number set up and represented by the pins 82 is most easily read by these setting-index wheels 86.

The pins 82 may be adjusted by eye to the numerals; but it is more convenient when the necessary personal skill is acquired to set them by touch. To set a pin on "9," it is moved to the rear end of the slot; to set it on "0," it is moved to the front end of the slot; to set it on "8," the spring-cap 91 is pressed down, so that the pin 92 on it will strike the shoulder 93 on the setting-plate 84; to set it on "1," the spring-cap is pressed down and the pin 82 moved until the pin 94 on the cap 91 strikes the shoulder 95 on the setting-plate 84; to set it on "7," it is thrown back to the end of the slot and then brought forward and pressed to the right until it is stopped by the notch 96; to set it on "6," it is pressed to the left and stopped by the notch 97; to set it on "2," it is thrown into the notch 99; to set it on "4," it is first set on "2" and then pressed to the right and moved back into the notch 100; to set it on "5," it is moved forward and the spring-cap 91 pressed down to strike on the small pin 101, set close to the slot; to set it on "3," the spring-cap 91 is pressed down and the pin thrown back until the pin 92 strikes the pin 101. Thus the setting-pin 82 can be quickly set at any numeral by touch and without the aid of the eye.

The locking-bar 102 on the swinging locking-lever 102′ extends across the series of adding-racks 78 and 79 and is pivoted on pins 103 in the frame of the adding-carriage 64, and when pressed down into the teeth of the racks will lock all of them in the positions they are in, and by reason of the shape of the bar will correct any error of less than half a tooth in their positions. The weights 104 and 105 on the bar 102 hold the locking-bar up out of the way of the racks when the adding-carriage is in the position of the figures of the drawings, the position for setting the adding-pins in position; but as soon as the adding-carriage moves backward the roller 106 on the locking-bar will rise up on the end of the guide 107, attached to the rod 4, and all the racks will be locked and held until the adding-carriage returns to the position of the figures. The heavy checking-weight 105, being practically under the pivot-pin 103, will by its momentum oppose the momentum of the adding-rack when the adding-carriage is suddenly stopped in the position of the figures and hold the locking-bar 102 down against the effort of the rack to lift it.

The indicator-pawl 108 operates the indicator-wheels 58, and the spring-detent 109 holds them from motion in the wrong direction.

The adding-carriage 64 being set in the positive position, to the right in Fig. 1, the point 111 of the pawl 108 will strike one of the indicator-wheels 58 and will rotate it one tooth, while the point 110 of the detent 109 at the same time strikes the same indicator-wheel and holds it from moving backward as the pawl 108 returns. If the adding-carriage is in the negative position, to the left in Fig. 1, the hook-point 113 of the spring-pawl 108 will pass under the indicator-wheel and at the same time the point 112 of the spring-detent 109 will strike the wheel and prevent it from moving. Now as the adding-carriage returns the hook-point 113 will rotate the indicator-wheel to the right one tooth. The detent 109, being hung on a pin and held by a spring, is so placed that it will strike the indicator-wheel it acts upon before the pawl 108 strikes it and will remain in contact with that wheel until the pawl leaves it on the return of the carriage. In multiplication the indicator-wheels are brought to read "0" at the start and are rotated each one the number of teeth of the number of turns given the operating-crank and to the left, so that their readings at the right-hand rows of numerals show the multiplier. If during the operation the operating-crank 72 is rotated with the adding-carriage in the negative position, the indicator wheels then in action will be turned backward and the number of negative rotations taken from the number of positive rotations indicated. In division, the indicator-wheels being brought to read "0" at the start, the crank-wheel 25 is rotated with the adding-carriage in the negative position and the number of rotations given to it as shown by the left-hand or negative numerals on the indicator-wheels. If the crank is then rotated with the carriage in the positive position, the number of positive rotations will be taken from the number of negative rotations shown by the indicator-wheels. When the adding-carriage 64 reaches the rear end of its motion, the points 117 will strike the indicator-bar 36 and will force its edge 118 between the teeth of all the numeral-wheels 44 and correct any small error in their position, at the same time locking them all and preventing any accidental rotation due to momentum.

The arm 115, attached to the adding-carriage 64, will pass through the notch 116 in the guide 107 when the adding-carriage is adjusted laterally to either the positive or negative position, and as it can pass the guide only at that notch the adding-carriage cannot be adjusted when it is in any other position.

The lever 122 oscillates on a stud 125, fixed in the frame 3, and is oscillated by the link 119, joined to it at the pivot-pin 121 and attached to the adding-carriage at the pivot-pin 120. The internal segment-gear 126 on the lever 122 meshes with the gear 127 on the carry-shaft 128, so that the carry-shaft is oscillated by the reciprocating motion of the adding-carriage through a definite amount, here about half a rotation in bearings in the frame 3. The six carry-teeth 130 are pivoted on pins 132 to swing laterally each on a seat on the piece 129, that is attached to the carry-shaft 128. The seats on which the carry-teeth are placed are arranged helically about the carry-shaft 128. The carrying-lever 51 is provided with a horn 135 and with a wing 136 on its side, and the jaw 52, that supports the carrying-lever 51 on one side, is provided with an incline 137. The carry-tooth 130 has a shoulder 138 cut in its side and is pressed upon by a friction-spring 131, that is held by the pivot-pin 132 and by the pin 133 on the carry-tooth, the friction-spring passing under the carry-shaft 128 and bearing on it. The rearward projection 123 on the lever 122 will pass into one of the six notches 124 cut in the rock-shaft 12 and thus hold the numeral-carriage in any one of its six positions, so that it can be moved only when the adding-carriage 64 is forward in the position of the figure.

The speed-wheel 143, so called because by reason of its size a slight rotation of it will impart an increased rotation to the gear it drives, is on the shaft 146, that rotates in bearings in a post 147, and carries at its farther end a gear 142. This gear, by means of a pinion 141, a gear 140, and a pinion 139 on the boss of the crank-wheel 25, rotates the crank-wheel nine times to one turn of the speed-wheel. The speed-wheel is provided with nine handles 145 and is surrounded by a fixed dial 144, having the numerals "1," "2," "3," "4," "5," "6," "7," "8," and "9" equally spaced around it. The speed-wheel is to assist in turning the cam-wheel 25 any given number of turns at a rapid rate and without counting the turns. To turn the crank-wheel seven times, for example, the handle 145 that happens to be at the figure "7" on the dial is brought around, rotating the speed-wheel to the left to the pin 148 at the point "9" on the dial. It is not necessary that the ratio of the train of gearing between speed-wheel and crank-wheel shall be nine to one, although that is the most convenient ratio, for any other ratio will answer the purpose, and a ratio of five to one would answer the general purpose very well. Neither is the dial essential, for an expert operator readily selects the desired handle by its position.

The operation of the machine is as follows: The indicator and numeral wheels must be set to zero before every operation. The numeral-wheels 44 are set to zero by pressing the detent 56 and turning the zero-setting crank 55 around once, when it will catch again on the detent and the wheels will all read "0," as observed from the front over the top of the indicator-bar 36. The index-wheels 58 are set to zero by pressing the shaft 57 over and turning the crank 62 once around until the shaft slips back and is again held. To set up any number on the adding-racks, I set the pins 82 to the figures of that number by the

side of the slots 83 in the setting-plates, or I can set them by touch, as before described in detail. The setting register-wheels 86 will show the number set up. All five pins 82 must be set up either to some significant figure or to zero. The two leader-racks 90 must be set fully back with their pins opposite the figure "9" on the slots. To add the number thus set up by the pins 82, the handle 145 that is opposite the figure "1" on the dial 144 is quickly turned to the pin 148 on the dial, and the detailed operation of the mechanism is as follows: The speed-wheel 143 will be rotated one-ninth of a rotation, the crank-wheel 25 will be rotated once, and the adding-carriage 64 will be reciprocated a definite distance from and returned to the position shown by the figures. As it moves back each positive rack 78 will strike and mesh with the numeral-wheel 44 that is placed opposite it and will rotate it a definite number of teeth, depending on the setting of the pin 82. If the pin 82 is set to zero, the rack 78 will be so placed that its first tooth will just reach the opposite wheel 44 and will not turn it. If the pin 82 be then set at "1," the first tooth of the rack will strike the wheel 44 one tooth sooner than before and will rotate it one tooth, causing one to be added to whatever numeral was before shown by it. Similarly each rack will rotate the corresponding numeral-wheel according to its setting. As the adding-carriage 64 reaches the end of its travel toward the rear it will gradually come to a stop and as it starts to return the numeral-carriage will suddenly rise and lift all the numeral-wheels off the racks, so that the return motion does not affect them. During the outward or rearward motion of the adding-racks one or more of the wheels 44 will probably have been rotated past its figure "9," so that the carriage of a unit to the next wheel is necessary. As the wheel 44 passes from "9" to "0" the carry-pin 50 will throw up the carry-lever 51, and the friction-spring 54 upon it will hold it up. All the carry-teeth 130 will be behind, to the right of, the carry-levers 51 at the end of the motion of the adding-carriage 64 to the rear and will be rotated forward as the adding-carriage is moved forward. The carry-tooth 130 that is between the wheel 44 that is opposite the units or right-hand adding racks 78 and the next wheel beyond will first pass the carry-lever 51, and if that lever has been thrown up, indicating a carriage of tens to be made, it will strike the wing 136 of the lever 51 and will swing on its pivot-pin 132 and, passing between the teeth of the next wheel beyond it to the left, will rotate that wheel one tooth. That carry-tooth having passed its carry-lever, the next carry-tooth beyond or to the left comes into action and operates in the same manner on the third wheel, and so on to the sixth carry-tooth, the helical arrangement being to provide for cases where the carriage of a unit to any wheel which already reads "9" requires the unit to be carried to the next wheel again. If five of the wheels be set on "9" and one be added to the first one, the carry-teeth will act consecutively and leave the carried unit to the sixth wheel. During the next motion of the adding-carriage 64 to the rear the set of carry-teeth 130 will be rotated back, as before; but as the wheels are then held down out of their reach they will not operate on them. Each carry-tooth will strike the incline 137 and be returned to its starting position. If when the carry-teeth are moving forward the carry-lever has not been thrown up, the wing on the carry-lever will pass under the shoulder 138 on the carry-tooth and that tooth will not be thrown over between the teeth of the next wheel. Immediately after the carry-tooth has been swung over between the teeth of the next wheel the edge 134 of the piece 129 will strike the horn 135 and throw the lever 51 back into its working position, ready for another operation. Therefore the setting of a number of the setting-pins 82 and the moving of the pin 145 at "1" to the pin 148 at "0" when the adding-carriage 64 is in its positive position will add the number set up by the pins 82 to the number then standing on the numeral-wheels 44. The indicator-wheel 58 will be rotated one tooth in the manner before described and will read "1" at the right-hand figure of the indicator-wheel that is opposite the indicator-pawl 108.

To subtract the number set up by the pins, the operation is precisely as described for addition, but with the adding-carriage set over into its negative position, so that the number added is the complement of the number set up. As the two leader-racks 90 are set on "9," there will be seven numeral-wheels 44 acted on, and as there are but six carry-teeth 130 there is none to act on the eighth wheel, and the tens will not be carried to that wheel, so that the subtraction is complete. The indicator-wheel 58 will be acted on as before, but will be rotated in the reverse direction, so as to cancel the indicator-number shown by the addition, or if there has been no previous addition it will show "1" by the left-hand or negative numerals. If a number is set up by the pins and one positive motion made and then one negative motion made, the two motions will balance and the numeral-wheels and indicator-wheels be left as they were before either motion, the subtraction being exact. This operation of addition or that of subtraction can take place with the numeral-carriage in either one of its six positions, so that the number can be added to or subtracted from the number on the numeral-wheels in six different decimal positions at will.

Multiplication is simply repeated addition. The number is set up as before for addition; but the pin 145 that is opposite a figure of the multiplier is to be brought around to the stopping-pin 148. Thus if the pin that is opposite "7" on the dial 144 is brought to the stopping-pin 148 the number set up by the

pins 82 will be added seven times in succession to the number already on the numeral-wheels 44, and the indicator-wheel 58 will show "7." To multiply by a multiplier having two or more figures, each figure is used by itself and in its proper decimal place. Thus to multiply the multiplicand by "147" the multiplier "7" is first used, then the numeral-carriage 6 is shifted one decimal place to the right in Fig. 1, then the multiplier "4" is used, then the numeral-carriage shifted one more place to the right, and then the multiplier "1" is used, the numeral-wheels 44 showing the product and the indicator-wheels 58 showing the multiplier. If during the operation of multiplication a mistake is made and the wrong multiplier used, the indicator 58 will show the mistake, and it may be corrected by setting the adding-carriage 64 to the negative position and using the multiplier that is necessary to bring the indicator to the right number.

Division is repeated subtraction. The dividend is set up on the numeral-wheels 44, preferably by first setting it by the setting-pins 82 and transferring to the numeral-wheels, and then, with the adding-carriage in the negative position, the speed-wheel 143 is rotated, or preferably the crank-wheel 25 is rotated, directly and slowly by the crank 72 until it is seen that the divisor has been subtracted from the opposite dividend so many times that the latter is smaller than it, when the numeral-carriage 6 is shifted one decimal place to the left and the operation repeated. The quotient will be shown by the indicator-wheels 58 reading the left-hand or negative figures. The better way is to judge the quotient-figure and then use that number on the speed-wheel. An easier method is to turn without watching or judging until it is seen that the numeral-wheel 44 opposite the farther leader-rack 90 reads "9." Then one positive turn will correct the error and show the true quotient-figure. It will be seen that if the farther leader-rack 90 be set at "0" instead of at "9" the quotient-figure will be counted up on the numeral-wheel 44 that is opposite that rack and that the increasing quotient will take the place of the decreasing dividend. As the indicator 58 is not essential to multiplication, and as the quotient in division may be thus counted on the numeral-wheels, the indicator-wheels may be dispensed with altogether. Again, the negative racks 79 may be dispensed with, for the divisor may be set up by setting the pins 82 to the complement of the divisor, and that operation will be assisted by a second set of numerals by the side of each slot 83, each numeral being the complement of the numeral of the regular set. It is also seen that the speed-wheel 143 is merely an assistance, for the machine may be operated by the crank-pin 72 alone. Again, the numeral-carriage 6 may be shifted from side to side of the machine by taking hold of it with the hand and moving it, thus dispensing with the handle 14 and special shifting apparatus. Further, the cap 91 is not a necessity, for the pins 82 may be set to the setting-numerals by sight alone. The spring 31 and adjusting device is merely an accessory that may be dispensed with. By leaving off all of these accessories a very much simpler machine may be made, and it will be reasonably efficient and have everything that is necessary to perform the desired operations.

The principle of the mechanism is not confined to the precise forms adopted to carry it out, but may be nearly as well applied in other ways. I prefer to oscillate the set of numeral-wheels vertically; but they may be moved laterally to separate them from the racks. I prefer to operate the numeral-wheels, but could oscillate the adding-carriage and racks instead. I prefer to add while the carriage is going backward, but could start the carriage at the rear end of its stroke and add while moving it forward. The carry-tooth return-inclines are placed on the numeral-carriage; but they can easily be placed on the main frame of the machine. The carry-shaft is made to oscillate because that motion is the easiest to obtain; but it could receive a continuous rotary motion with the same result. I prefer to use adding-gears in the form of straight racks; but circular segments could easily be made to serve instead. I prefer to reciprocate the adding-gears; but if they were of the form of circular segments they could receive a continuous rotary motion. All previous calculating-machines known to me have depended for a variable addition either on an adding-wheel with a variable number of loose and adjustable teeth on a set of several separate adding-gears with varying numbers of teeth or on a variable motion of an adding-gear with an invariable number of teeth. The leading idea of the adding motion of this machine is that there are a set of adding-gears which are adjustable in position with respect to each other and are locked in adjusted position and then moved as a whole and all at the same speed with respect to a set of numeral-wheels, the numeral-wheels being put into meshing position with the adding-wheels at a fixed point of the motion and put out of that position at another fixed point, and there are many ways in which the details of this mechanism may be changed without altering this principle in the least.

I claim—

1. The combination in a calculating-machine, of a series of toothed numeral-wheels, a series of corresponding toothed adding-gears independently adjustable relatively to their corresponding numeral-wheels, and mechanism to move the series of adding-gears in unison throughout a fixed distance, whereby each numeral-wheel will be operated by its adding-gear an amount determined by the adjustment of the latter, substantially as described.

2. The combination in a calculating-machine, of a series of toothed numeral-wheels, a series of corresponding toothed adding-gears independently adjustable relatively to their corresponding numeral-wheels, a locking device to lock said adding-gears in adjusted position, and mechanism to move the series of adding-gears in unison throughout a fixed distance, the locking device retaining said gears in fixed position relatively to each other during such movement, substantially as described.

3. The combination in a calculating-machine of a series of toothed numeral-wheels, a corresponding series of adjustable toothed adding-gears, mechanism to move the series of adding-gears as a whole through a limited fixed distance with respect to the series of numeral-wheels from an original position, and mechanism to disengage the gears and the numeral-wheels at a definite point of the movement and to maintain them disengaged during the return of the gears to their original position, substantially as described.

4. The combination in a calculating-machine, of a series of toothed numeral-wheels, a series of corresponding toothed adding-gears independently adjustable relative to their corresponding numeral-wheels, means to reciprocate the series of adding-gears in unison through a fixed distance, whereby each numeral-wheel will be operated in accordance with the adjusted position of its corresponding gear, mechanism to disengage the wheels and gears at a definite point in the movement, and to maintain them disengaged during the return of the gears to original position, and connections between the disengaging mechanism and the means for reciprocating the series of gears to automatically operate said mechanism, substantially as described.

5. The combination in a calculating-machine of a series of toothed numeral-wheels, a corresponding series of adjustable toothed adding-gears, and mechanism to give the series of adding-gears a reciprocating motion as a whole through a limited fixed distance with respect to the series of numeral-wheels, whereby each adding-gear acts upon the corresponding numeral-wheels and returns to its original position, substantially as described.

6. The combination in a calculating-machine, of a series of adding-gears, a series of numeral-wheels to be engaged and driven by the adding-gears, actuating mechanism to move the series of adding-gears in unison throughout the whole of a fixed distance with respect to the numeral-wheels, and disengaging means controlled by said actuating mechanism to disengage the wheels and gears when the latter have reached and are stationary at the end of their operative stroke, substantially as described.

7. The combination in a calculating-machine, of a series of numeral-wheels, a series of independently-adjustable adding-gears, means to lock them in adjusted position, and a crank and connecting mechanism to give the series of locked adding-gears a reciprocating motion in unison throughout a fixed distance with respect to the series of numeral-wheels, and mechanism to disengage the wheels and gears at the end of the reciprocation, whereby the adding-gears act upon the numeral-wheels, are disengaged therefrom while stationary, and finally are returned to their original position, substantially as described.

8. The combination in a calculating-machine, of a series of numeral-wheels, a series of independently-adjustable straight-adding rack-gears, means to lock said gears in adjusted position, and mechanism to give one of the series a reciprocating motion in unison throughout a fixed distance with respect to the other series, substantially as described.

9. The combination in a calculating-machine, of a series of toothed numeral-wheels, a series of corresponding toothed adding-gears independently adjustable relatively to their numeral-wheels, means to lock said gears in adjusted position, and mechanism to move one of said series through a fixed distance relatively to and to coöperate with the other series, whereby each of the numeral-wheels will be operated by and to an extent depending upon the adjustment of its corresponding adding-gear, substantially as described.

10. The combination in a calculating-machine of a series of numeral-wheels, a sliding and oscillating numeral-carriage, an adding-carriage, a crank, and a cam and connecting mechanism, whereby the adding-carriage is given a reciprocating motion, and the numeral-carriage an oscillating motion, substantially as described.

11. The combination in a calculating-machine of a series of numeral-wheels, two series of adding devices, each member of one series being geared to the corresponding member of the other series, in pairs, and being adjustable in position with respect to the numeral-wheels, whereby the adjustable member when being adjusted moves the other member in the contrary direction, substantially as described.

12. The combination in a calculating-machine of a series of numeral-wheels, two series of adding devices and connecting mechanism between the two series, whereby when one series is adjusted to represent any number the other is automatically adjusted to represent the arithmetical complement of that number, substantially as described.

13. The combination in a calculating-machine of a series of numeral-wheels, a series of positive adding-gears and a series of negative adding-gears, and a train of gears connecting each positive adding-gear with a corresponding negative adding-gear, whereby when either positive adding-gear is adjusted the corresponding negative adding-gear is adjusted a like distance in the opposite di-

rection with respect to the numeral-wheels, substantially as described.

14. The combination in a calculating-machine of the adding-carriage carrying a double series of positive and negative adding devices, the series of numeral-wheels and mechanism to shift the adding-carriage with respect to the numeral-carriage to bring either series of adding devices into working position, substantially as described.

15. The combination in a calculating-machine of a positive rack and a negative rack each provided with teeth on its edge, a gear meshing with the positive rack, and a gear meshing with that gear and in engagement with the teeth of the negative rack, whereby the two racks are simultaneously moved in opposite directions, substantially as described.

16. The combination in a calculating-machine of the indicator-wheels 58 on the laterally-adjustable indicator-bar 36, the fixed post 40 holding the indicator-bar, the oscillating numeral-carriage 6 and means for laterally adjusting it, and the arms 38 attached to the numeral-carriage and to the indicator-bar, substantially as described.

17. The combination in a calculating-machine of the reciprocating adding-carriage 64, the link 119, the lever 122, the gear 126 attached to the lever 122, the carry-shaft 128 and the gear 127 on the carry-shaft and running in the gear 126, whereby the carry-shaft is oscillated in unison with the reciprocation of the adding-carriage, substantially as described.

18. The combination in a calculating-machine of the cam-wheel 25, the frame 3 the lever 21, pivoted upon the frame 3, the laterally-adjustable numeral-carriage 6, the guide-rod 10 upon the numeral-carriage and the link 29 sliding upon the guide-rod and attached to the lever, substantially as described.

19. The combination in a calculating-machine of the frame 3, the lever 21 pivoted upon the frame 3, mechanism to oscillate the lever the numeral-carriage 6, and means for laterally adjusting it with respect to the lever, substantially as described.

20. The combination in a calculating-machine of the driving-shaft 26, the ratchet-wheel 25 having a single tooth 74 and one or more holding-teeth at a distance from the tooth 74, and the detent 73, whereby reverse motion of the driving-shaft is permitted only near the single tooth, substantially as described.

21. The combination in a calculating-machine, of a toothed adding-gear, and a setting-pin attached thereto and adjustable in a setting-slot, the opposite walls of the slot being notched in a predetermined manner at points between the ends of the slot, the notches to be entered by the setting-pin, substantially as described.

22. The combination in a calculating-machine of the setting-pin 82, the setting-slot 83, the pin 92, and the shoulder 93, substantially as described.

23. The combination in a calculating-machine, of a series of numeral-wheels, a sliding and oscillating numeral-carriage, an adding-carriage, and means to reciprocate the adding-carriage and to oscillate the numeral-carriage, substantially as described.

24. The combination in a calculating-machine of the adding-gear 78, the setting-pin 82, setting-plate 84 having a slot 83, and setting index-wheel 86 geared to the adding-gear, whereby the position of the pin in the slot is shown upon the index-wheel, substantially as described.

25. The combination in a calculating-machine of an adding-carriage, a series of toothed adding-gears carried by the carriage and separately adjustable in position upon it, a correcting-bar and mechanism forcing it into the teeth of the adding-gears, whereby the correcting-bar corrects any error of less than half a tooth in the position of the adding-gears, substantially as described.

26. The combination in a calculating-machine of an adding-carriage means for reciprocating the adding-carriage, a toothed adding-gear carried by the adding-carriage, a device locking the adding-gear to the adding-carriage and releasable by the momentum of the adding-gear, and a checking-weight operating upon the locking device and opposing its momentum to that of the adding-gear, whereby the effort of the adding-gear to move itself in the adding-carriage by its own momentum is overcome by the momentum of the locking device, substantially as described.

27. The combination in a calculating-machine of the toothed adding-gear 78, the locking-bar 102, and the momentum-check 105, substantially as described.

28. The combination in a calculating-machine of an adding-carriage, a series of toothed adding-gears carried by the adding-carriage and separately adjustable in position upon it, mechanism to move the adding-carriage from a fixed position and return it to that position again, and devices locking all the toothed adding-gears in their adjusted positions when the adding-carriage moves from the said fixed position and releasing them when it returns to that position again, substantially as described.

29. The combination in a calculating-machine of an adding-carriage, a series of toothed gears carried by the carriage and separately adjustable in position upon it, mechanism to move the adding-carriage from a fixed position and to return it to that position again, a locking-bar engaging in the teeth of all the adding-gears, and devices engaging the locking-bar and adding-gears when the carriage moves from the said fixed position and releasing them when it returns to that position, substantially as described.

30. The combination in a calculating-ma-

chine of the reciprocating adding-carriage 64, the toothed adding-gears 78, the locking V-bar 102, the swinging locking-lever 102′, and the locking-guide 107, substantially as described.

31. The combination in a calculating-machine of the reciprocating adding-carriage 64, the toothed adding-gears 78, the locking V-bar 102, the swinging locking-lever 102′, the locking-guide 107, and the releasing-weight 104, substantially as described.

32. The combination in a calculating-machine of the shifting handle 14, the numeral-carriage 6, mechanism connecting the shifting handle with the numeral-carriage, and the indicating-pins 19 placed close to the path of motion of the shifting handle 14, whereby the position of the numeral-carriage is indicated by the position of the shifting handle with respect to the pins, substantially as described.

33. The combination in a calculating-machine of the shifting handle 14 at the front of the machine, the lever 16 at the back of the machine, the rock-shaft 15 connecting the shifting handle and the lever, the numeral-carriage 6, and the link 17 connecting the lever and the numeral-carriage, substantially as described.

34. The combination in a calculating-machine of an operating-shaft one rotation of which causes the machine to perform one operation of addition, a speed-wheel having several equidistant driving-handles, a train of gears connecting the speed-wheel and operating-shaft and having a velocity ratio equal to the number of said driving-handles, whereby the rotation of the speed-wheel by moving any one of the several driving-handles from its position to a fixed position causes the machine to perform a definite number of operations of addition, substantially as described.

35. The combination in a calculating-machine of an operating-shaft one rotation of which causes the machine to perform one operation of addition, a speed-wheel having nine driving-handles, a train of gears connecting the speed-wheel and the operating-shaft and having a velocity ratio of nine to one, whereby the rotation of the speed-wheel by moving any handle from its position to a fixed position causes the machine to perform from one to nine operations of addition according to the handle moved, substantially as described.

36. The combination in a calculating-machine of a speed-wheel having several handles, and a fixed and figured dial indicating the position of the handles, substantially as described.

37. The combination in a calculating-machine of a series of numeral-wheels, each numeral-wheel having a carrying-pin upon it, a series of carrying-levers, a wing upon the side of each carrying-lever, a series of helically-arranged carrying-teeth, a series of carrying-lever returners, and a series of carrying-tooth returners, whereby when a carrying-lever has been moved by a carrying-pin a carrying-tooth will be thrown between the teeth of the next numeral-wheel for the purpose of carrying the tens, substantially as described.

38. The combination in a calculating-machine of a series of numeral-wheels, a series of oscillating carrying-teeth and mechanism for oscillating the two series with respect to each other, whereby the numeral-wheels are in working position with the carrying-teeth during the oscillation of the latter in one direction, but are all removed from working position during their return oscillation, substantially as described.

39. The combination in a calculating-machine of a series of reciprocating adding-gears, a series of oscillating numeral-wheels, and a series of oscillating carry-teeth, whereby the numeral-wheels are in working position with the adding-gears during their motion in one direction and are put into working position with the carry-teeth during the return motion of the said gears, substantially as described.

40. The combination in a calculating-machine of a series of adding-gears and an adding-carriage, means for adjusting and means for locking the adding-gears in adjusted position in the adding-carriage, a series of numeral-wheels, mechanism to move the adding-carriage with respect to the series of numeral-wheels, and mechanism to move the series of numeral-wheels into position to mesh with the series of adding-gears and to remove them from that position at fixed points in the motion of the adding-carriage, whereby the adding-gears and numeral-wheels are in meshing position during a limited and fixed part of the motion of the adding-carriage, and the adding-rack is in actual mesh with the numeral-wheel during an adjusted and limited part of that motion, substantially as described.

41. The combination in a calculating-machine of a series of adding-racks and an adding-carriage, means for adjusting and means for locking the adding-gears in adjusted position in the adding-carriage, a series of numeral-wheels, mechanism to give the adding-carriage a reciprocating motion with respect to the series of numeral-wheels through a limited and fixed distance, and mechanism to move the series of numeral-wheels into position to mesh with the adding-racks and to remove them from that position at fixed points in the motion of the adding-carriage whereby the adding-gears and numeral-wheels are in meshing position during a limited and fixed part of the reciprocating motion of the adding-carriage, and the adding-rack is in actual mesh with the numeral-wheel during an adjustable and limited portion of that motion, substantially as described.

42. The combination in a calculating-machine of the shaft 45 rotatable in bearings in the numeral-carriage 6, the zero-setting crank 55 and the detent 56 by which the shaft and crank are fixed to the numeral-carriage, the series of numeral-wheels 44 on the shaft 45, the carrying-pins 50 on the numeral-wheels,

and the series of carrying-levers 51 yielding to the motion of the numeral-wheels upon the shaft in one direction and holding against their motion in the other direction, whereby the carrying-levers strike the carrying-pins and hold the numeral-wheels when the shaft is turned by means of the zero-setting crank, and the wheels are set to zero by means of the same carrying-levers and carrying-pins that act in the operation of the carriage of tens, substantially as described.

43. The combination in a calculating-machine of an oscillating numeral-carriage laterally adjustable in guides, an index-bar separate from the numeral-carriage and laterally adjustable in guides, and mechanism connecting the numeral-carriage and the index-bar, whereby the numeral-carriage and the index-bar receive a simultaneous lateral adjustment, substantially as described.

GEO. B. GRANT.

Witnesses:
VESTA C. BAYLEY,
ROBERT C. MOAKLEY.