No. 825,363.

PATENTED JULY 10, 1906.

J. VERMEHREN.

CALCULATING MACHINE.

APPLICATION FILED SEPT. 20, 1901.

2 SHEETS—SHEET 1.

Fig. 1.

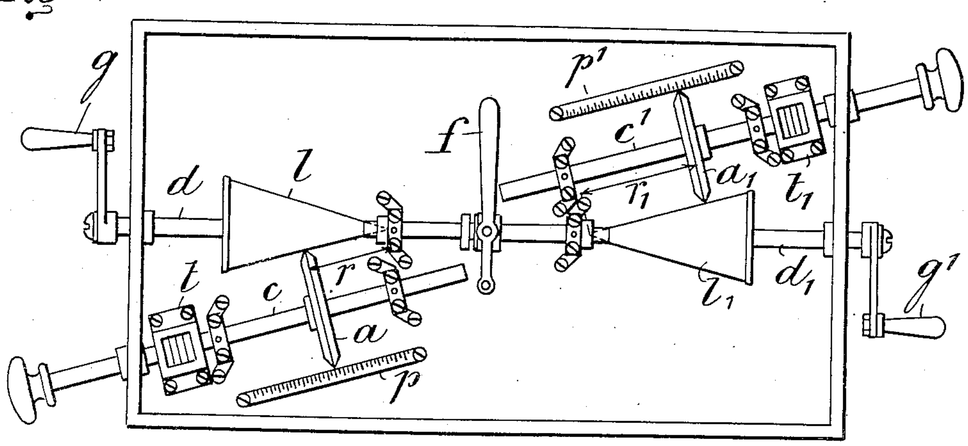


Fig 2

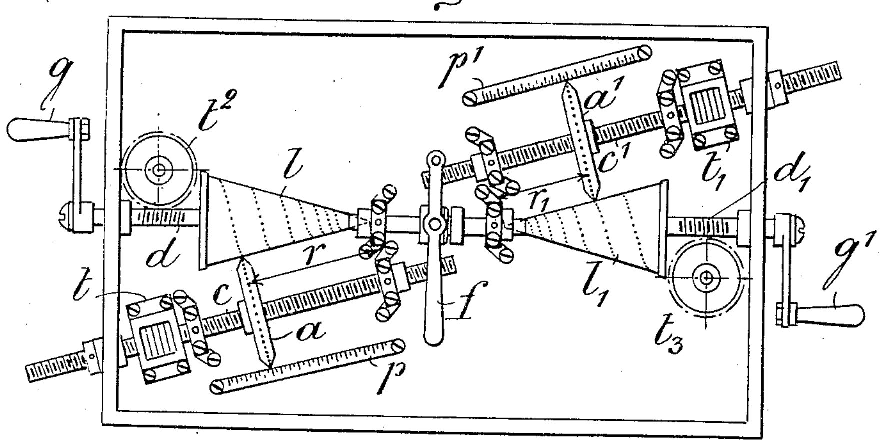
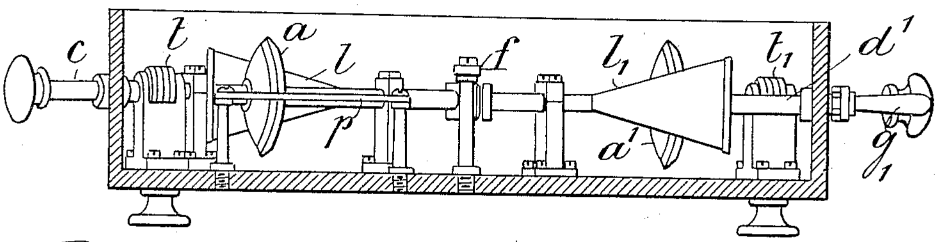


Fig 3



Witnesses

H. M. Kuehne

J. D. Stephens

Inventor

Johannes Vermehren

By Richards & Co

ATTORNEYS

No. 825,363. PATENTED JULY 10, 1906.

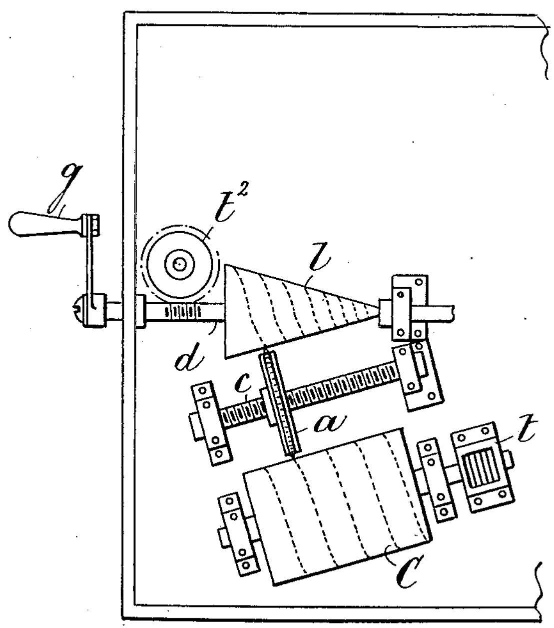
J. VERMEHREN.

CALCULATING MACHINE.

APPLICATION FILED SEPT. 20, 1901.

2 SHEETS—SHEET 2.

Fig 4



Witnesses.

W. P. Burke

W. J. Donovan

Inventor

Johannes Vermehren

By Richards & Co

ATTY'S.

UNITED STATES PATENT OFFICE.

JOHANNES VERMEHREN, OF HELLERUP, DENMARK, ASSIGNOR TO AKTIESELSKABET VERMEHRENS REGNEMASKINER, OF COPENHAGEN, DENMARK.

CALCULATING-MACHINE.

No. 825,363. Specification of Letters Patent. Patented July 10, 1906.

Original application filed September 1, 1900, Serial No. 28,786. Divided and this application filed September 20, 1901. Serial No. 75,695.

To all whom it may concern:

Be it known that I, JOHANNES VERMEHREN, a subject of the King of Denmark, and a resident of Hellerup, Denmark, have invented certain new and useful Improvements in Calculating-Machines, of which the following is a specification, this application being a division of an application filed by me September 1, 1900, Serial No. 28,786.

This invention relates to calculating-machines; and it consists in the special construction and combination of two or more pairs of friction or calculating members, one member of each pair being cone-shaped, while the other one is shaped as a disk or a ring whose edge runs on the outer or inner surface of the cone in frictional contact with it, so that the disk or ring is rotated when the cone is rotated. The disk or ring may be mounted in such a manner that its contact-points with the cone have a constant but adjustable distance from the apex of the cone or so that it during its rotation also has a lengthwise motion in the direction of its axis, whereby its consecutive contact-points with the cone form a curve the projection of which on the base of the cone forms a logarithmic spiral. By the combination of said pairs of calculating members with a number of counting apparatus the machine is able to perform multiplications and divisions of whole numbers and fractions and multiplications, divisions, involutions, evolutions, and calculations by means of logarithms.

The accompanying drawings give diagrammatical views of the improved calculating-machine.

Figure 1 shows a plane view of the machine designed for multiplications and divisions of whole numbers and fractions; Fig. 2, a slightly different form of the machine designed for multiplications, divisions, evolutions, involutions, and calculations by means of logarithms; and Fig. 3, a front view of the machine in Fig. 1. Fig. 4 is a plan of one side of a modified form of machine.

In Fig. 1 a machine is shown having two pairs of calculating members *a l* and *a′ l′*, of which the disk-shaped members *a* and *a′* are connected with a counting apparatus, respectively, *t* and *t′*, for registering the complete and partial rotation of the said members. The disk *a* (*a′*) is mounted in such a manner that it runs with its edge on the surface of the cone-shaped member *l* (*l′*) and that its contact-point with said cone may be set at any desired distance *r* (*r′*) from the apex of the cone *l* (*l′*) by moving lengthwise the spindle *c* (*c′*), to which the disk *a* (*a′*) is secured, and which spindle is operatively connected with the corresponding counting apparatus *t*, (*t′*.) The distance may be indicated by the disks themselves on scales *p p′*, parallel with the spindles *c c′*. When rotated, the cones *l l′* rotate the disks *a a′* by friction, and they are mounted on spindles *d d′*, which may be rotated by means of cranks or handles *g g′*. The spindles *d d′* may be rotated independently of each other or they may be coupled together, for instance, by means of a clutch operated by a handle *f*, so that both the spindles rotate when one of them is rotated. The spindles *c* and *c′* are parallel to the sloping surface of the corresponding cone. In this case the counting apparatus *t t′* are both of such known construction that they may be set at zero without turning the spindles *c* and *c′*, and when now the crank *g* is turned (the spindles *d* and *d′* being coupled together) the values of the indications of the two counting apparatus will be in the ratio of *r* to *r′*. The multiplication of a figure with a fraction is therefore easily performed by means of this simple machine. If, for example, it is required to take $18\frac{3}{4}$ per cent. of a series of numbers (values)—that is to say, to multiply the same by $\frac{75}{400}=\frac{3}{16}$—the two disks *a a′* are set so that *r* equals sixteen and *r′* equals three, in which case the disk *a′*, and consequently the counting apparatus *t′*, connected with *a′*, will rotate at $\frac{3}{16}$ or $\frac{300}{16}$ per cent., $18\frac{3}{4}$ per cent. the speed of the disk *a* and the counting apparatus *t*, connected with *a*. The counting apparatus *t′* shows in this case the $18\frac{3}{4}$ per cent. of the numbers indicated by the counting apparatus *t*.

This mechanism presents great advantages, specially for calculating the exchange value of bonds and the like. If, for example, one German mark is eighty-eight oere, Danish, and one French franc equals 72.5 oere, the disks *a* and *a′* must be adjusted so as to make *r* equal eighty-eight and *r′* equal 72.5, so that the counting apparatus *t* will indicate the number of francs and the other one, t', the corresponding number of marks; but the said arrangement may also be employed for general multiplications, as may be seen from the example quoted. If, for example, any given number is to be multiplied by sixty-seven, it is the same as multiplying with the fraction $\frac{670}{10}$. It is obvious that the machine may be used for performing divisions also.

Instead of having the disks a a' secured to the spindles c c' the arrangement may also be such that the disks take their spindles along with them when they rotate, but can be moved lengthwise on the spindles, and of course the spindles c c' must always be able to turn the counting apparatus t t' when the disks are rotated by means of the cones. The improved machine may also be provided with a greater number of pairs of calculating members than a l and a' l'. If, for example, four such pairs are used, it is feasible simultaneously to indicate dollars and cents with one counting apparatus and the corresponding values in marks, florins, and francs with the other three. The machine will therefore prove to be of the greatest advantage for money changers and bankers.

In the form shown in Fig. 2 the disks a a' are secured to screw-threaded spindles c c', which turn in screw-threaded bearings, so that they move lengthwise when the disks are rotated. The cones l l' are mounted as already explained. As now the spindles c and c' move lengthwise when rotated, it will be seen that the consecutive points of contact of the pairs of calculating members will describe curves on the surface of l l', the vertical projections of these curves forming logarithmic spirals on the bases of the cones. If it be assumed that cone l is rotated at angle $d\Theta$ and that it upon radius r takes the disk a along by friction at angle $d\varphi$ at the same time that the disk a has radius R, then we have by a similar consideration as in Amsler's planimeter:

$$R\, d\, \varphi = r\, d\, \Theta$$

and by this rotation the point of contact will move on cone l a distance from the point of the cone, the projection $d\, r$ of which distance on the base of the cone relates to $d\varphi$ as H to 2π when H is the projection on the cone-base of the height of the screw, so that

$$d\, r = \frac{H}{2\pi} . d\, \varphi$$

and subsequently is $\frac{d\, r}{r d\, \Theta}$ constant.

It follows that with said infinitely small movement the projection on the base of the cone at the first and last point of contact between the disk a and the cone l always lies upon a line situated on the base of the cone under a constant angle with the radius vector. The logarithmic spiral has meanwhile just a constant angle between a tangent and radius vector. When the equation for a logarithmic spiral in polar coördinates is written

$$r = k\, .\, e^{\frac{\Theta}{a}}$$

and when for the sake of simplicity it is desired that the drift of the spiral on which all the projected points of contact are lying shall begin at radius 1 and after ten full rotations end at radius 10 to determine k and a, it is found that

$$1 = k\, .\, e^0 \text{ and } 10 = k\, .\, e^{\frac{10\, .\, 2\pi}{a}}$$

whereof

$$k = 1 \text{ and } 10 = e^{\frac{10\, .\, 2\pi}{a}}$$

or

$$1 = \frac{10\, .\, 2\pi}{a} \log.\, e$$

or

$$a = 10\, .\, 2\pi \log.\, e$$

where

$$e = 2,71828,$$

so that the equation of the spiral will be

$$r = e^{\frac{\Theta}{10\, .\, 2\pi \log.\, e}}$$

or

$$\log.\, r = \frac{\Theta}{10\, .\, 2\pi}$$

taking the Briggish logarithm on both sides of the equation symbol. Now if the calculating apparatus t is to show "100" when the disk a stands on radius 1 and "1,000" when the disk a stands on radius 10 and if the screw has nine fillets on the distance which the screw c must shift lengthwise, whereas the point of contact between the disk a and the cone l shifts from radius 1 to radius 10, the radius R of the disk a may easily be figured out, since we have there H equals 1, for we have, as quoted above,

$$R\, d\, \varphi = r\, d\, \Theta$$

and by differentiation from the equation of the spiral:

$$\log.\, r = \frac{\Theta}{10\, .\, 2\pi}$$

we get

$$\frac{\log.\, e}{r} \frac{d\, r}{d\, \Theta} = \frac{1}{10\, .\, 2\pi}$$

that is

$$r\, .\, d\, \Theta = 10\, .\, 2\pi \log.\, e\, .\, d\, r,$$

and therefore

$$R\, d\, \varphi = 10\, .\, 2\pi \log.\, e\, .\, d\, r,$$

and as

$$d\, r = \frac{H}{2\pi} d\varphi,$$

we again get

$$R = 10 \cdot 2\pi \, log. e \cdot \frac{dr}{d\varphi} =$$

$$10 \cdot 2\pi \, log. e \cdot \frac{H}{2\pi} = 10 \cdot log. e = 4,3429.$$

If R be accepted as having this dimension and the cone l or, as shown in Fig. 2, its axis d, is combined with a disk which is caused to rotate at only one-tenth of the speed of that of l, the part of a revolution of that disk represents the mantissa of logarithm of the figure which is shown by t. For example, if t shows "789" an angle Θ corresponds to this figure, which may be found from the equation:

$$log. 7,89 = \frac{\Theta}{10 \cdot 2\pi} = \frac{S}{2\pi}$$

wherefore $\frac{S}{2\pi}$ represents the part of a whole revolution performed by the disk above referred to. If now this disk is combined with a third counting apparatus t^2, the said part of the revolution may be read with still greater accuracy.

It follows from the foregoing description that the counter t^2 may be employed to indicate the mantissa of the log. p, supposing the counter t indicates the figure p, and in the same way a fourth counter t^3, combined with the cone l' in the same manner as the above-named counting apparatus t^2 with the cone l, may indicate the mantissa of the log. q if t' shows the figure q. It is therefore rendered possible by adjusting the counter t at the figure p so that the counter t^2 indicates the mantissa of log. b and by coupling afterward the counters t^2 and t^3 together, while t^3 points at zero, and by then turning handle g' so far that counter t' indicates q to obtain that the counter t^2 indicates the mantissa of log. p+log. q. By this means the counter t will be brought to indicate the product of p multiplied by q. This machine is therefore capable of being used for multiplications, and consequently it may be used for divisions also. If, however, the cones l and l' are not coupled as shown in Fig. 2, but connected together in such a manner—for example, by means of cogged wheels—that l' is caused to rotate at double the speed of l, it is obvious that the operator by means of counter t' is enabled to indicate the square of second power of any figure shown by the counter t, and if the cones l and l' are connected together in such a manner that l' is brought to rotate at three times the speed of l the operator may find at the counter t' the cube or third power of the figure shown at the counter t. The machine may consequently be employed for calculations of the second and third powers of numbers also. Moreover, all calculations dealing with raising a number to a higher power (therefore also the calculation of annuities) and those dealing with extracting root may be performed by first adjusting the counter t on a number, say p, whereby the counter t^2 will indicate the mantissa of log. p. If then the counter t' is adjusted to indicate the log. p, it is rendered possible to perform a multiplication or a division, respectively, with the number indicating the higher power of which it is required to raise the said figure or with that representing the root to be extracted. As the result of the operation a logarithm is found to which the counter t^2 must be adjusted in order to indicate with the counter t the number sought.

Generally speaking, one half of the machine may be used as a logarithmic table, the counter t^2 indicating the mantissas of Briggs's logarithms which correspond to the numbers indicated by the counter t.

In order to insure that the projection on the base of the cone of the points of contact between the members a and l when connected by lines shall result in a logarithmic spiral and in order to avoid dependence on friction between the two members, the circumference of disk a may be provided with pointed teeth and the cone l may have corresponding cavities or holes the projection of which on the base of the cone when connected by a curve form a logarithmic spiral. In Fig. 2 teeth are shown on the circumference of the disks a a' and holes in the cones l l'. If the regular motion of the disk a in its relation to the cone l is thus insured by means of teeth and corresponding holes, it is also possible, if desired, to dispense with the screw-threads of the spindle c of disk a and with the corresponding threads in the bearing, and it is even feasible, if desired, to cause the spindle c to partake in the rotary movement of disk a, but without moving in its longitudinal direction. It is, however, also possible to construct the improved calculating-machine in such a manner that the contact-points between the disk a and the cone l have a constant distance from the apex of the cone, while projection of the contact-points between the disk a' and the cone l' form a logarithmic spiral, or vice versa. In such case the counter t may be employed for determining the mantissas of the logarithms of the numbers indicated by the other counter t', or vice versa. The improved machine may also be provided with a greater number of pairs of calculating members than a l and a' l'. By combining many such pairs of calculating members it is possible to obtain results with more figures than hitherto. As such arrangement, however, is well known, a further description is not necessary. Instead of being mounted to work like a screw in its bearing the spindle c might be fixed and be screw-threaded, so that the disk a may be screwed along it like a nut; but in this case the rotary motion of the disk a must be transmitted to the counter t, for example, by means of a cylinder C, mounted parallel to spindle *c* and actuated by the pointed teeth of disk *a* engaging the cavities formed along a spiral drawn upon the surface of the said cylinder C. (See Fig. 4.)

It will be seen that the construction of this improved calculating-machine is based on a novel principle, which makes it superior to all other machines of this kind by reason of the fact that so many different calculations may be performed on it and by reason of the high speed with which it works.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is—

1. In a calculating-machine, a main shaft, a number of cone-shaped friction members carried thereby, a corresponding number of disks having their edges in contact one with each cone, rotary spindles parallel with the sloping surface of the corresponding cone and each supporting one of the said disks, and a calculating apparatus operatively connected with each spindle, substantially as described.

2. In a calculating-machine, a main shaft, a number of cone-shaped friction members carried thereby, a corresponding number of disks having their edges in contact one with each cone lengthwise-adjustable rotary spindles parallel with the sloping surface of the corresponding cone and each supporting one of the said disks, and a calculating apparatus operatively connected with each spindle, substantially as described.

3. In a calculating-machine, a main shaft, a number of primary cone-shaped friction members carried thereby, a corresponding number of disks having their edges in contact one with each cone, rotary spindles parallel with the sloping surface of the corresponding cones and each adjustably supporting one of the said disks, and a calculating apparatus operatively connected with each spindle, substantially as described.

4. In a calculating-machine, a main shaft, a number of primary cone-shaped friction members carried thereby, a corresponding number of disks having their edges in contact with each cone, rotary screw-threaded spindles parallel with the sloping surface of the corresponding cone and each supporting one of the said disks, and a calculating apparatus operatively connected with each spindle, substantially as described.

In witness whereof I have hereunto set my hand in presence of two witnesses.

JOHANNES VERMEHREN.

Witnesses:

MARCUS MÖLLER,

MAGNUS JENSEN.