(No Model.) 5 Sheets—Sheet 1.

H. ESSER.

CALCULATING MACHINE.

No. 561,099. Patented June 2, 1896.

Fig. 2.

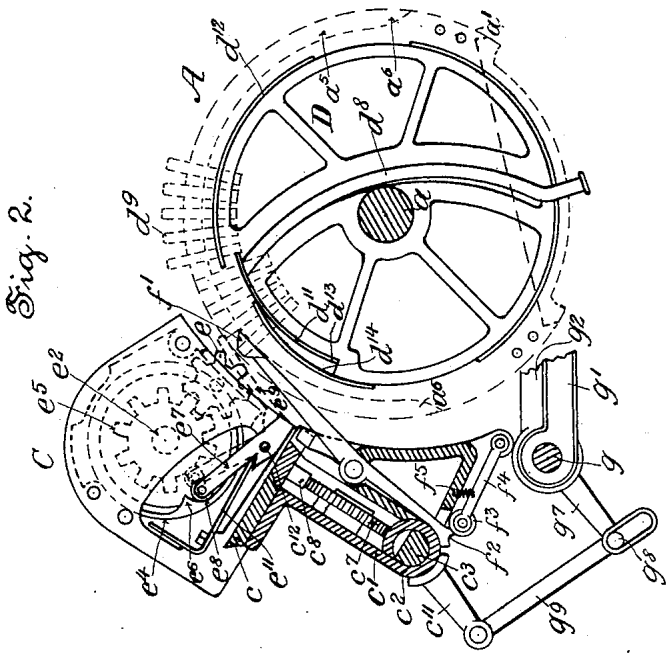
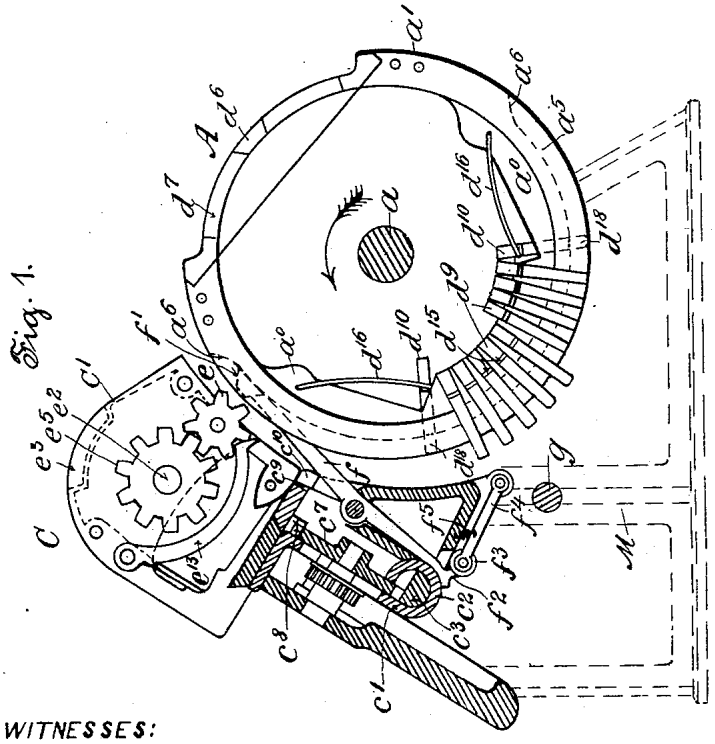


Fig. 1.



WITNESSES:

Carl Greiner

J. Heyer.

INVENTOR

Heinrich Esser

BY

Hermann Bormann

ATTORNEY.

(No Model.) 5 Sheets—Sheet 2.

H. ESSER.

CALCULATING MACHINE.

No. 561,099. Patented June 2, 1896.

Fig. 5.

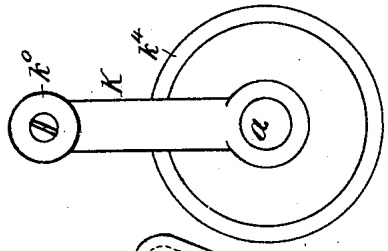


Fig. 4.

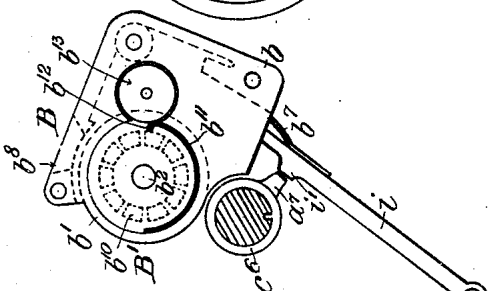
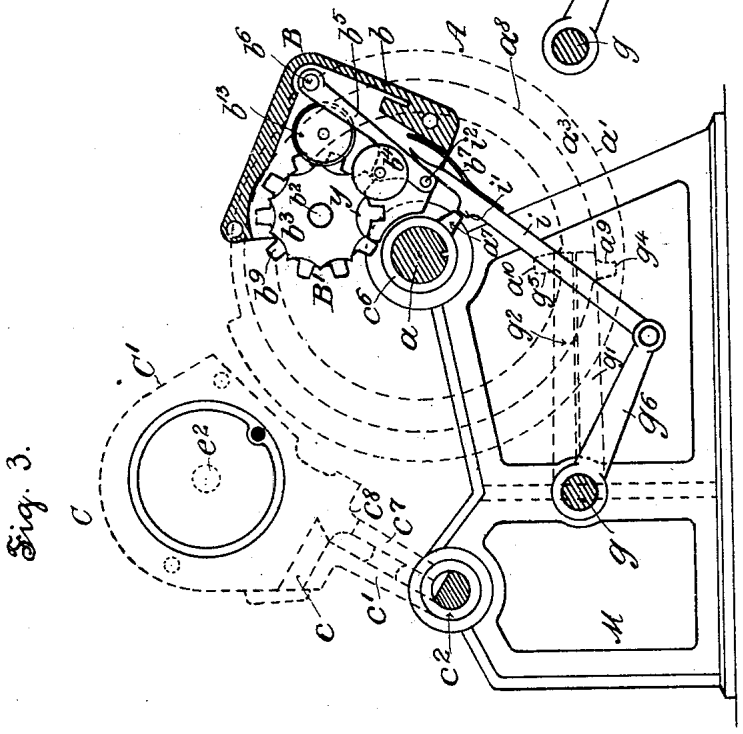


Fig. 3.



WITNESSES:

Carl Greiner

J. Heyer

INVENTOR

Heinrich Esser

BY

Hermann Bormann.

ATTORNEY

(No Model.) 5 Sheets—Sheet 3.

H. ESSER.

CALCULATING MACHINE.

No. 561,099. Patented June 2, 1896.

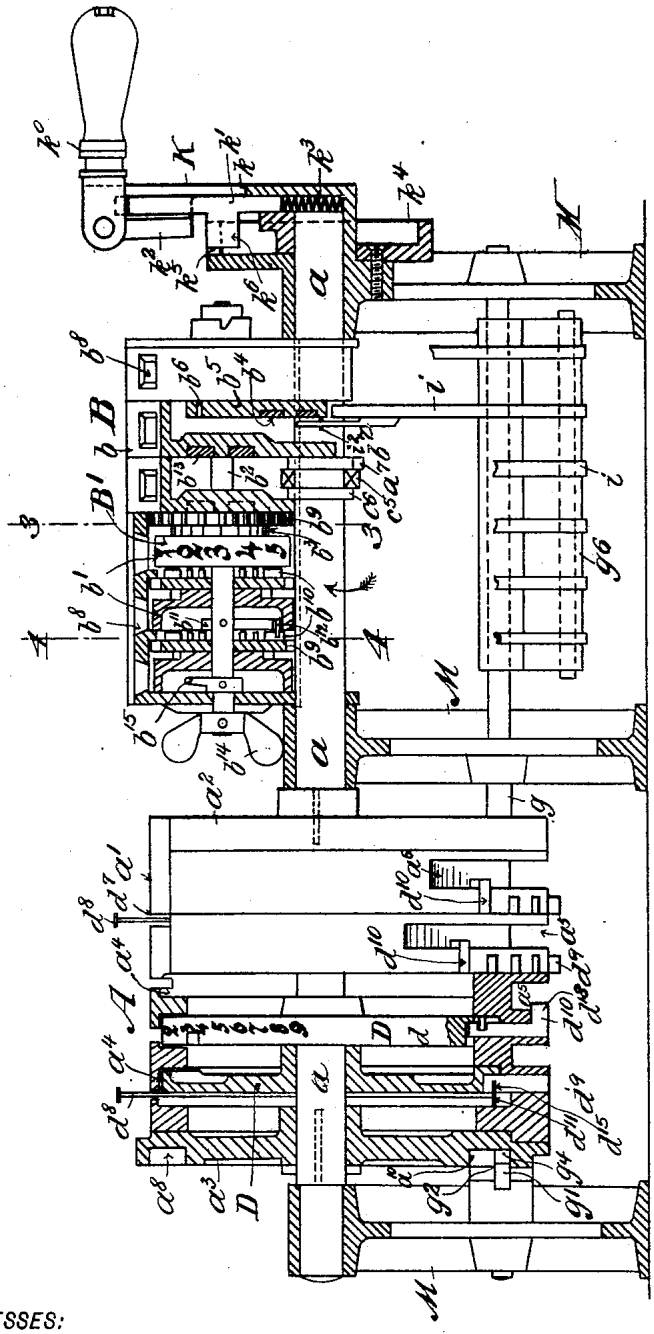


Fig. 6.

WITNESSES:

Arthur A. Brown

J. Heyer

INVENTOR

Heinrich Esser

BY

Hermann Bormann

ATTORNEY.

(No Model.) 5 Sheets—Sheet 4.

H. ESSER.

CALCULATING MACHINE.

No. 561,099. Patented June 2, 1896.

Fig. 8.

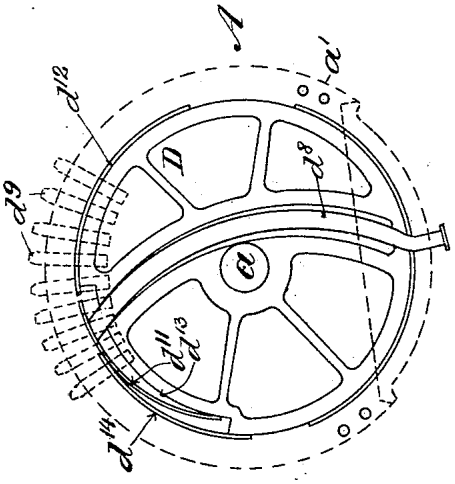
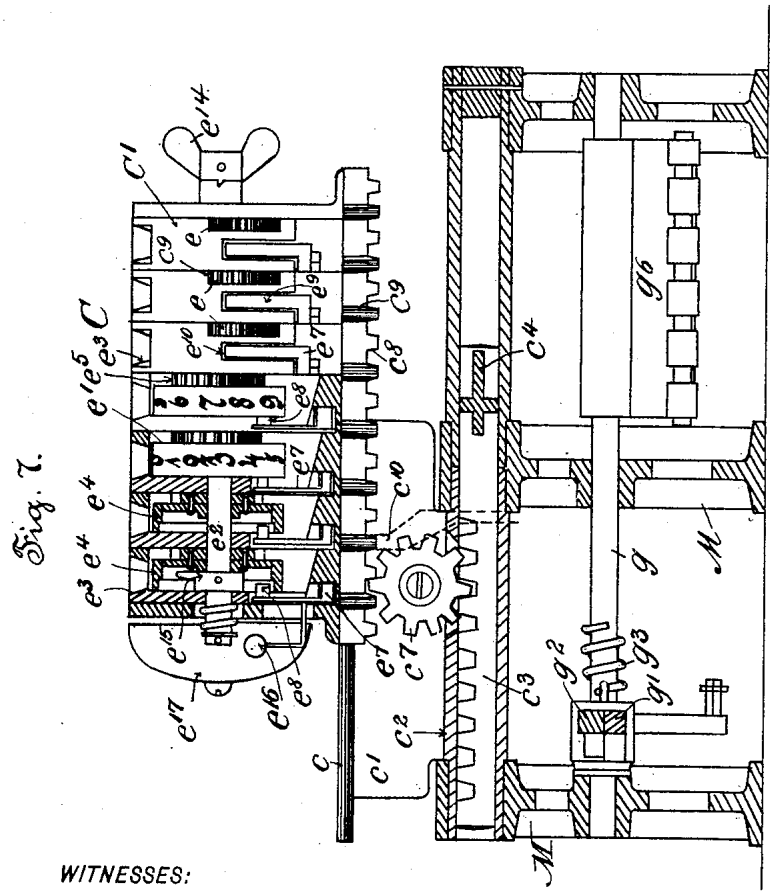


Fig. 7.



WITNESSES:

Arthur A. Brown

J. Heyer

INVENTOR

Heinrich Esser

BY

Hermann Bormann.

ATTORNEY.

(No Model.) 5 Sheets—Sheet 5.

H. ESSER.

CALCULATING MACHINE.

No. 561,099. Patented June 2, 1896.

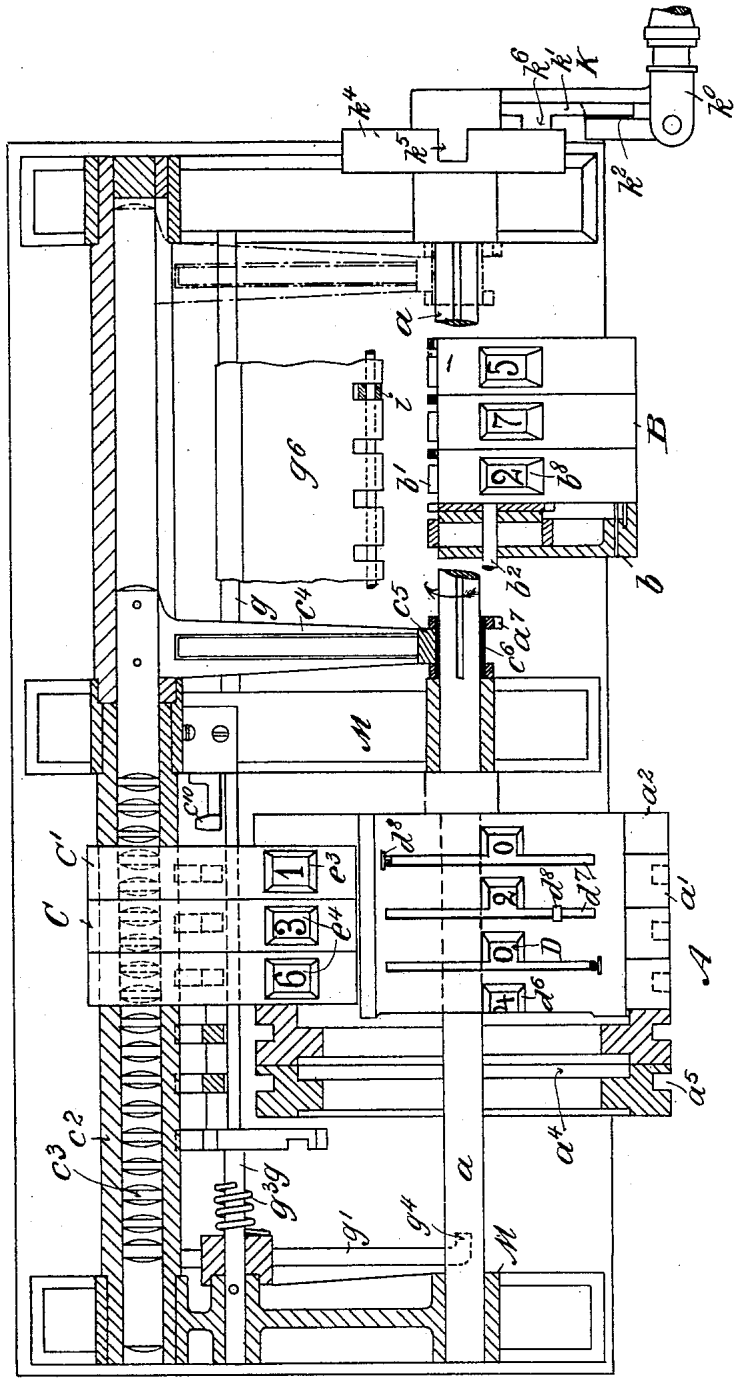


Fig. 9.

WITNESSES:

Arthur A. Brann.

J. Heyer

INVENTOR

Heinrich Esser

BY

Hermann Bormann

ATTORNEY.

UNITED STATES PATENT OFFICE.

HEINRICH ESSER, OF AIX-LA-CHAPELLE, GERMANY.

CALCULATING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 561,099, dated June 2, 1896.

Application filed May 21, 1894. Serial No. 511,980. (No model.)

To all whom it may concern:

Be it known that I, HEINRICH ESSER, a subject of the Emperor of Germany, residing at Aix-la-Chapelle, Germany, have invented new and useful Improvements in Calculating-Machines, of which the following is a specification.

My improvements relate to calculating-machines by which long and tedious calculations may be solved; and the object of the improvements is to provide a machine of comparatively simple construction by which the results of problems to be solved, especially in multiplying or dividing numbers, are obtained in the shortest possible time and absolutely correctly indicated on and by the machine. The improved machine comprises three indicators, which may be designated as "operating-indicator," "product-indicator," and "quotient-indicator," because by setting a number as multiplier in the quotient-indicator and a number as multiplicand in the operating-indicator the product-indicator, after manipulating with the operating-indicator in one direction, shows or indicates the product of the multiplication, and, vice versa, by setting a number in the product-indicator as the dividend and a number in the operating-indicator as the divisor and manipulating the operating-indicator in a reverse direction the quotient-indicator will show or indicate the result of the division.

The invention consists in the arrangement, disposition, and construction of these indicators and devices for manipulating with and carrying numbers and results from one indicator to another, as will be hereinafter more fully described, and pointed out in the claims.

My invention will be more fully understood when taken in connection with the accompanying drawings, forming part hereof, in which—

Figure 1 is a vertical cross-section of my improved calculating-machine, showing an element of the operating-indicator mounted on a shaft, the product-indicator slidingly mounted on a hinged bed, and means for manipulating the product-indicator from the operating-indicator. Fig. 2 is a similar view showing the means of setting and locking an element of the operating-indicator and also showing the sliding and hinged product-indicator and means connected to the latter for automatically locking the operating-indicator when the product-indicator is to be moved one or more places. Fig. 3 is a section on the line 3 3 of Fig. 6, showing the quotient-indicator, means for holding each element thereof in position, means for operating a certain element from the shaft of the operating-indicator, and also showing in dotted lines the devices for braking or locking the said operating-indicator. Fig. 4 is a section on the line 4 4 of Fig. 6, showing a connection between two elements of the quotient-indicator by which the element of a high order is turned one tooth or space by the adjacent element of the next lower order. Fig. 5 is an elevation of the crank attached to the shaft of the operating-indicator and the locking device for the said crank. Fig. 6 is a longitudinal elevation, partly in section, of the machine, showing the operating-indicator, the operating or main shaft, and the crank therefor, the quotient-indicator, and the means for actuating a certain element of the latter from the shaft of the operating-indicator. Fig. 7 is a longitudinal elevation, partly in section, of the machine, showing the product-indicator slidingly mounted on a hinged bed, and showing also the means by which a sliding tooth on the main shaft of the operating-indicator is moved opposite a certain element of the quotient-indicator when the product-indicator is moved on its hinged bed. Fig. 8 shows in detail the construction of an element of the operating-indicator; and Fig. 9 shows a plan of the machine, partly in section, taken at various lines.

Referring now to the drawings for a further description of my invention, A is the operating-indicator mounted on the main or operating shaft a, journaled in the machine-frame M.

B is the quotient-indicator arranged at the right-hand side of the operating-indicator and above the shaft a.

C is the product-indicator slidingly mounted on a bed c, which latter is journaled to the frame of the machine by the bed extension c' and hollow sleeve c^2, for a purpose to be hereinafter more fully described.

The operating-indicator comprises a drum or circular housing a', which is fastened by the head-pieces a^2 a^3 to the shaft a, so that

the drum turns with the said shaft whenever the latter is turned in one or the other direction by the crank K. Inside the drum are provided in grooves a^4 the wheels or elements D, which are supported by the shaft a and are partially rotatable thereon. Any number of wheels may be provided, but usually five or six are found sufficient to carry on greater calculations, and these wheels or elements D, Fig. 9, representing units, tens, hundreds, &c., are each provided at a part of their periphery with the numerals or digits from "0" to "9," which may alternately be brought to view at sight-holes d^6, arranged in the housing and in line with the numerals on each of the said wheels. Adjacent to the sight-holes d^6 are provided slots d^7 for the handle-bars d^8, Figs. 2, 6, 8, and 9, which are contained in recesses of the wheels D and serve to partially rotate the latter, and also operate the teeth d^9, held in apertures of the housing or drums a'. There are nine teeth d^9 for each wheel D, corresponding to the numerals "1" to "9" on each wheel. In addition to these there are further provided in slots of the housing a' two other tens-teeth d^{10} for each wheel D, one tooth being located in advance of the (unit) tooth corresponding to the numeral "1" and the other in succession to the (unit) tooth corresponding to the numeral "9," and these two tens-teeth d^{10} are operated and serve a purpose, as will be hereinafter more fully described.

The teeth d^9 are normally flush with the outside of the housing a', except when the machine is in operation, at which time certain teeth of one or all the wheels D may be projected beyond the surface of the housing in order to engage a gear-wheel e of the product-indicator C, as will be described. To bring one or more of the outer ends of a series of teeth d^9 beyond the surface of the housing, there are provided two curved plates d^{11} and d^{12}. The plate d^{11} is fastened to the inner end of the handle-bar d^8 and is held in a recess d^{13}, cut in the periphery of the wheel D, Figs. 2 and 8, by a spring d^{14}. The other curved plate d^{12} is held on the periphery of the wheel D and projects laterally from one side thereof. At the inner ends of the teeth and on one side thereof are provided notches d^{15}, Fig. 11, which engage one or the other of the curved plates d^{11} d^{12}. When the machine is not in operation, the notches are in engagement with the plate d^{11}, and if desired to bring a certain number of teeth d^9 beyond the surface of the drum a' in order to engage the gear-wheel e the handle-bar d^8 is pushed inward and turned until the desired numeral of the wheel D to be operated with presents itself in the sight-hole d^6, indicating that a corresponding number of teeth d^9 has been transferred to the curved plate d^{12}. The handle-bar d^8 is then released and automatically pushed outward by the spring d^{14} pressing against the curved plate d^{11}. When one or more teeth d^9 are pushed outward in the manner described, the respective wheel is locked to the housing a' and is prevented from being further turned by accident or other cause, the locking being effected by the curved plates d^{11} and d^{12} and the teeth d^9. The curved plate d^{11} abuts the last of the drawn-out teeth d^9 and the curved plate d^{12} the next succeeding drawn-in tooth d^9, as will be readily seen from Fig. 2. To bring the teeth d^9 into their normal position again, the handle-bar d^8 is again pressed inward until the two ends of the curved plates d^{11} d^{12} are flush with each other and then turned so as to transfer the outdrawn teeth d^9 from the curved plate d^{12} onto the curved plate d^{11}. By then releasing the handle-bar d^8 the spring d^{14} pushes all of the teeth into their normal position and within the housing a'.

The tens-teeth d^{10}, disposed at each end of a series of teeth d^9 for a wheel D, are each provided with shoulders d^{18}, extending into grooves a^5, Figs. 1, 2, 6, and 9, of the housing a', so that a wedge-shaped projection f' formed on lever f, Figs. 1 and 2, of the product-indicator C may force one of the said teeth d^{10} outward to engage the gear-wheel e of the product-indicator C and to rotate the said wheel one tooth backward or forward, according to the direction in which the shaft a and the housing a' of the operating-indicator A, together with the various wheels D locked thereto, is turned, as will be more fully explained. The two tens-teeth d^{10} are normally held within their apertures of the housing by the springs d^{16}, which are fastened at one end to a flange a^9 at the inside of the housing.

The quotient-indicator B, which is illustrated in Figs. 3, 4, 6, and 9, is located above the main shaft a and is actuated by the latter. This indicator consists of a housing b, fixed to the machine-frame in any suitable manner, and any desirable number of elements B', Figs. 3, 4, and 6, journaled on a shaft b^2. Each element of the indicator consists of a recessed wheel b', having on its peripheral surface numbers or digits from "0" to "9" inscribed thereon. On one side of the wheel b' is formed a brake or regulating wheel b^3, having ten indentations, Fig. 3, in which a roller b^4, journaled to a lever b^5, hinged at b^6 to the inside of the housing b, engages. The roller b^4 is constantly pressed into one of the said indentations by the spring b^7, so that the wheel b' cannot, accidentally or otherwise, be moved and present a number at the respective sight-hole b^8, Figs. 4, 6, and 9, of the housing B which is not put there by the actions of the machine, as will be readily understood. One of the indentations of the brake-wheel b^3, and corresponding to the number "0" inscribed on the peripheral surface of the wheel b', is cut deeper than all the others, as shown at y, Fig. 3, to allow the roller b^4 and its lever b^5 to move toward the shaft a, for a purpose to be described. On the side of the brake-wheel b^3 of each element B' is formed or secured a gear-wheel b^9, in the teeth of which a tooth a^7, Figs. 3, 4, 6, and 9, slidingly mounted on the shaft a, engages

to turn the said element B′ the space of one tooth when the shaft *a* is turned in one or the other direction, as will be more fully described. A crown-wheel b^{10}, Figs. 4 and 6, having also ten teeth, is secured to the side of the gear-wheel b^9, and this is provided for carrying ten units, tens, hundreds, &c., to the element B′ of the next higher order or deducting ten units, tens, hundreds from such element, according to the direction of rotation of the shaft *a*. For accomplishing such manipulations a spring b^{11}, Fig. 4, having a tooth b^{12} at its free end, is fastened to the recessed wheel b', and this spring-tooth b^{12} is ready to engage a tooth of the crown-wheel b^{10} whenever the numeral "9" is exposed in the sight-hole b^8 of the housing *b*. If then the wheel b' is turned to present a "0" at the sight-hole, the spring-tooth b^{12} is forced, by means of a roller b^{13}, journaled inside the housing *b*, as shown in Figs. 4 and 6, into the crown-wheel b^{10} and turns the wheel b' of the next element B′ one tooth, indicating that ten units, tens, hundreds, &c., have been carried.

The product-indicator C is slidingly mounted upon a way *c*, which is fastened to the angular bed *c′*, forming a sleeve or hollow shaft c^2, journaled to the standards of the machine, as shown in Figs. 1, 2, 7, and 9. Inside the hollow shaft c^2 is contained a sliding bar c^3, which carries at one end the arm c^4, Figs. 7 and 9. This arm c^4 is extended toward the shaft *a* and is provided at its end with a fork c^5, engaging the grooved collar c^6, slidingly mounted on the feathered shaft *a*, and on which the tooth a^7 for actuating the respective elements of the quotient-indicator is formed. The other end of this sliding bar c^3 is provided with teeth, with which the teeth of a gear-wheel c^7, studded to the hinged bed c^2, engage, Figs. 1, 2, 3, and 7.

The housing C′ of the sliding product-indicator C is provided with a rack c^8, meshing also with the gear-wheel c^7 of the bed c^2, so that when the product-indicator is at its utmost position toward the left the arm c^4 is in its utmost position toward the right. In such positions the unit elements of the product-indicator and the operating-indicator are in line with each other, while the tooth a^7, moved along the shaft *a*, is in position to engage the unit element of the quotient-indicator B. If now the product-indicator C is moved one place toward the right, so that the tens element of the product-indicator is in line with the unit element of the operating-indicator, the arm c^4 and tooth a^7 are in position to actuate the tens element of the quotient-indicator.

In the drawings, Fig. 9, the arm c^4 is shown in position toward the left in full lines and toward the right to clearly illustrate the tooth a^7 and its movement.

The product-indicator C is composed of a number of elements *e′*, rotatably mounted on a shaft e^2, contained in the sectional housing C′, and the latter is provided with as many sight-holes e^3 as there are elements *e′*. Each element *e′* comprises a recessed wheel e^4, Figs. 2, 7, and 9, on the peripheral surface of which digits from "0" to "9" are inscribed or printed, so that one number at a time may be seen through the respective sight-hole e^3. On one face of the wheel e^4 is secured a gear-wheel e^5, meshing with the gear-wheel *e*, located in a slot c^9 and journaled to the wall of a section of the housing C′, as shown in Figs. 1, 2, and 7. These elements *e′* are actuated by the teeth d^9 and tens-teeth d^{10} of the operating-indicator A, which mesh with the gear-wheel *e*, as will be more fully described. A spring-lever e^{13} is provided on the housing C′ for each of the gear-wheels *e* to hold and adjust the elements *e′* into proper positions.

On the recessed side of the wheel e^4, or, rather, on the inside of the rim of the wheel, is formed a triangular projection e^6, Fig. 2, acting as a cam for the right-angular lever e^7, Figs. 2 and 7, which is hinged to the wall of a section of the housing C′. One arm of this lever is provided with a roller e^8, and the other arm is normally held in a slot e^{10} by a spring e^{11}, which also tends to keep the roller e^8 in contact with the said rim of the recessed wheel e^4. If an element *e′* of the product-indicator C is rotated by the teeth d^9 of the operating-indicator and the cam e^6 engages the roller e^8, the right-angular lever e^7 is turned about its pivot e^{12} and the free end of the arm e^9 is forced out of its slot e^{10} and against a projection of the lever *f*, forcing the cam-shaped end *f′* thereof into the groove a^5 of the operating-indicator, so that the said end is caused to engage one tens-tooth d^{10} of the operating-indicator and draw it out to engage with the teeth of the gear-wheel *e*. To facilitate this movement, the lower arm of the lever *f* may be provided with a triangular bearing f^2, two sides of which are alternately in contact with a roller f^3, journaled to a lever f^4, pivoted to the frame of the machine. A spring f^5, interposed between the lever f^4 and the machine-frame, always tends to keep the lever *f* in a position as shown in Figs. 1 and 2. If therefore the roller f^3 engages the side of the triangular bearing f^2—*i. e.*, in the other position of the lever *f*—little power is required to force the roller f^3 out of this side of the bearing and the lever *f* into the position as shown.

The levers *f* are automatically brought into the other or normal positions (not shown in the drawings) by the grooves a^5 of the housing of the operating-indicator, which grooves are not cut entirely around the peripheral surface of the said housing, but run gradually at two places a^6 to the surface of the housing, and it is by these wedge-shaped terminations of the grooves a^5 that the levers *f* are brought into normal position when the housing of the operating-indicator is rotated in one or the other direction, as will be readily understood.

The housing C′, composed of sections fas-

tened together, of the product-indicator C is provided near its bottom with an additional rack c^9, Figs. 1 and 7, the teeth of which are pitched the distance between two elements of the operating, quotient, or product indicator, and a tooth c^{10}, Figs. 7 and 9, is provided on either the standard or a part of the frame M of the machine. This rack c^9 and tooth c^{10} are for the purpose of maintaining the various indicators and parts in proper relative position while certain operations are performed by the machine.

To operate the machine, any kind of a crank-lever K may be applied to the main shaft a, provided that the same does not permit more than one rotation in one direction at a time.

In the drawings I have illustrated a crank-motion K, which has been found efficient and which consists of the handle-bar k, secured to the shaft a. To the handle-bar k is slidingly mounted a bolt k', one end of which is constantly pressed into or toward a guide k^2 near the handle k^0 by the spring k^3. The bearing of the shaft a is provided with a circular rim k^4, having a notch k^5, into which a projection k^6 on the bolt is forced by the said spring as soon as one rotation of the crank-shaft a and operating-indicator A is completed. To release the said projection k^6 from the notch k^5 and to make the crank operative the bolt k' is pushed against the action of the spring k^3 until the projection k^6 engages the inside of the rim k^4, allowing the crank K to be turned in any direction, as will be readily understood.

To automatically lock the machine when the quotient-indicator is at zero, a brake is provided on the operating-indicator and consists of a shaft g, journaled in the frame of the machine and extending from end to end thereof, Figs. 3, 6, 7, and 9. At the left-hand end of this shaft is fastened a lever g', to which another lever g^2 is held by the helical spring g^3. Both levers therefore are secured to the shaft g and are provided with oppositely-disposed hooks or projections $g^4 g^5$, Fig. 3. The head a^3 of the housing a' of the operating-indicator A is provided with a circular groove a^8 and two oppositely-disposed notches a^9 a^{10}, into which the said hooks or projections $g^4 g^5$ may enter. Either hook falling into its respective notch, therefore, will lock the machine. The groove a^8 of the head a^3 is of such a width as to allow the passage of the two hooks $g^4 g^5$ when the machine is in operation. At and to the right-hand end of the shaft g and extending the full length of the quotient-indicator B is secured a plate g^5, Figs. 3, 4, 6, and 7, acting as lever for a number of rods i, which are hinged to the outer edge of the plate g^6. There are as many rods i as there are elements B' of the quotient-indicator B. Each rod is provided with a tooth i' on its free extremity, and this extremity is in contact with a pin e^2 on the hinged lever b^5, carrying the brake-roller b^4. When the quotient-indicator is brought to zero position—that is, when the machine is to be locked—the roller b^4 is in contact with the deep indentation y, corresponding to "0" on the wheel b'. The tooth i' on the rod i, contacting with the lever b^5, is therefore in the path of the sliding tooth a^7 of the main shaft a, and when the latter is rotated in one or the other direction it will either elevate or depress the rod i and oscillate the plate g^6, which in turn rocks the shaft g and causes the engagement of one or the other hook g^4 g^5 of the levers g' g^2 with one of the notches a^9 a^{10}, Fig. 3. The hook g^5 of the lever g^2 engages the notch a^{10} when multiplication in the ordinary manner is executed on the machine, and the hook g^4 of the lever g' engages the notch a^9 when the machine is operated and set for division or abridged multiplication.

The lever g' of the shaft g is provided with an extension g^7, Fig. 2, having a trunnion g^8, and on the sleeve c^2 of the bed of the product-indicator is secured an arm c^{11}, to the free extremity of which one end of a rod g^9 is pivoted. The other end is connected to the trunnion g^8 by a slotted connection, so that when the product-indicator C is moved manually the distance of one or more teeth of the rack c^9, which necessitates the said indicator to be oscillated toward the rear of the machine, the hollow sleeve c^2, in order to clear the wheels e from the levers f, the locking of the operating-indicator must be performed, as otherwise the product-indicator cannot be disengaged from the tooth c^{10} of the frame, because the hook g^5 of the lever g^2, which is then contained in the groove a^8 of the head a^3, as well as the extension g^7 of the lever g', and rod g^9 will not permit the disengagement of rack c^9 and tooth c^{10}. It is evident, therefore, that the operating-indicator A is locked when the product-indicator C and the sliding tooth a^7 on the main shaft a are to be moved, which insures the proper setting of the elements of the operating-indicator with the desired elements of the product-indicator, as well as the alinement of the teeth d^9 d^{10} with the gear-wheels e and the alinement of the sliding tooth a^7 with a tooth i' of any one rod i and a gear-wheel b^9 of the quotient-indicator.

The elements of the product-indicator and the quotient-indicator may be readily brought into zero position by turning the respective shafts e^2 b^2, to which knobs e^{14} b^{14} are attached. On the shafts e^2 b^2 and inside the respective indicators are secured to the shafts arms e^{15} b^{15}, adapted to engage pins of the wheels e^4 b', so that when the shafts e^2 b^2 are turned the wheels or elements are brought into the desired zero position.

Any number of elements for the various indicators may be employed. In Fig. 6, for instance, is shown the operating-indicator comprising four elements and the quotient-indicator composed of six elements, while the product-indicator, Fig. 7, contains seven elements. For multiplying numbers the ele-

ments B′ of the quotient-indicator B are set so as to expose the numerals constituting a multiplier through the sight-holes b^8, while the elements D of the operating-indicator A are set to show the numerals constituting the multiplicand. The operating-indicator is then turned in the direction of the arrow, Figs. 1, 6, and 9—*i. e.*, toward the right—by turning the crank K in the same direction. The rotation of the shaft *a* is repeated until all the elements of the quotient-indicator are brought in position to expose the numerals "0," (zero position.) The product of the multiplication is then indicated or shown by the numerals exposed through the sight-holes e^3 of the product-indicator C. It is understood, however, that all the elements of the latter indicator are set at zero position before beginning the operation.

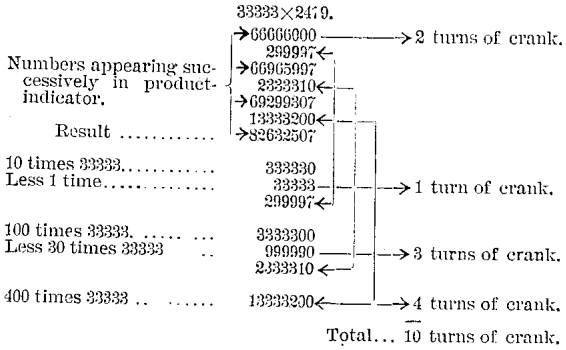
For dividing numbers the elements *e′* of the product-indicator are set to expose the numerals constituting the dividend, while the elements D of the operating-indicator are set to show the numerals constituting the divisor, and the elements of the quotient-indicator are set at zero position. By now turning the crank K in the opposite direction or toward the left the quotient of the division will appear on the quotient-indicator.

In multiplying numbers an abridged method may be employed by which considerable time and labor are saved. If a large number—say "33,333"—is to be multiplied, for instance, with the number "2,479," the operation may be performed on this machine in the same manner as is employed on machines heretofore built—*i. e.*, the multiplication of two factors may be carried on in the usual way and as indicated here:

```
  33333
   2479
---------
 299997     The main shaft thus is to be
 233331     turned 9+7+4+2=22 times.
133332
 66666
---------
82632507    Result indicated on product-indi-
              cator.
```

By my improved machine such operation may be very much simplified, as the operating mechanism may be set to perform the functions in the shortest possible time. In multiplying, for instance, the above factors the operation is commenced by placing the element *e′* respresenting thousands of the product-indicator in a position as that the sliding tooth a^7 of the main shaft *a* is in contact with the element B′, representing the thousands of the quotient-indicator. By now turning the crank twice in the direction of the arrow in Figs. 1 and 9, or toward the right, the number "66666000" will appear in the product-indicator, as shown in the chart below, while the digit "0" of the element B′ of the quotient-indicator B will appear at the sight-hole b^8, which formerly exposed the digit "2."

Chart.



The next operation is to multiply the figures "33333" by "9," the unit number of the multiplier. The product-indicator is therefore moved so that the sliding tooth a^7 of the main shaft *a* is in line with the corresponding part of the element B′ representing the tens of the quotient-indicator B. If now the operating-indicator A—*i. e.*, the shaft *a*—is turned once toward the right, the multiplicand "33,333" would be multiplied ten times instead of nine. This, however, is not desired, and the shaft *a* is turned only once toward the left, by which operation the multiplicand is multiplied by ten less one time the multiplicand. (See chart.) The number in the product-indicator is hereby changed to "66,965,997," while the digit "9" of the unit element B′ of the quotient-indicator is changed to "0." The next favorable step in this operation would be to multiply the multiplicand by the number "7" of the multiplier "2,479," and this is accomplished very quickly by setting the product-indicator C so that the sliding tooth a^7 on the main shaft *a* is in alinement with the corresponding part of the element B′ representing the hundreds of the quotient-indicator. The crank K is again turned toward the left, and in this instance three times, meaning that the multiplicand has been multiplied by one hundred times less thirty times the multiplicand. (See chart.) The number in the product-indicator has by this manipulation been changed to "69,299,397," and the digit "0" of the element B′ of the quotient-indicator appears at its sight-hole b^8. The next and last step in this operation is to multiply the multiplicand with the number "4" of the multiplier, and this is done by leaving the product-indicator in its position, so that the sliding tooth a^7 of the main shaft *a* is in alinement with the element B′ representing the hundreds. The crank is now turned four times toward the right, bringing the element B′ of the quotient-indicator in a position to expose a "0" in the sight-hole b^8. The operation is now completed, and the result, "82,632,507," is shown by the product-indicator C. Instead of having made 9+7+4+2=22 revolutions, as is necessary by machines of other types, only 2+1+3+4=10

revolutions were necessary to produce the same result.

It sometimes may happen by abridged multiplications that when beginning to multiply with a number of a higher order the ciphers remain in the sight-holes at the left end of the product-indicator, and this is due to incomplete manipulation of the tens-teeth d^{10}. Such defects are, however, soon detected by providing an auxiliary lever f, which is arranged at the left end of the operating-indicator, and its free end with a hook instead of a wedge-shaped projection, and the surface of the housing a of the operating-indicator with a groove terminating in a hole, so that when the upper end of the lever f is depressed by the right-angular lever e^7 of the product-indicator it engages the said hole, and thereby stops the operating-indicator and also the machine. This lever f must then be released by hand and the operation be commenced with a number of a still higher order or in the usual way, beginning with the number of the lowest order.

Should a product of a multiplication contain more digits than there are elements in the product-indicator, a signal will be given that the said indicator is not sufficient, and this is accomplished by attaching to the free end of the right-angular lever e^7 at the left-hand end of the product-indicator C a bell-hammer e^{16}, and providing a bell e^{17} against which the said bell-hammer strikes as soon as the said lever e^7 is operated in the usual manner to carry tens from one element to another.

It will be understood by those skilled in the art to which my invention appertains that modifications in the construction and detail arrangements may be made without departing from the spirit of the invention.

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

1. In a calculating-machine the combination of an indicator comprising a cylindrical housing fastened to the main shaft of the machine a number of elements or wheels partly rotatable on said shaft, a set of grooved teeth for each element mounted in apertures of the housing, an operating-lever for each element, a recess in the periphery of each wheel, a plate secured to the inner end of the operating-lever and engaging the grooved teeth, another plate on the periphery of the wheel adapted to receive and hold the teeth transferred from the lever-plate, substantially as and for the purpose set forth.

2. In a calculating-machine the combination of a number of elements or wheels rotatably mounted on a main shaft, a housing fastened to said shaft, surrounding and guiding the said element, a set of grooved teeth provided in apertures of the housing for each element, a curved plate on the periphery of each wheel, a recess formed in the periphery adjacent to one end of the said plate, a hand-lever for each of the elements, a curved plate on the inner end of said lever normally pressed into said recess by a spring, a spring tens-tooth at each end of a set of teeth, before mentioned, mounted in the wall of the housing, a groove extending partially around the housing and adjacent to said teeth, and means for operating the latter, substantially as and for the purpose set forth.

3. In a calculating-machine the combination of two indicators designated as "operating-indicator" and "product-indicator" the operating-indicator comprising a housing secured to the main shaft of the machine, a number of wheels rotatably mounted on the same shaft, a set of grooved teeth for each of the wheels guided in apertures of the housing, a curved plate on the periphery of each wheel, a recess formed in the periphery adjacent to one end of the said plate, a hand-lever for each of the wheels or elements, a curved plate on the inner end of said lever normally pressed into said recess by a spring, operating to project or depress any number of said teeth beyond the surface of the housing and to automatically lock the wheels to the housing and main shaft, a spring tens-tooth arranged at each end of a set of teeth, and normally held within the housing, a groove extending partially around the housing, and a shoulder projecting from each of the said tens-teeth into the said groove; the product-indicator comprising a housing secured to the frame of the machine, a shaft journaled in said housing, a number of elements rotatably mounted on said shaft, said element composed of a wheel having cam-shaped projections and a gear-wheel, a right-angular lever for each element pivoted to said housing, an idle gear and brake wheel studded to said housing, meshing with the gear-wheel and being in line with a set of teeth and the tens-teeth on the operating-indicator, a lever for each element of the latter indicator hinged to the frame of the machine, and adapted to be pressed with its free end into the groove of the operating-indicator by the said right-angular lever to draw one or the other of the tens-teeth partially out of its aperture and into the teeth of the idle-gear, substantially as and for the purposes set forth.

4. In a calculating-machine the combination of the elements or wheels D, teeth d^{10}, setting-lever d^8, main shaft a, elements e^4, gear-wheels e and e^5, levers f and means for operating the levers f to bring the teeth d^{10} into contact with the wheels e, substantially as described.

5. In a calculating-machine the combination of the housing a' secured to the main shaft a, the grooved teeth d^9 and spring-operated tens-teeth d^{10}, elements D rotatably mounted on the shaft a, levers d^8 carrying the plate d^{11}, said plate being normally held in the recess d^{13} by the spring d^{14} and engaging the grooved teeth d^9, plate d^{12} adapted to receive the outdrawn teeth d^9, said plates d^{11} and d^{12} also adapted for locking the element

D to the main shaft a, the housing C', elements e' having gear-wheels e^5, idle-gear wheels e meshing with the wheels e^5 and being in line with projection f' on levers pivoted to the frame of the machine, right-angular levers e^7 having rollers e^8 adapted to ride over cam-shaped projections on the elements e' to bring either a tooth d^{10} into contact with the gear and brake wheel e or cause a signal to be given, and means for bringing and holding the lever f into normal position, substantially as and for the purposes set forth.

6. In a calculating-machine the combination of the frame M, bed c, product-indicator C having rack c^8, gear-wheel c^7, rack c^3, arm c^4, sliding tooth a^7 and quotient-indicator B, substantially as and for the purposes set forth.

7. In a calculating-machine the combination of the frame M, hinged bed c, product-indicator C having racks c^8 and c^9, tooth c^{10} gear-wheel c^7, rack c^3, arm c^4, sliding tooth a^7 and quotient-indicator B, substantially as described.

8. In a calculating-machine an indicator B comprising the housing b, shaft b^2, a number of elements B' each composed of a wheel b', brake-wheel b^3, lever b^5, hinged to the housing b, roller b^4 journaled in lever b^5, gear-wheel b^9, crown-wheel b^{10}, spring-tooth b^{12} and roller b^{13} in combination with a tooth of the main shaft of the machine adapted to engage the said gear-wheel b^9, substantially as described.

9. In a calculating-machine the combination of an operating-indicator comprising a housing fixed to the main shaft, a groove a^8 and recesses a^9 and a^{10} in said housing, a hinged bed for the product-indicator, an extension on said bed, a rock-shaft journaled to the machine-frame and having secured thereto two levers provided with teeth adapted to engage the said recesses, and a connection between said rock-shaft and the extension of the hinged bed, substantially as and for the purposes set forth.

10. In a calculating-machine the combination of an operating-indicator comprising a housing, a groove a^8 and recesses a^9 and a^{10} therein, a hinged bed supporting a sliding product-indicator, an extension c^{11} on the said bed, a rock-shaft g journaled to the machine-frame and having secured thereto two levers g', g^2 provided with teeth adapted to engage the said recesses, an arm g^7 secured to the shaft and a link g^9 between said arm and extension, a quotient-indicator comprising a housing attached to the frame and carrying rotatable elements having brake-wheels b^3 provided with indentations, a deep indentation corresponding to zero on the elements, a roller journaled on a spring-lever hinged to the housing and engaging said brake-wheel, a main shaft, a sliding tooth a^7 on the same adapted to engage any one of the said elements, a toothed lever i for each element hinged to an arm g^6 of the shaft g and contacting with said spring-lever, said toothed lever adapted to contact with the sliding tooth a^7 when the respective element is to be brought into zero position and to lock the main shaft and operating-indicator at such position, substantially as and for the purposes set forth.

11. In a calculating-machine the combination of the elements B' having gear-wheels b^9, and brake-wheels b^3 provided with a deep indentation y, a roller for each brake-wheel journaled to a spring-lever b^5, a main shaft a, a sliding tooth a^7 thereon, an operating-indicator comprising a housing secured to the main shaft, a groove a^8 and recesses a^9, a^{10} in said housing, a rock-shaft, two levers g' and g^2 secured to said shaft and having teeth g^4 and g^5 adapted to engage the said recesses, a plate g^6 attached to said shaft and having as many rods i hinged thereto as there are elements B' and a tooth on each rod i adapted to be engaged by the sliding tooth a^7, substantially as and for the purposes set forth.

12. In a calculating-machine, the combination of the main shaft a, a sliding tooth a^7 thereon, elements B' having a brake-wheel b^3 with a deep indentation y, a roller b^4 in line with the said brake-wheel, said roller pivoted to a spring-lever b^5, a housing a' fast to the main shaft, a groove a^8 and recesses a^9, a^{10} in said housing, a shaft g, levers g', g^2 attached to said shaft and provided with teeth g^4, g^5 adapted to engage the said recesses, a plate g^6 on said shaft g and toothed levers i, substantially as and for the purposes set forth.

13. In a calculating-machine the combination of the operating-indicator A comprising the housing a', teeth d^9, d^{10}, grooves a^5 with terminations a^6, elements D, levers f, sliding product-indicator C comprising the housing C', gear-wheels e and right-angular levers e^7 pivoted thereto, elements e' having cam-shaped projections e^6 corresponding to zero position of the same, and adapted to operate the said levers e^7, f and the teeth d^{10} to bring the latter into engagement with the said gear-wheels e, substantially as described.

14. In a calculating-machine the combination of the main shaft journaled in bearings of the frame, a circular rim attached to one bearing and having a notch, a crank-arm attached to the shaft and provided with a guide, a bolt slidingly mounted in said guide, a projection on said bolt adapted to enter said notch, and a spring tending to force the said projection into said notch, substantially as and for the purposes set forth.

Signed at Aix-la-Chapelle, Germany, this 26th day of April, 1894.

HEINRICH ESSER.

Witnesses:
JOHN HECKMANN,
W. C. EMMET.