2 Sheets—Sheet 1:

G. B. GRANT.

CALCULATING MACHINE.

No. 368,528. Patented Aug. 16, 1887.

Fig. 1.

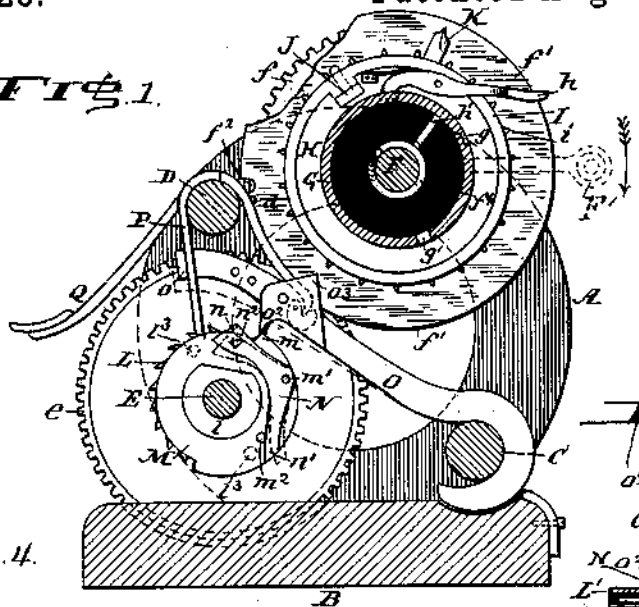


Fig. 3.

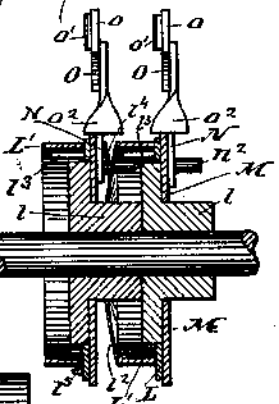


Fig. 4.

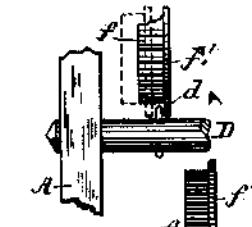
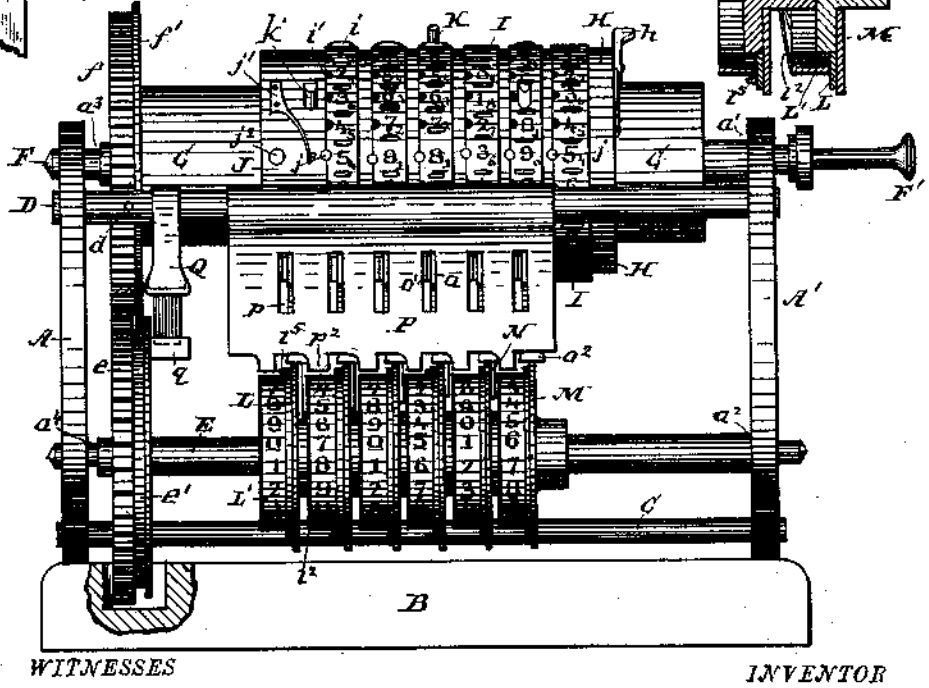


Fig. 2.



WITNESSES

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2 Sheets—Sheet 2.

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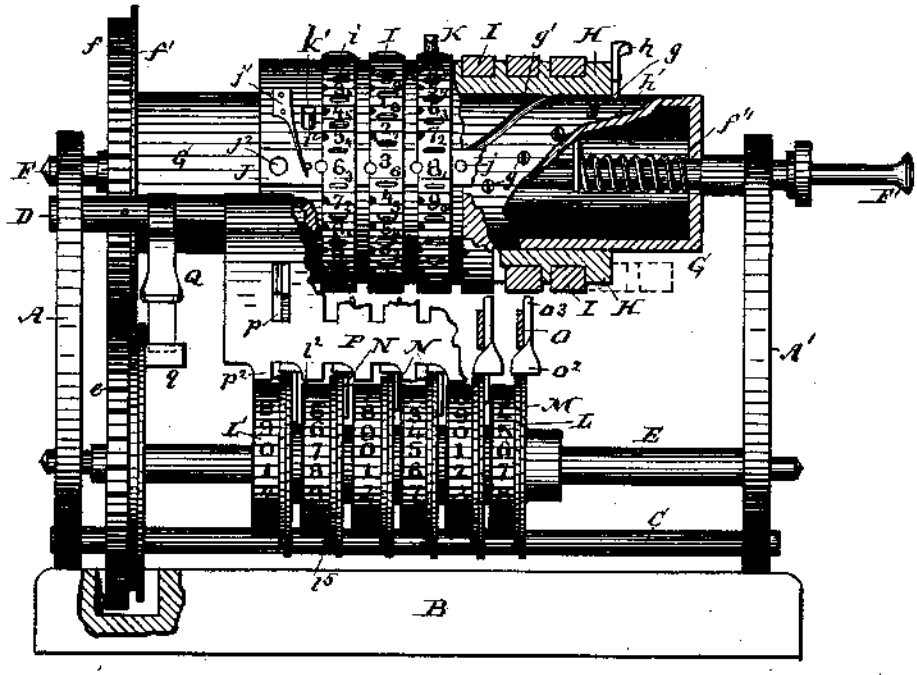
Fig. 5.



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UNITED STATES PATENT OFFICE.

GEORGE B. GRANT, OF MAPLEWOOD, MASSACHUSETTS.

CALCULATING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 368,528, dated August 16, 1887.

Application filed June 24, 1878.

To all whom it may concern:

Be it known that I, GEORGE B. GRANT, a citizen of the United States, residing at Maplewood, in the county of Middlesex and State of Massachusetts, have invented a new and useful Improvement in Calculating-Machines, of which the following is a specification.

My invention relates to that class of calculating-machines whose object it is to perform the four cardinal operations of arithmetic—addition, subtraction, multiplication, and division—and more particularly to the kind which perform the actual operation and produce the result anew at each operation, as distinguished from those which point out the result previously calculated by means of conveniently-arranged tables of results or logarithmic scales.

The drawings show a six-figure machine capable of using a number, minuend, multiplicand, or divisor of not exceeding six decimal places. Similar machines may also be made, however, according to this invention having more than six adding-rings, according to the number of decimal places desired to be used.

Figure 1 is an end view with the frame removed and partly in section to show the parts more plainly. Fig. 2 is a front view. Fig. 3 shows a detail of the registering-wheels. Fig. 4 is a detail of the erasing apparatus, and Fig. 5 is a front view partly in section.

The two frames A A′ are fastened to the base-board B, and are securely fastened together by the two parallel tie-rods C and D. The two shafts E and F revolve in bearings in the frames, and are geared together by the gears *e* and *f*, so that both are revolved by the single crank F′.

The upper shaft, F, carries a long hollow cylinder, G, and on this cylinder slides a carriage, H, which may be fixed in either one of six positions at equal intervals by the click *h* on the carriage, which will catch in either one of the six notches *g* on the cylinder, Fig. 5. As the carriage slides along on the cylinder, it also turns partially around it, being guided by a pin, *h′*, fixed in it, which runs in a spiral slot, *g′*, in the cylinder. The spiral slot is made of such a pitch as to cause the carriage to turn around one-twentieth of a full turn each time it is moved from one of its six positions to the next. The pin *h′*, which guides the carriage, extends into the cylinder, and a spiral spring, f^4, presses against it, tending to throw it forward to the left, Fig. 5. If the outer end of the click *h* be pressed down, the click will leave the notch *g* and allow the carriage to move forward until the click catches in the next notch.

The carriage H carries six or more adding-rings, I, mounted in annular slots, and which may be revolved on it by hand, being provided with pins or ridges *i*, to assist the operation. Each adding-ring is provided with ten notches, *i′*, in its side at equal intervals of one-twentieth of its circumference. A locking-bar, J, lies in a slot cut in the carriage H, and runs under all the rings. It has a locking-pin, *j*, at each adding-ring, a spring, *j′*, and a knob, j^2. Each adding-ring may thus be fixed in either one of ten different positions by drawing out the bar J by the knob, moving the ring around to the desired position, and again locking it by allowing the pin *j* to take into another notch. Each ring bears ten large figures, one at each notch, by which the ten positions of the ring are numbered, and each figure has near it a smaller or negative figure, its complement with 9.

Each adding-ring has an adding-pin, K, projecting from its surface, and an adding-pin, *k′*, is fixed in the carriage beyond the last ring in the zero position, or the position it would have if it was on a ring and the ring placed in its zero position.

The lower shaft, E, carries six or more registering-wheels, L, (shown by the enlarged section, Fig. 3,) each revolving on a hub, *l*, fixed to the shaft. Each registering-wheel has twenty teeth and a flange, L′, carrying two sets of figures, (from 1 to 10, inclusive,) running around the wheel, one at each tooth.

The sheet-steel cam-plate M, having incline *m*, for engaging with the hook o^2, is fastened to the hub *l*, so that the wheel L runs close to it, being pressed against it by a plate friction-spring, l^2. The cam-plate M is larger than the wheel L, (over nine teeth,) and is cut away, so as to expose the other eleven teeth above its edge. On the side of the cam-plate there is a sheet-steel lever, N, which I call a "carrier," pivoted on a pin, *m′*. This lever has an incline

face, n, which projects above the teeth of the wheel L one tooth in advance of the incline m of the cam-plate, and a tail, n', which lies flush with the higher part of the cam-plate when the said tail is resting on a stop-pin, m^2. The carrier has a pin, n^2, projecting from its side, which projects under the flange of the next registering-wheel to the right. This carrier may be swung on its pivot-pin, so as to take the position shown by the dotted lines, Fig. 1, with its tail n' projecting above the cam-plate M and its incline face n depressed below the teeth of the wheel L. It is returned to its first position when its tail strikes against the hook o^2.

Each wheel L carries two carrying-pins, l^2, projecting from its side under its flange. The carrier N is held in its position by a friction-spring, preferably made, as shown, by cutting a tongue, l^3, in the edge of the plate spring l^2 and bending it back so that it presses firmly against the carrier.

The cam-plates M and carriers N are so placed on the shaft E that each incline face n is one tooth farther around the circle than the corresponding incline of the next wheel to the right.

The levers O—one for each registering-wheel L—are pivoted on the back tie-rod, C, and rest their front ends, o, in slots p in a plate, P, that is fastened to the front tie-rod, D. Each lever can be depressed into the position indicated by dotted lines, Fig. 1, and each lever has a plate-spring, o', riveted to one side of it, which bears against the side of the slot p and holds the lever in position wherever placed. Each lever carries a steel hook, o^2, resting on the cam M, and said hook has a beak, o^3, projecting upward close to the adding-ring I and directly in the path of an adding-pin, K.

The plate P has a pointer, p^2, at each registering-wheel, projecting down close to the wheel, to designate the figure that is to be taken when reading the wheel. A catch, Q, and pin q hold the machine from turning unless held out of action by the finger, and will stop it at a fixed point of its revolution if released at any time.

In decimal position the right-hand registering-wheel or adding-ring is the lowest and represents units, the next to the left representing tens, and so on. After every operation the registering-wheels show the result, and before the next operation is commenced this result must be erased and all the wheels brought to read "0." This operation could be effected by turning the wheels to 0 by hand, one by one, but it is much better to have an apparatus that will erase all the figures at once in one-tenth of the time required by hand.

The plate f' is fastened to the side of the upper gear, f, and its edge runs close to the front tie-rod, D, as shown by Fig. 4, and close to one side of the pin d, fixed in the rod. Provision is made for a slight lateral movement of the shaft F in its bearings in the end frames, A A', and when in its normal position the shaft is confined laterally between the pin d and the shoulder at a'.

The plate f' runs in a groove, e', made in the edge of the lower gear, e. Said groove is considerably wider than the plate, and provision is also made for the lateral movement of the shaft in its bearings, and the plate f', bearing against the side of the groove, confines the lower shaft, E, laterally between itself and the shoulder at a^2. There is a notch, f^2, cut in the edge of the plate f' in such a position that said notch has just passed the pin d when the machine is held by the catch Q. If now the catch Q be released and the crank F' turned backward, (in the direction shown by the arrow in Fig. 1,) and at the same time pressed over to the left, Figs. 2 and 4, the pin d will shortly pass through the notch f^2 and allow the whole upper shaft to shift laterally in its bearings until stopped by the shoulder a^3. The whole lower shaft will shift laterally with the upper shaft being pressed over by the plate f' until stopped by the shoulder a^4. The upper shaft will slip over far enough to allow the adding-pins K to pass the hook-heads o^3 as they are turned backward in the process of erasing.

Upon each registering-wheel L are two short erasing-pins, l^3, which will generally pass by the pointer p^2, but which will strike it when the shaft is moved over in its bearings, so that as the shaft is turned backward all the wheels will be held by the pointers and be moved backward until they read "0."

The width of the groove e' in excess of that of the plate f' is such that the lateral motion of the lower shaft is just enough to engage the pointers and erasing-pins and less than that of the upper shaft. The plate f' moves over a little before it pushes the lower shaft with it. By this means all the wheels are quickly brought to read "0" by turning the crank backward and at the same time pushing it inward.

The mechanism having now been described, we can examine its action and its method of operation.

The primitive or fundamental operation of the machine is to add one figure to another, which is accomplished as follows: Suppose we wish to add 3 to 5. Any adding-ring is turned by hand so that it reads "3" at the locking-bar and the corresponding registering-wheel is set so as to read "5" at the pointer p^2. The catch Q is then pressed down and the crank given one turn. As the adding-ring revolves, the adding-pin K will strike the head o^3 of the hook o^2, throwing that hook between the teeth of the registering-wheel and holding it until thrown off by the incline m, having turned it over three teeth, so that it will now read "8," the sum of 5 and 3. The adding-pin is so placed on the ring I that when the ring is placed at 0 it will throw the hook o^2 into the registering-wheel just in advance of the carrier-incline m, and consequently when the ring is moved around to read "3" the pin will throw the hook three teeth earlier than before and similarly for any position of the ring. The operation

of simple addition is the same between each ring and the wheel opposite it, so that if the figures 1346 were set up on the rings and 4301 on the wheels, one turn of the crank would add the two together and give their sum, 5647. Furthermore, as the carriage H can be moved along on the cylinder, the number on the rings can be placed opposite any part of the number on the wheels, so that the result is 1346 + 4301 = 5647, or 13460 + 4301 = 17761, or 134600 + 4301 = 138901, and so on.

The second fundamental mechanical operation is the carriage of tens. When the units-registering wheel passes from 9 to 0 the tens-wheel must be turned one more tooth than otherwise. As the units-wheel passes from 9 to 0, its carrying-pin l^3 will strike the pin n^2 on the carrier belonging to the tens-wheel, and will throw down the incline n of that carrier below the teeth of its wheel. Now, when the hook o^2 moves the tens-wheel it will not be thrown off by the incline n, as usual, but by the incline m one tooth farther on, having added one tooth more than usual to the reading of its wheel. It is this operation of the carriage that necessitates the spiral or consecutive arrangement of the incline and the corresponding spiral motion of the carriage as it moves along on the cylinder. Each operation of the carriage must take place after the same operation of the wheel next lower, for if the tens-wheel should read "9" a carriage of one to it would bring it to 0 and require a carriage to the hundreds-wheel, and to the thousand-wheel if the hundreds happened to read "9."

All operations are formed of the single operation of addition.

Subtraction is the negative of addition—the addition of the complement of the minuend to the subtrahend. The minuend is set up by the smaller or negative figures on the rings, remembering to set up the units place one less, and its addition to the subtrahend previously placed upon the registering-wheels will produce the remainder. Thus, if the subtrahend is 4763 and the minuend 1972 the remainder, 2791, would be the result of the addition of 4763 and 8028, the complement of 1972, the latter being set up 1971, making the rings read "$8_1\ 0_9\ 2_7\ 8_1$."

Multiplication is the compound form of addition. If the figure 7 be set up on the units-ring it will be added to the opposite wheel by every turn of the crank, and the result will be the product of 7 and the number of turns given the crank. Example: 137×243. Set up 137 on the rings, the wheels are reading "0," and turn three times, the result, $137 \times 3 = 411$, showing on the wheels. Then slide the carriage one place to the left and turn four times, the result, $137 \times 40 + 137 \times 3 = 5891$, showing on the wheels. Then slide the carriage one more place to the left and complete the operation by two turns, the wheels showing the result, $137 \times 200 + 137 \times 40 + 137 \times 3 = 137 \times 200 + 40 + 3 = 137 \times 243 = 33291$.

Division is the compound form of subtraction, the negative form of multiplication. Set up the dividend 33291 on the wheels and the divisor 137 by the negative figures on the rings. Place the carriage so that the divisor, 137, is opposite the 332 of the dividend, and turn the crank, subtracting the divisor at each turn until the dividend is within the divisor, which in this case will allow two turns. Then move the carriage to the right and obtain the remaining figures, 4 and 8, in the same way.

The machine, as above described, has but six adding-rings and six registering-wheels; but the principle of the mechanism is not limited to any particular capacity. There must always be ten more teeth on each wheel than there are registering-wheels, twenty teeth on each wheel answering for ten or less wheels, thirty teeth for twenty wheels, and so on, and there must be one erasing-pin and one carrying-pin for each ten teeth.

It will be observed that when the rings I are moved to the right some of them will not have opposite registering-wheels, and this feature is a matter of some consequence as affecting the simplicity of the machine.

In general, in multiplying two numbers together, we do not need the whole of the product, the lower decimal places being either unnecessary or inaccurate. When either factor is a decimal quantity, of which we use but the highest figures—for example, the circular ratio 3.1415926536, of which we use but the five highest, 3.1416—or whenever either factor is the result of a measurement, such as 1.47 feet or 3.4475 gallons, we can have no more correct places in the product than in the decimal factor. The circumference of a circle whose diameter is 1374 is found by multiplying 1374 by 3.1416, giving 4316.5584, of which only five figures, 4316.58, are correct, for the full value is 4316.558306.

As the adding-rings will pass below the registering-wheels, this machine will give the partial product of two numbers, omitting the lower and useless figures and dispensing with the registering-wheels and mechanism necessary to obtain them. This form of machine, with ten registering-wheels, will give the partial product of nine figures into nine, as well as the usual whole-product machine having twenty wheels.

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

1. The combination of a revoluble adding-ring, I, provided with an adding-pin, K, a registering-wheel, L, having ratchet-shaped teeth, the gears e and f, and a lever, O, provided with the hook o^2 and the beak o^3, substantially as described and shown, and for the purposes set forth.

2. The combination of a revoluble adding-ring, I, provided with an adding-pin, K, a registering-wheel, L, having ratchet-shaped teeth, a cam, M, having the incline m, the gears e and f, and a lever, O, provided with the hook o^2 and the beak o^3, substantially as

described and shown, and for the purpose set forth.

3. The combination of the shaft F, carrying a series of adding-rings, I, provided with means for securing them on the said shaft so that they turn with it, the adding-pins K, projecting from rings I, the shaft E, carrying a series of registering-wheels, L, which revolve with the said shaft, the gears *e* and *f*, the frames A A′, the crank-handle F′, and a series of levers, O, pivoted on the rod C and provided with hooks o^2 and beaks o^3, substantially as and for the purpose set forth.

4. The combination of the adding-rings I, the carriage H, provided with grooves in which the said rings I are circumferentially adjustable, and with a longitudinal groove for the locking-bar, the locking-bar J, provided with pins *j*, engaging with the adding-rings, and the spring *j′*, substantially as and for the purpose set forth.

5. The combination of a revolving shaft, a hub, *l*, secured upon the said shaft, a registering-wheel, L, journaled on the said hub and provided with ratchet-teeth and the flange L′, a cam-plate, M, having an incline, *m*, fastened on hub *l*, a friction-spring, l^2, for pressing the wheel L upon the cam-plate, and a lever, O, provided with the hook o^2, for engaging with the teeth of wheel L and arresting its motion, substantially as and for the purpose set forth.

6. The combination of a series of hubs, *l*, secured upon a revolving shaft, a series of registering-wheels, L, journaled on the said hubs, the cam-plates M, having each an incline, *m*, and fastened on hubs *l*, the friction-springs l^2, having spring-tongues l^4 integral with them, the carriers N, pivoted on the said cam-plates and having inclined faces *n*, tails *n′*, and projecting pins n^2, and the carrying-pins l^3, projecting from the wheels L and engaging with the said pins n^2 at the required intervals, substantially as described and shown, and for the purposes set forth.

7. The combination of a series of hubs, *l*, secured upon a revolving shaft, a series of registering-wheels, L, journaled upon the said hubs, a series of cam-plates, M, secured on the said hubs in connection with the wheels, and provided with inclines *m*, each of which is arranged in advance of the incline on the cam-plate connected to the wheel L next decimally lower to that wheel to which it is connected, a series of levers, O, each having a hook, o^2, and a beak, o^3, and the series of springs l^2, substantially as shown and described, and for the purpose set forth.

8. The combination of the bar C, a lever, O, pivoted on the bar C and provided with hook o^2, beak o^3, and front end, *o*, the cam M, having the incline *m*, the plate P, secured to the rod D and provided with a slot, *p*, through which the end *o* of lever O passes, and a plate-spring, *o′*, for holding the said lever in any position, substantially as and for the purpose set forth.

9. The combination of a series of adding-rings, I, the carriage H, provided with grooves in which the said rings are circumferentially adjustable, the spring-click *h*, and the pin *h′*, the shaft F, the cylinder G, revolving with shaft F and provided with spiral slot *g′* and spirally-arranged notches *g*, the adding-ring shaft F, the gears *f* and *e*, the shaft E, the friction-springs l^2, and a series of registering-wheels adjustable with respect to each other and connected to the said adding-ring shaft by the said gearing and friction-springs, substantially as described and shown, and for the purpose set forth.

10. In a calculating-machine, the combination of a series of adding-rings having notches and a single locking-bar simultaneously engaging with the notches in all the adding-rings constituting the said series, substantially as and for the purpose set forth.

GEO. B. GRANT.

Witnesses:
I. C. GRANT,
BENJ. F. BROWN.