(No Model.) 3 Sheets—Sheet 1.

H. HOLLERITH.

ELECTRICAL CALCULATING SYSTEM.

No. 430,804. Patented June 24, 1890.

Fig. 1.

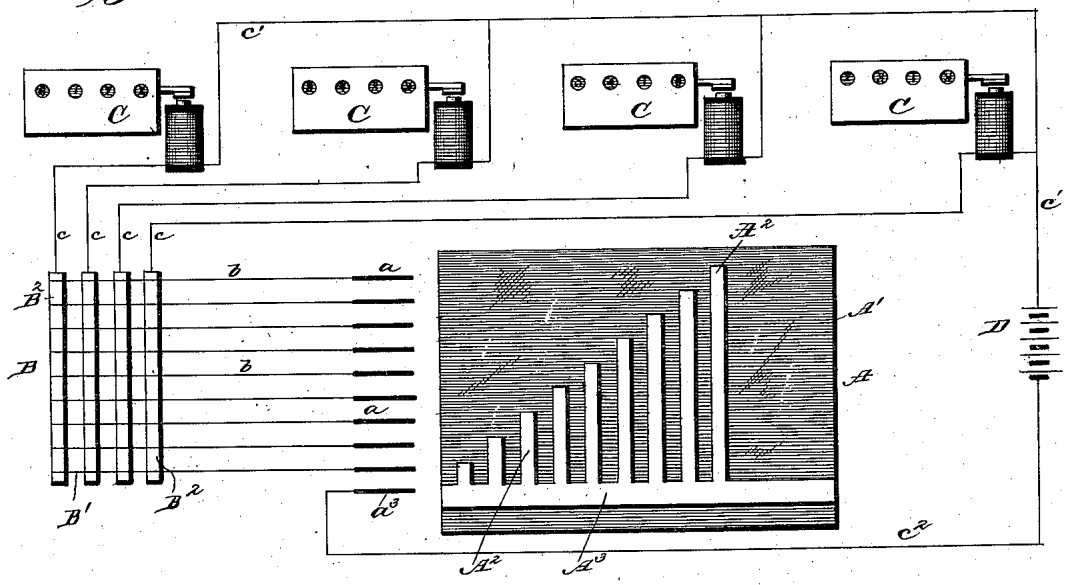


Fig. 5.

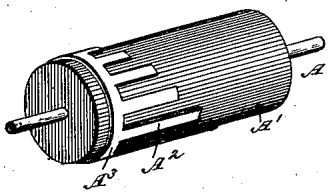


Fig. 6.

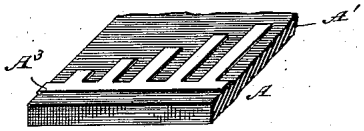
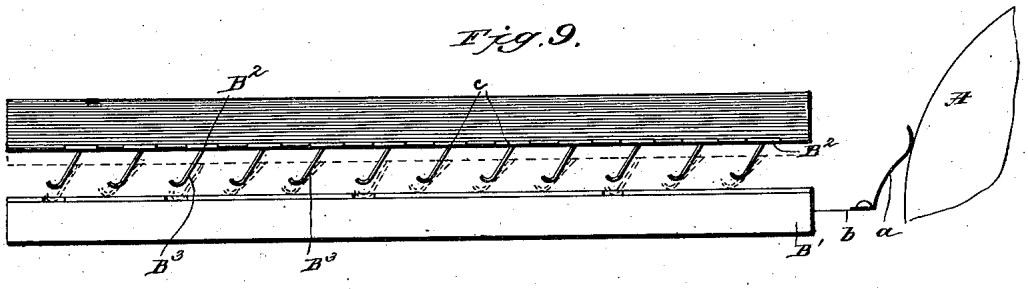


Fig. 9.



Witnesses

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By his Attorneys

Church & Church

(No Model.) 3 Sheets—Sheet 2.

H. HOLLERITH.

ELECTRICAL CALCULATING SYSTEM.

No. 430,804. Patented June 24, 1890.

Fig. 4.

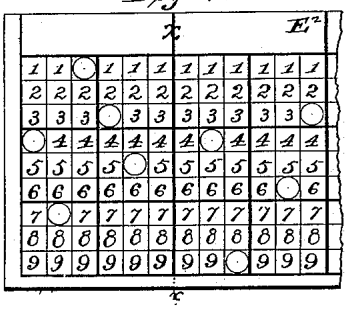


Fig. 7.

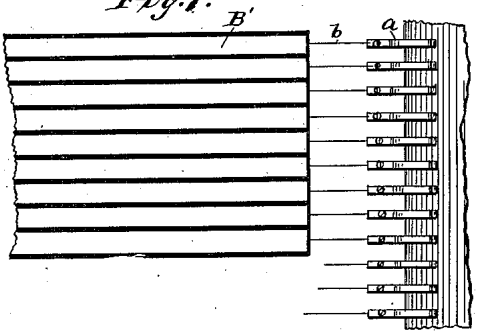


Fig. 6.

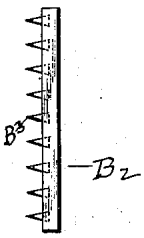


Fig. 2.

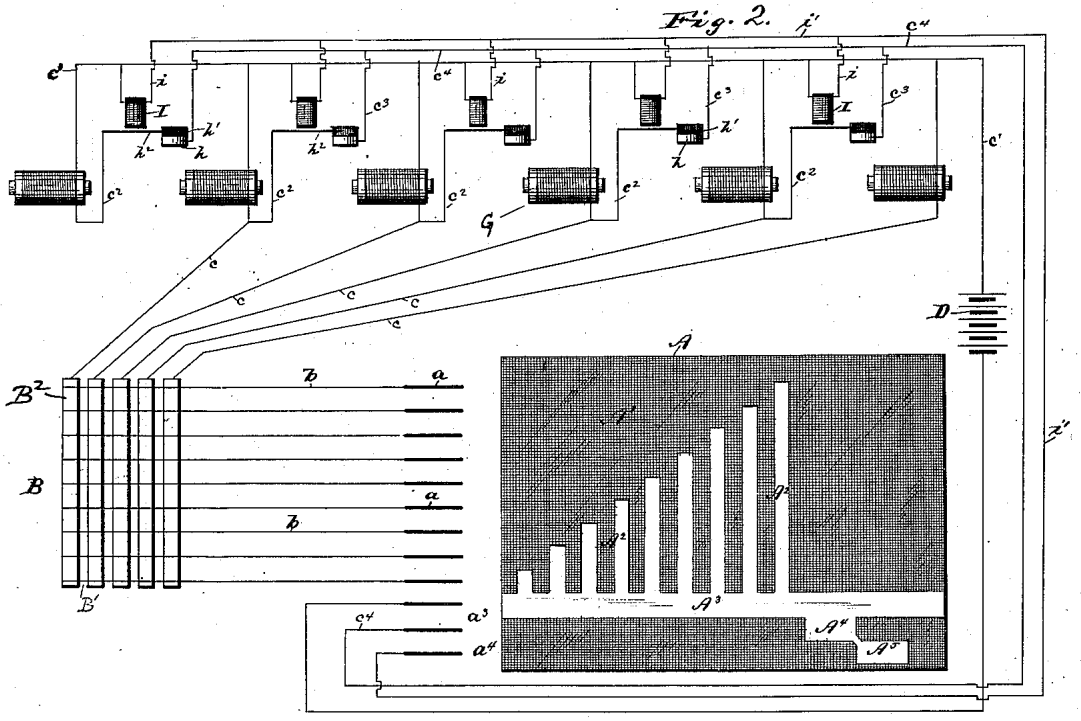


Fig. 10.

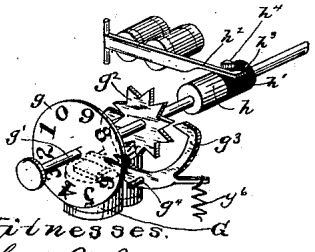


Fig. 11.

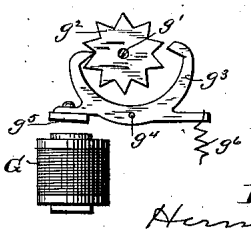
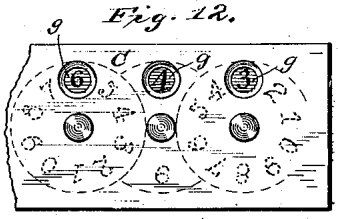


Fig. 12.



Witnesses.
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(No Model.) 3 Sheets—Sheet 3.

H. HOLLERITH.

ELECTRICAL CALCULATING SYSTEM.

No. 430,804. Patented June 24, 1890.

Fig. 13.

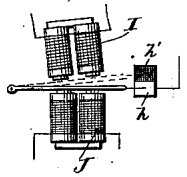


Fig. 14.

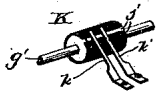


Fig. 3.

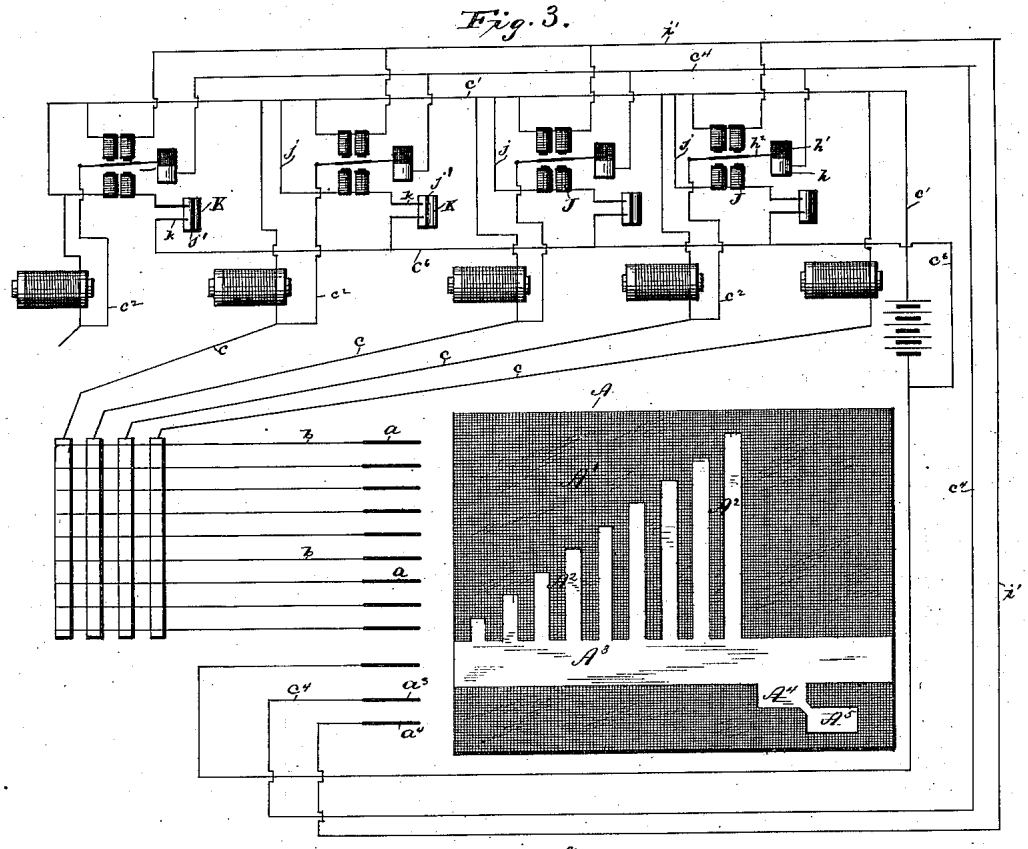


Fig. 16.

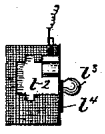


Fig. 15.

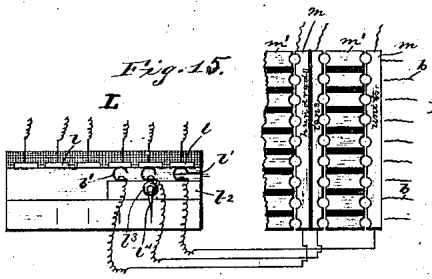
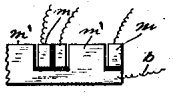


Fig. 18.

Fig. 17



Witnesses.
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R. F. Stewart.

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UNITED STATES PATENT OFFICE.

HERMAN HOLLERITH, OF ST. LOUIS, MISSOURI.

ELECTRICAL CALCULATING SYSTEM.

SPECIFICATION forming part of Letters Patent No. 430,804, dated June 24, 1890.

Application filed January 4, 1887. Serial No. 223,377. (No model.)

To all whom it may concern:

Be it known that I, HERMAN HOLLERITH, of St. Louis, in the State of Missouri, have invented certain new and useful Improvements in Electrical Calculating Systems; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming a part of this specification, and to the letters of reference marked thereon.

This invention relates to a new and improved system and apparatus for automatically effecting certain mathematical computations by the aid of electrical appliances, and, inasmuch as substantially the same method of operation described and claimed in my prior patents, Nos. 395,782 and 395,783, is made use of in a modified form, it may to that extent be regarded as an improvement upon the invention as set forth in said prior patents.

Broadly considered, the present invention in its simplest form embraces the combination with a system, such as described in my prior patent, of what is herein termed an "integrator" or device for automatically producing in any one or more of the circuits, when closed by the record-strips or equivalent switching mechanism, a predetermined number of successive electrical impulses, whereby the registering device or counter is set in operation or advanced as many points as there are electrical impulses sent over the circuit by the integrator. The system as a whole may be said to include, first, a series of separate electrical circuits each containing an electro-magnet operating a mechanical counter or registering mechanism which is caused to be advanced or actuated by electrical impulses proceeding from a generator and traversing the circuits; second, a switch mechanism for putting each of said conductors or wires into connection with any one of a second series of wires or conductors, and, third, an integrating device arranged at a point between the opposite terminals of the first-named series of conductors and the series of conductors connected to the switch mechanism, said integrating device operating to close or interrupt or otherwise vary the conductivity of one or more of the circuits to produce a series of fluctuations in the current or currents traversing said circuit or circuits. The integrating device is arranged to close, open, or otherwise vary in a manner to produce electrical impulses, each circuit leading to the switch mechanism a number of times corresponding to its assigned value. Thus it may operate with respect to the first wire in a manner to produce a single impulse, on the second wire to produce two impulses, on the third three, and so on throughout the series; but until the switch mechanism is operated to close the circuits through one or more of the conductors embracing the registering mechanism no current will flow through said circuit and the register will remain at rest. By means of the switch mechanism any one or more of the conductors containing registering mechanism can be placed in connection with any of the conductors leading to the integrating device, so that as the latter is operated electrical impulses corresponding in number with the assigned value of the conductor will be transmitted through the registering-circuits, and the counters or registers will be advanced accordingly.

The invention also includes new and improved carrying mechanism connecting the counters or registers of a lower with those of the next higher values in the system adopted, a switch mechanism for facilitating the process of multiplication and division, and several other minor improvements in the construction and arrangements of parts, as hereinafter more fully described and pointed out.

In the accompanying drawings, illustrating the application of my said invention, Figure 1 is a diagrammatic view of my improved system as arranged for adding totals. Fig. 2 illustrates a modified form of apparatus including automatic carrying devices. Fig. 3 is a diagrammatic view of the apparatus with a modified form of carrying mechanism applied thereto. Fig. 4 illustrates a form of record card or strip suitable for setting the switch mechanism. Figs. 5 and 6 represent in perspective curved and flat integrators. Figs. 7, 8, and 9 illustrate details of a switch mechanism such as may be employed in connection with the record-strips. Figs. 10, 11, and 12 illustrate details of registering mech-

anisms suitable for use in connection with the present system, a part of the carrying system being also included in Fig. 10. Figs. 13 and 14 illustrate two forms of switches forming part of the carrying mechanism as arranged in Fig. 3. Figs. 15, 16, 17, and 18 illustrate detached parts of a modified form of the switch mechanism found in Figs. 1, 2, and 3, together with a switch for use in multiplying and dividing.

Similar letters of reference in the several figures indicate the same parts.

Referring more particularly to the form of apparatus as shown in Fig. 1, A is the "integrating device," so called; B, the switch mechanism, and C the mechanical counter or other suitable form of registering device for noting the number of electrical impulses sent over the circuit.

The integrator or multiplier A is composed, essentially, of a surface A′ of non-conducting material, having embedded or otherwise secured thereto a graduated series of conducting-strips A^2, electrically connected to a common conductor A^3. The conductors A^2, preferably nine in number, are disposed in the order of their relative length across the non-conducting base A′.

The switch mechanism B is composed of a series of insulated conductors B′, corresponding in number with the strips A^2 of the integrating device, and facing said conductors B′ is a second series of conductors B^2, arranged transversely of the conductors B′, and each of said conductors B^2 is provided with a contact point or spring B^3 opposite each conductor B′, so that when the two members of the switch are brought together each conductor B^2 will, through the springs B^3 attached thereto, be placed in electrical contact or connection with all of the strips or conductors B′.

To each conductor B′ is attached a wire *b*, whose opposite end is furnished with or attached to a spring-finger or contact-point *a*, located and maintained in such relation to the strips A^2 of the integrating mechanism that when the latter is operated each finger *a* will make contact with one or more of said strips A^2, according to its location. To effect this operation, the fingers *a* may be drawn across the strips on the integrator, or the latter may be moved by and in contact with the former, or both may be moved simultaneously either by hand or mechanical devices. For convenience I prefer to mount the strips A^2 A^3 upon a drum supported to rotate about an axis parallel with the strips A^2.

To each strip or conductor B^2 of the switch mechanism is connected one end of a wire *c*, each of the latter including the coils of an electro-magnet or other equivalent device for operating a counter C, connected therewith, and said wires *c* are connected at their other ends to one pole of an electric generator D, or, what is the same thing, to a wire c'', which is in turn connected to the generator. The opposite pole of the generator is connected by a wire c^2 with a contact-finger a^3, resting upon the strip A^3 of the integrator.

As before mentioned, the several conducting-strips A^3 are of different lengths, and the several contact-fingers *a* are so arranged relative thereto and to the direction of motion of the integrator, that the first contact-finger shall touch but one strip, another two, and so on through the series, each finger engaging a different number of strips. As thus arranged, at each complete movement of the integrator the several wires *b* leading to the switch mechanism will each be placed in electrical communication with the generator D one or more times, according to the number of strips A^2 that its finger *a* is brought into contact with successively, so that when any one or more of the wires *c* are placed in electrical communication with the wires *b* through the switch mechanism a series of electrical impulses will be produced to actuate the counters, and the number of such impulses will depend upon the number of contacts made by the finger *a* of the wire *b*, with which the former is connected.

The counters or registers C, as arranged in Fig. 1, being located in separate circuits, each represents a distinct class of items pertaining to the system employed. Thus the first register represents the units, the second the next higher value, and so on throughout the whole series. In the example given the apparatus is arranged according to the decimal system for adding totals, the first register indicating the units, the second tens, the third hundreds, and so on to any desired degree. With the devices arranged as described any required number of units belonging to each of the classified series can be added or indicated on the register or counter belonging to that series by placing the wire *c* in connection with that one of the wires *b* whose finger is in position to engage the series of strips A^2 on the integrator corresponding with the number of units to be added in said series. For example, suppose the sum to be added is 2,346, the wire *c*, controlling the thousands-counter, would be connected to the wire *b*, whose finger *a* engages two of the strips on the integrator; the circuit controlling the hundreds-counter would be connected with the finger making three contacts; the circuit controlling the tens-indicator would be connected with the finger making four contacts, and the circuit containing the units-indicator would be connected to the finger making six contacts. These connections having been made by the switch mechanism, the integrating device is set in action or given one revolution, when, by the action of the successive contact of the strips with the series of fingers, two electrical impulses will be transmitted over the thousands-circuit, three over the hundreds, four over the tens, and six over the units, advancing the counting or registering mechanisms in each circuit as many points as there are electrical

impulses generated in each circuit. To add any amount to the sum thus registered, it is only necessary to arrange the circuits in the manner described according to the numbers accruing in each division and again operate the integrator, when each counter or register will be advanced as many points as there are units of its class contained in the amount to be added. As is obvious, numerous well-known arrangements and modifications of switch mechanism may be employed for thus effecting the proper adjustment of the circuits; but that preferred for various reasons is based upon the principle made use of in the system described in my prior patents.

The record-strip or switch-operating device E^2, Fig. 4, is but a modified form of the record-strip described in my prior patents hereinbefore referred to.

The card or record strip is divided in one direction by actual or imaginary lines into as many spaces as there are registers or counters, and each space is subdivided into as many parts as there are units in the particular division of the system to which they relate. Thus when, as in the illustration given, the decimal system is adopted, the first division or column on the right will represent units, the next tens, and so on, and each column will be again divided into nine divisions representing nine units, and numbered 1 to 9, as in Fig. 4. Each division and subdivision has a fixed relation to all the others and to the standard, and has a definite value, as described in my prior patents, and the sum to be added or registered is recorded in like manner—that is to say, each figure occurring in the amount as written represents a certain characteristic pertaining to that particular thing—*i. e.*, the amount represented in figures; and these characteristics are recorded on the record strip or card by punching holes therein. Thus in Fig. 4 I have shown a card upon which has been recorded 471,350,049,063, or, if divided on the line *x x*, two record-strips containing the one 471,350 and the other 49,063. The switch with which this card E^2 is designed to co-operate is shown in Figs. 7, 8, and 9, and consists of two members, the one composed of a series of bars or conductors B′, each connected by a wire *b* to one of the contact-fingers *a*, and the other of bars or conductors B^2, each connected to one of the circuit-wires *c* and provided with a series of spring fingers or contacts B^3. The several bars or conductors B′ are so arranged that each one shall coincide with one row or series of subdivisions on the record-strip, representing the number of units in the several divisions, while the bars or conductors B^2, each representing one of the main divisions of the series or table, are so arranged relative to the divisions on the record card or strip that the springs or contact-fingers B^3 of each strip will correspond with each subdivision or unit of its particular division and will be in position to make electrical contact with all of the strips B′. The record card or strip, being composed of insulating material, operates, when interposed between the sections of the switch, to hold the springs B^3 at all points, excepting when the perforations occur, and at such points permits the spring to be pressed into contact with the bars B′, thus closing the appropriate circuit or circuits in accordance with the location of said perforations. As is obvious, instead of employing open circuits, as described, the same results may be accomplished in substantially the same and equivalent manner with normally-closed circuits, in which case the record strip or card should be correspondingly modified.

Thus far we have considered only the simplest form of apparatus, as illustrated in Fig. 1, wherein a recording mechanism is employed for each division or value according to the system employed, and in order to ascertain the sum total it is necessary to add together the several partial totals, as indicated by the registers, and although the decimal system has been adopted as the simplest for illustration, it is obvious that the same principle is applicable to other systems or scales. Thus the first register may be used to designate the units or fractions thereof of the scale adopted as ounces, gills, inches, &c.; the second register, the next higher division, as pounds, pints, feet, &c., and so on in succession to any desired degree, the number of contacts on the integrator being modified to suit the particular scale.

In order to avoid the necessity which would otherwise arise for computing the several amounts or partial totals registered by the indicators to find the total amount, I have introduced an automatic carrying device, whereby each counter registers the units only of its division on the scale and advances the register of the next higher division one point each time the lower counter has registered as many points as the units of its division are contained in the units of the next higher division. An apparatus involving this principle is illustrated in Fig. 2, where the automatic carrying device is shown as connected in a system such as previously described with reference to Fig. 1. The integrator, switch mechanism, circuits, and electro-magnets of the registering mechanisms here shown are the same as in Fig. 1; but the indicator of the register is divided into ten parts, (when the decimal system or scale is adopted, the number of divisions used depending upon the number of units contained in the particular subdivision of the scale employed,) lettered from 0 to 9, and the propelling mechanism of any approved form is so constructed and arranged that each electrical impulse sent through the coil of the electro-magnet will advance the indicator one space or division.

In Figs. 10 and 11 I have illustrated a well-known form of actuating mechanism, wherein

g is the indicator in the form of a disk mounted upon a spindle g', and g^2 is an escapement-wheel, whose teeth are engaged by the anchor g^3, pivoted as at g^4, and provided with an armature g^5 opposite the core of the electro-magnet G. A spring g^6, (or weight,) attached to the anchor g^3, acts in opposition to the electro-magnet, so that each time an electrical impulse is sent through the coil of the electro-magnet G the armature will be attracted and released, thereby vibrating the anchor, and through the action of its arms on the escapement-wheel the indicator will be caused to advance one division.

Upon the spindle g' of the registering mechanism, or any other part moving in unison with the indicator, is located the device or devices for automatically actuating the switch for closing and opening a circuit, including the electro-magnet G of the register belonging to the next higher subdivision of the scale. A switch mechanism suitable for the purpose is shown in Figs. 2 and 10, wherein h represents a metallic or conducting cylinder or surface, and h' a non-conducting cylinder or surface, both of said cylinders being mounted upon or moving in unison with the spindle g'.

Above the cylinders h and h' is arranged a pivoted or movable arm h^2, whose outer or free end is provided with an inclined arm or projection h^3, and upon the insulating or insulated drum h' is secured a pin or cam projection h^4 for engaging the end of the arm h^2 and forcing the latter over onto the conducting-drum h. The pin h^4 and the arm h^2 are so arranged relatively to the marks on the indicator that as the indicator passes from the last or ninth division to the zero-mark the arm h^2 will be shifted from the non-conducting surface of the switch onto the conducting-surface, and thus close a circuit. The circuit last referred to is independent of the main circuit, passing through the switch mechanism B, and may be arranged as follows: To the wire c, at a point intermediate of the switch B and electro-magnet G, is attached a wire c^2, whose opposite extremity is connected to the switch lever or arm h^2. The drum or conducting surface h is electrically connected to a wire c^3, whose opposite end is connected to a wire c^4, common to the several registers. This wire c^4 terminates at a spring finger or contact a^3, located in such relation to the integrator A as to make contact with a conducting-surface A^4, which latter is arranged in rear of the strips A^2 and is electrically connected to the strip A^3.

The operation of the carrying mechanism is as follows: The carrying mechanisms are the same in each of the registering mechanisms, with the exception of the first and last in the series, the first being provided with the switch only and the last with the circuit-connections; hence a description of one circuit will answer for the whole series. Assuming the register to indicate 8, and it is required to add eight units in that division. The switch mechanism B having been set, as before described, and the integrator rotated or advanced to produce in the main circuit eight separate electrical impulses, the indicator will be rotated or advanced eight points or divisions, or from eight to six. As the indicator passes from nine to zero the switch-arm h^2, which previously rested upon the non-conducting surface of the switch, will be thrown over onto the conducting surface, where it will remain, thereby closing at this point the circuit, of which the wires c^2, c^3, and c^4 form part. This circuit, although closed through the arm h^2 and conducting-surface of the switch, is not closed through the battery, as the spring-finger a^3 rests upon the non-conducting surface or portion of the integrating device. As soon, however, as the strips A^2 have passed beyond or out of contact with the finger a in the main circuit, the finger a^3 is brought into contact with the conductor A^4, thereby establishing electrical communication with the battery and producing a single electrical impulse in the circuit passing through the electro-magnet G of the registering mechanism belonging to the next higher division and advancing the indicator one point or division. Thus each time any one of the indicators passes from nine to the zero point, it establishes circuit-connections with the next succeeding register, without, however, interfering with its action as controlled by the strips A^2 of the integrator, and after the units of the several divisions have been correctly registered the carrying is automatically effected. As with the arrangement described it is necessary that the switch-arm h^2 should be shifted onto the conducting portion of the switch when the indicator passes from the last figure to the zero-point, and should remain in that position to hold the circuit closed while the remaining units in the particular division are being registered, and until the finger a^3 makes contact with the conducting-surface a^4, it is necessary that some means be employed for withdrawing the arms h^2 from contact with the conducting-surface before the integrator is again actuated. As is obvious, this operation can be accomplished by hand or by mechanical devices; but I prefer to employ electrical devices controlled by the movement of the integrating devices, so arranged that after each computation has been made the switch-levers will be automatically retracted or returned to their normal positions preliminary to the next operation. This result may be accomplished by arranging an electro-magnet I opposite each switch-lever h^2, and in position to move the latter when released from the shifting pin or device from the conducting to the non-conducting surfaces of the switch when said electro-magnets are energized. The wires forming the helices of these electro-magnets are connected at one end to the wires c, attached to one pole of the battery, and at the other by wires i to a wire i' terminating in a

spring or contact finger a^4 located adjacent to the multiplier A and in line with a conductor A^5 thereon. This conductor A^5 is connected electrically with the conducting-strips A^3, in communication with the opposite pole of the battery, as before described, and is located in rear of the conductor A^4, which sends the electrical impulses through the switches of the carrying devices, so that after the electrical impulse has been transmitted through the circuits including the switches of the carrying devices previously set in the manner described, to advance the indicator of the next higher division on the scale, an electrical impulse will be transmitted through the circuits including the electro-magnets I, causing the latter to attract the switch arms or levers h^2 and move them back, thereby breaking the circuits through the carrying devices and simultaneously carrying the said switch arms or levers into position to be engaged by the shifting devices when the indicators are again advanced. As will be readily understood, with a system arranged and operating substantially as described above, the totals of the various computations can be read at once from the series of indicators or registering mechanisms, as each represents the units only of its particular subdivision on the scale adopted.

Instead of employing mechanical devices for shifting the switch-levers of the carrying devices, as described and illustrated in Fig. 2, the same results may be accomplished and in a like manner by the employment of electrical shifting or shunting devices, and an arrangement of this kind is illustrated in Fig. 3, the same being regarded as one of the numerous modifications of the invention which would readily be suggested to a person skilled in the art. The integrating mechanism A, switch mechanism B, registering devices C, carrying devices, and switch-retracting devices shown are substantially the same as heretofore described and shown in Fig. 2. Instead of employing a mechanical contrivance for shifting the switch-lever h^2 onto the contact for closing the circuit passing through the electro-magnet G belonging to the indicator of the next division of the scale, an electro-magnet J is arranged to act upon each switch-lever h^2 to draw the latter over onto the contact-surface of the carrying-switch whenever a current is sent through its helix. The conducting and insulated sections $h\,h'$ of the carrying-switch are in this instance shown as flat plates, Fig. 13, a well-known equivalent for the rotary switch shown in connection with the system illustrated in Fig. 2, and which can be used, if desired, in said system. Each registering mechanism C, with the exception of the last in the series, is furnished with an automatic switch or circuit-breaker K, Fig. 14, moving in unison with the indicator, and, if desired, connected to the spindle g' of the register, its function being to close a circuit including the electro-magnet J of the next register, and thereby effect a movement of the switch-lever h^2 onto the conducting-section h of the carrying-circuit whenever the indicator passes from the last number to the zero-point. Each electro-magnet J is located in a separate circuit j, between wires c' and c^6, the latter being connected to the opposite poles of a battery or generator. Each circuit j when closed passes through a conducting strip or portion j' of the switch or circuit-closer K, the connection being made through contacts k, bearing upon the switch K, which latter is composed of non-conducting material and carries the conducting-strip j', so that the circuit j remains broken and its electro-magnet J inactive during the major portion of the revolution of the switch K and until the conducting-strip j' connects with and bridges the interval between the contacts k, and this takes place whenever the indicator is carried forward to or beyond the zero-point. The shifting of the switch-arm h^2 closes the circuit through the electro-magnet G of the next registering mechanism, so that the latter will be actuated when the finger a^3 makes contact with the conducting-strips A^4, after which the switch-arms are withdrawn from their contacts and the circuits broken by the action of the electro-magnets I, as before described.

Thus far in explaining the invention the systems and apparatus have been described as used for effecting the addition of sums or values and registering the totals; but its capacity is not limited to such computations, as the same apparatus may be employed for working out and registering sums in multiplication, and, if desired, adding the product to the amounts previously registered. To effect these operations it is only necessary to arrange the switch mechanism of the main circuits in such manner that each circuit containing the register corresponding to several divisions found in the multiplicand shall be placed in communication with that one of the circuit-breakers of the multiplier A whose contacts correspond in number with the units of the division. Thus if the multiplicand is 436 the circuit c of the hundreds-register will be placed in communication with the finger a, making four contacts, the circuit of the tens-register will be connected to the finger making three contacts, and the circuit containing the units-register will be connected to the finger making six contacts, so that at each complete rotation or movement of the integrating devices the registers will be advanced to indicate the sum of 436. By repeating the movement of the integrator or circuit-breaker A as many times as the unit is contained in the multiplier the product will be registered. If instead of repeating the action of the circuit-breaker or integrator for each unit the circuits leading from contact-fingers a are shifted to connect with the wires c of the registers in the next higher division of the decimal scale, it will have the effect

of increasing the value of the multiplier ten points or one division at each rotation of the circuit-breaker, and by so doing the process will be greatly simplified and abridged. Thus assuming that three hundred and forty-six is to be multiplied by three hundred and forty-six. The switch mechanism having been set as before described, and the integrator or circuit-breaker A rotated six times, the registers will be advanced to indicate 2,076, being the product of three hundred and forty-six multiplied by six. The circuit-connections are now changed, so that the three fingers *a*, making, respectively, three, four, and six contacts, shall be placed in circuit with the registers of the thousands, hundreds, and tens, thereby multiplying or increasing the register effected by each rotation of the circuit-breaker ten points. The circuit-breaker or integrator A is now rotated four times, advancing the registering mechanisms thirteen thousand eight hundred and forty points, (three hundred and forty-six multiplied by forty,) which, being added to the 2,076 previously registered, will give as the total 15,916, which is the product of three hundred and forty-six by forty-six. The circuits being again changed to connect the third, fourth, and sixth fingers *a* with the ten thousands, thousands, and hundreds registers, respectively, thereby multiplying the value of each rotation of the circuit-breaker one hundred times, the integrator or circuit-breaker A is rotated three times, thereby adding the sum of one hundred and three thousand eight hundred (three hundred and forty-six multiplied by three hundred) to the amount previously registered, making the total 119,716, which appears upon and can be read at once from the several indicators. This changing of the circuits for multiplying can be accomplished either by shifting the record card or strip (when that form of switch-operating device is used) laterally, so as to transfer the perforations in each division to the strip B^2 of the next or a higher division, at the same time retaining contact with the same line of the strip B′, as before, or a separate switch mechanism—such, for example, as shown in Figs. 15 and 16—may be located between the switch mechanism B and counters C. This switch L contains a series of contact-plates *l*, corresponding to the number of counters and divisions in the scale, each strip *l* being connected to one of the wires *c* in circuit with the electro-magnet for operating the registering or counting mechanism. The wires leading from the contact plates or strips B^2 are each connected to an insulated spring-contact *l′*, mounted upon a movable block or carriage l^2, provided with a knob or handle l^3 and carrying a pointer l^4. When used for simple addition, the block l^2 is placed at one extremity of the switch with the springs *l′*, bearing upon strips *l* in their regular order, thus closing the circuits *c*, as before described. Whenever the multiplier is to be raised or increased the value of one or more divisions on the scale, the block l^2 is moved until the springs *l′* of all the circuits are advanced the same number of divisions and brought into contact with the desired series of strips B^2, which is determined by the position of the pointer l^4.

As hereinbefore intimated, it is not essential to the operation of the system described, although deemed a desirable feature, that the setting of the circuits controlled by the integrator should be effected through the instrumentality of perforated record strips or cards and a switch mechanism such as described, as other equivalent devices may be employed for the purpose. One such modification is shown in Figs. 15, 17, and 18, wherein *m* represents a series of insulated conducting-strips corresponding in number with the registering mechanisms and connected to the wires *c*. A similar series of conducting-plates *m′*, corresponding in number with the fingers *a* and connected thereto by wires *b*, are arranged near the strips *m*, so that by inserting pins m^2, of conducting material, between the strips *m* and any one of the strips *m′* the circuits leading to the registers can be placed in communication with any of the contact-fingers *a* to send the desired number of electrical pulsations or impulses through the registering-circuit. In this instance, instead of locating the circuits by the perforations and then setting the switches with the cards, the locating and setting are simultaneously effected by hand.

One of the many advantages obtained by my improved system is the setting up in a manner to be read, compared, and, if necessary, corrected, the amount to be added before the operation is performed, thus avoiding errors in computation arising from mistakes. Thus when a given amount is to be added or used as a multiplier it is first set up or recorded, either by means of perforations in the strips or cards or by properly locating the contacts in the switch, and the sum thus registered can be read off and compared to ascertain if it is correct. If found correct, the remainder of the process is purely mechanical in adding and merely requires the shifting of the circuits in multiplying, as hereinbefore explained, a single complete rotation or movement of the integrating device serving to actuate all the circuits in which additions are to be made, and with the automatic carrying devices applied no further attention or manipulation is necessary.

Although I have shown but a single battery or generator for supplying the current for the several circuits, it is obvious that a separate generator may be used in each of the principal circuits or for two or more of said circuits. Other forms of counting or registering mechanisms may also be employed, it being essential only that they respond to the electrical impulses traversing the circuits.

In describing my improved system and apparatus I have only explained its use in effecting computations involving the multiplication and addition of quantities; but, as will be readily understood by those skilled in the use of such devices, sums in subtraction and division can as well be accomplished, the only alteration or modification required being such as relate to the arrangement of the actuating devices of the registering mechanism or the arrangement of the figures on the dials relative to the direction of movement. Thus the anchor movement, as shown in the illustration, may be adjusted so as to expose the numbers on the dial in the order of their succession from 0 to 9, or it may operate in the reverse direction to expose the numbers in the opposite order from 9 to 0, thereby adding or subtracting a unit in the division at each reciprocation of the armature, and the same result can be secured by the employment of a double series of figures arranged in reverse order on the dial, or different dials may be employed in connection with the same actuating mechanism, the one used for adding and multiplying values having the figures arranged as shown in the drawings, while the other, for use in subtracting and dividing, having the figures arranged in the reverse order. When the apparatus is thus arranged, so that the succession of index points or figures of each registering mechanism will be exposed or indicated in the reverse order—*i. e.*, from 9 to 0 instead of 0 to 9—and it is desired to subtract a certain amount from a given sum the operations performed are the same as in adding that amount. Thus if three hundred and ninety-two is to be subtracted from nine hundred and sixty-five, which latter amount has been previously ascertained by or is indicated upon the several registering devices by a proper manipulation of the circuit-connections or by setting the pointers or dials to indicate said amount, the card is punched at 3 in the hundreds, 9 in the tens, and 2 in the units and inserted between the numbers of the switch mechanism.

Upon operating the integrating devices, as hereinbefore explained, the units-dial will be moved two points, from 5 to 3, the tens-dial will be moved nine points, from 6 to 7, (if the carrying device is employed, the circuit through the hundreds-dial will be closed as the tens-dial is moved from 1 to 0,) and the hundreds-dial will be moved four points, three from 9 to 6 by the direct action of the integrator as controlled by the circuit closed through the perforation in the hundreds-column of the record card or strip and one from 6 to 5 by the action of the circuit controlled by the carrying devices belonging to the tens-register. Thus the dials will be caused to indicate 573.

Sums in division are performed in a manner the reverse of multiplication. To illustrate this, let it be assumed that the registers indicate 119,716, which sum it is required should be divided by three hundred and forty-six. The divisor 346 is recorded on the card, as before, and the circuits through the hundreds, tens, and units registers are closed through the fingers, making three, four, and six contacts, respectively. Each time the integrator is operated 3 4 6 will be deducted from the dividend, and by counting the number of times the integrator has to be operated to bring the registers to zero or has to indicate an amount less than the divisor 346 the number of times the divisor is contained in the dividend—*i. e.*, three hundred and forty-six times—will be ascertained. Should the registering device indicate a sum less than the divisor, the amount so indicated will represent the remainder.

As when used for multiplying the operation can be shortened by the employment of switching devices, such as L, for transferring the circuits from a higher to a lower division instead of from the lower to the next higher as in multiplying. Thus the dividend being 119,716 and the divisor indicated by the card 346 it is observed at a glance that the divisor is contained within the dividend more than one hundred times; hence the switch L is operated to increase the divisor one hundred times—that is to say, the third, fourth, and sixth fingers are connected with the ten-thousands, thousands, and hundreds registers, respectively. The integrator is now set in motion, each time subtracting 34,600 (346×100) from the dividend, and this operation is repeated until the dividend is observed to be less than the divisor ($346\times100=34,600$.) The number of times the integrator is operated to produce this result will represent the hundreds of times the divisor 346 is contained in the dividend—*i. e.*, three. In other words, the amount subtracted from the dividend will be $346\times300=103,800$. A record is made of the number of times—three—the integrator has been operated and the switch L is again adjusted by connecting the third, fourth, and sixth fingers with the thousands, hundreds, and tens registers, respectively, representing $346\times10=3,460$. The integrator is again set in motion and operated until the dividend has been reduced below three thousand four hundred and sixty, which will require four movements, representing $3,460\times4=13,840$, the amount subtracted from 15,916, (119,716—103,800,) leaving 1,076. A record is now made of the number of times—four—the divisor is contained in the dividend. The switch L is again changed, connecting the fingers to the hundreds, tens, and units registers, and the integrator operated until the dividend 1,076 is reduced below the divisor 346. In the example given six operations of the integrator (6×346) will cause the registers to stand at zero. It is thus shown by the operations described that 346 is contained in 119,746, $300+40+6$, or three hundred and forty-six times, as ascertained by first subtracting $346\times100\times3$, then $346\times10\times4$, and finally 346×6.

I claim as my invention—

1. The hereinbefore-described improved system for automatically effecting mathematical computations, comprising the following instrumentalities: a switch mechanism in two sections, each of the latter comprising a series of insulated conductors, with means for connecting any one or more of the conductors of one section with any one or more of the conductors of the opposite section, a series of circuit-wires, each connected to one of the conductors forming one section of the switch and to a generator, and embracing electrical devices controlling a registering mechanism, a second series of circuit-wires each connected to one of the series of conductors forming the other section of the switch, and an integrating mechanism located between the generator and the said second series of circuit-wires and operating to vary the resistance of the circuit leading from the generator to the switch mechanism in a manner to produce in each of the circuit-wires of the second series a predetermined number of electrical impulses, whereby when any wire of the second series is connected through the switch with one or more of the wires of the first series the registering mechanisms connected to said wires will be actuated or advanced as many points as there are electrical impulses created by the integrator in the particular wire so connected.

2. The hereinbefore-described improved system for automatically effecting mathematical computations and indicating the result obtained by means of a series of registering devices, consisting in the combination, with each of said registers, of an electrically-operated controlling device included in an independent line or circuit, an integrating device and a series of wires or circuits connected thereto and operating to produce in each of said last-named wires a separate series of electrical impulses, a generator, and the switch for connecting any one or more of the wires or circuits leading from the integrator with any one or more of the circuits containing the operating mechanism of the registers, substantially as described.

3. The improved system for automatically effecting mathematical computations and recording the results upon a series of registering devices, substantially as described, which consists in the combination, with the separate registers and electrical devices operating thereon and included in separate circuits, of generators for charging said circuits, a switch mechanism for connecting any one or more of said circuits with the wires of a second series of conductors, an integrating device operating in conjunction with said second series of conductors to produce a different number of electrical impulses in each, and an automatic conveying device acting in unison with the register of a lower value for throwing the actuating mechanism of the next higher register into a branch circuit, over which an electrical impulse is sent after the integrator has ceased to act upon the main circuits, substantially as and for the purpose set forth.

4. In a system such as described, the combination, with a series of registering devices, a separate circuit-wire for each register, a switch mechanism to which wires are connected, a second series of wires also connected to the switch, an electrical generator, and an integrating device connected to the generator and controlling the flow of electricity in said second series of wires to produce a separate series of electrical impulses in each wire, substantially as and for the purpose set forth.

5. In a system such as described, and in combination with a series of circuits, each containing an electrical device controlling a registering mechanism, an integrating device controlling the passage of the current from the generator to a series of conductors to produce a separate number of electrical impulses in each of said last-named series of conductors, and a switch mechanism for connecting any one of the wires of said series with any one or more of the wires of the first-mentioned series.

6. In a system such as described, the combination, with a generator and a series of circuit-wires connected thereto and to one section of a switch mechanism, of a second series of wires connected to the opposite section of the switch, and an integrating device provided with a series of sets of contacts, each set containing a different number of contacts, and co-operating with one of said second series of wires, whereby when said integrator is operated a different series of contacts or impulses will be produced in each of the several circuits, substantially as described.

7. In a system such as described, and in combination with the series of circuits, each including electrical registering devices and connected to a switch mechanism, a second series of conductors connected to the opposite section of the switch, and an integrating device operating to produce a series of electrical variations in each of said series of conductors when in circuit with a generator, of a card or sheet perforated at predetermined intervals and interposed between the sections of the switch mechanism, the contacts of the latter being effected through the perforations in the card or sheet, substantially as and for the purpose set forth.

8. In a system such as described, embracing registers, electrical devices for controlling said registers, and a series of circuit-wires connected to a series of conductors forming one member of a switch mechanism and in combination therewith, a second series of wires connected to the conductors of the opposing section of the switch, a sheet or card perforated at intervals to permit contact to be made between the conductors of the two sections of the switch at predetermined points, and mechanism for producing electrical impulses in each of said second series

of wires, substantially as and for the purpose set forth.

9. In a system such as described, the combination, with the switch, the perforated record-strip, through which connection between the switch-sections is established and controlled, and the two series of wires connected to the opposite sections of the switch for establishing electrical connection between the wires of the one series with those of the other, of a registering mechanism and electrical controlling devices connected to each wire of the one series and a circuit-interrupting device connected to each wire of the other series, and an electrical generator for charging the circuits controlled by the interrupter, substantially as described.

10. In a system such as described, and in combination with a series of circuit-wires, including separate registering mechanisms, an integrating device connected with a second series of circuit-wires and operating to vary the conductivity of each circuit a separate number of times, a switch mechanism with which all the wires in both series are connected, and a record-strip interposed between the sections of the switch and perforated at predetermined points to permit contact between the sections of the switch through the perforations, substantially as described.

11. In a system such as described, and in combination with a series of circuit-wires, each including an electro-magnet and a registering mechanism for each circuit controlled by the electro-magnet to advance the indicating device one point for each electrical impulse traversing its coils, of an integrating device operating to produce electrical impulses, a switch moving in unison with the register and arranged in branch circuit, including the electro-magnet of the next higher register, said branch circuit connected to the generator through a switch moving in unison with the integrating device, substantially as described, whereby when one register passes to the zero-point its switch will be operated to close the branch circuit through the electro-magnet of the next higher register, and after the impulses have ceased in the direct circuits an impulse will be sent through the branch circuits, as set forth.

12. In a system such as described, and in combination with the integrating device, the circuits controlled thereby, and the series of electro-magnets controlling registering devices, of an automatic switch mechanism moving in unison with the registering mechanism to close a branch circuit connected to the electro-magnet of the next register, and a device moving in unison with the integrator to send an electrical impulse over said branch circuit, substantially as described.

13. In a system such as described, and in combination with a series of registers, actuating electro-magnets therefor, a separate circuit-wire for each of said electro-magnets, and a device for producing electrical impulses in each circuit to actuate the registers, an automatic carrying mechanism consisting, essentially, of a switch operating in unison with the registering mechanism, a branch circuit connected to said switch and including the electro-magnet of the next higher register, a generator, and a device for sending an electrical impulse through the branch circuit, substantially as described.

14. In a system such as described, comprising a series of circuits each containing an electro-magnet, a corresponding series of registers controlled by said electro-magnets, and a device for producing in each of said circuits impulses for advancing the registers, and in combination with said circuits, registers, and electro-magnets, a branch circuit connected to the coil of the electro-magnet of a higher registering device and to a switch controlled by the next lower registering device to close said branch circuit as its indicator moves to the zero-point, and a device separate therefrom for producing an electrical impulse in said branch circuit, substantially as and for the purpose set forth.

15. The combination, with the integrating device, main circuits, and series of registering mechanisms of a system such as described, of a circuit connected with the electro-magnets of the higher registering mechanisms, a switch in said circuit, a supplemental electro-magnet operating to close said switch and included in a separate circuit, a switch in said last-named circuit operating in unison with the indicator of the lower registering mechanism, and devices for sending electrical impulses through the circuits connected to the electro-magnet of the higher registering mechanism, substantially as described, whereby as the indicator moves to the zero-point the circuit through the supplemental electro-magnet will be closed, causing said electro-magnet to close the switch through the electro-magnet of the higher register to actuate the latter, as set forth.

16. In a system such as described, and in combination with the registers, circuits, switch mechanisms, and integrating device, a carrying device operating, substantially as described, to change the circuit-connections between the integrator and registering devices from a lower to a higher division, or vice versa, as and for the purpose set forth.

17. In a system such as described, and in combination with a series of registers, controlling electro-magnets, and circuit-wires, the integrating device and its series of circuit-wires, and a switch interposed between the wires of the integrator and those of the register-circuits for simultaneously shifting the connections to throw the integrator-wires from the register-circuits of a lower to those of a higher value, or vice versa, substantially as and for the purpose set forth.

18. In a system such as described, and in combination with the series of register-circuits and a generator, of the integrating de-

vice consisting, essentially, of a non-conducting surface provided with a graduated series of conducting-plates and movable with respect to series of contact-pieces forming terminals of the register-circuits, said conducting-plates being also connected in circuit with the generator, whereby when said integrating device is operated the circuit will be closed through each register-circuit a predetermined number of times, substantially as described.

19. In a system such as described, and in combination with the register-circuits, switch mechanism connected thereto, and the series of wires connected to the opposite sections of the switch, of the integrating device for producing a different series of electrical impulses in each of said wires and the register-circuits, said integrating device comprising a movable drum carrying a series of graduated conducting-strips in circuit with the generator and arranged to successively close and open the circuits through each of the series of wires leading to the switch, substantially as and for the purpose set forth.

20. In a system such as described, the combination, with the register-circuits, the switch to which they are connected, the series of wires leading to the integrator and connected to the switch, and means for operating the switch to connect any of the last-named wires with any of the register-circuits, of the carrying-switch and the integrating device, substantially as described.

HERMAN HOLLERITH.

Witnesses:
I. HOLDSWORTH GORDON,
MAYHEW PLATER.