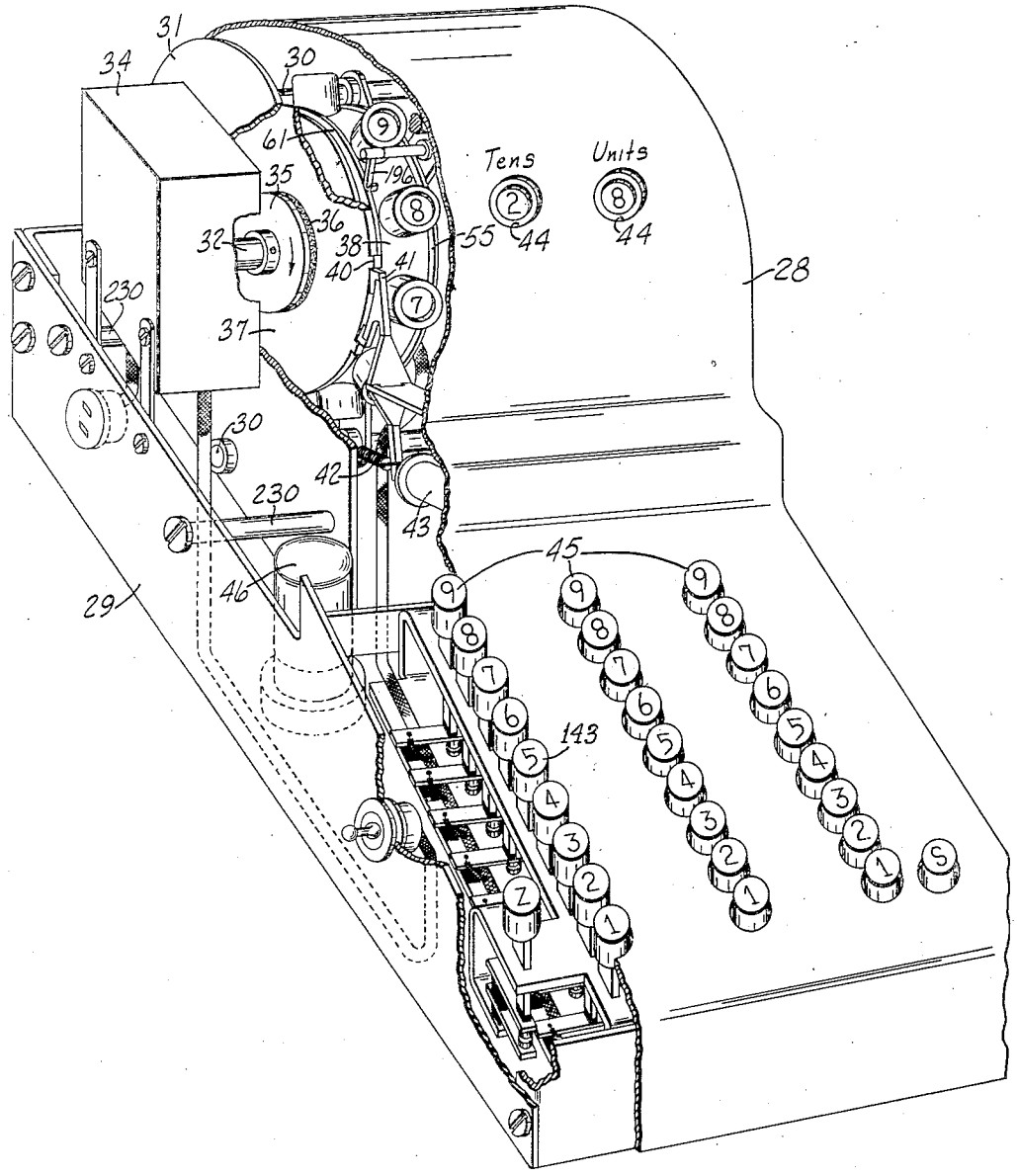
March 4, 1947. J. S. COMPTON 2,416,793

CALCULATING DEVICE

Filed June 25, 1943 5 Sheets-Sheet 1

FIG. 1



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CALCULATING DEVICE

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FIG. 2

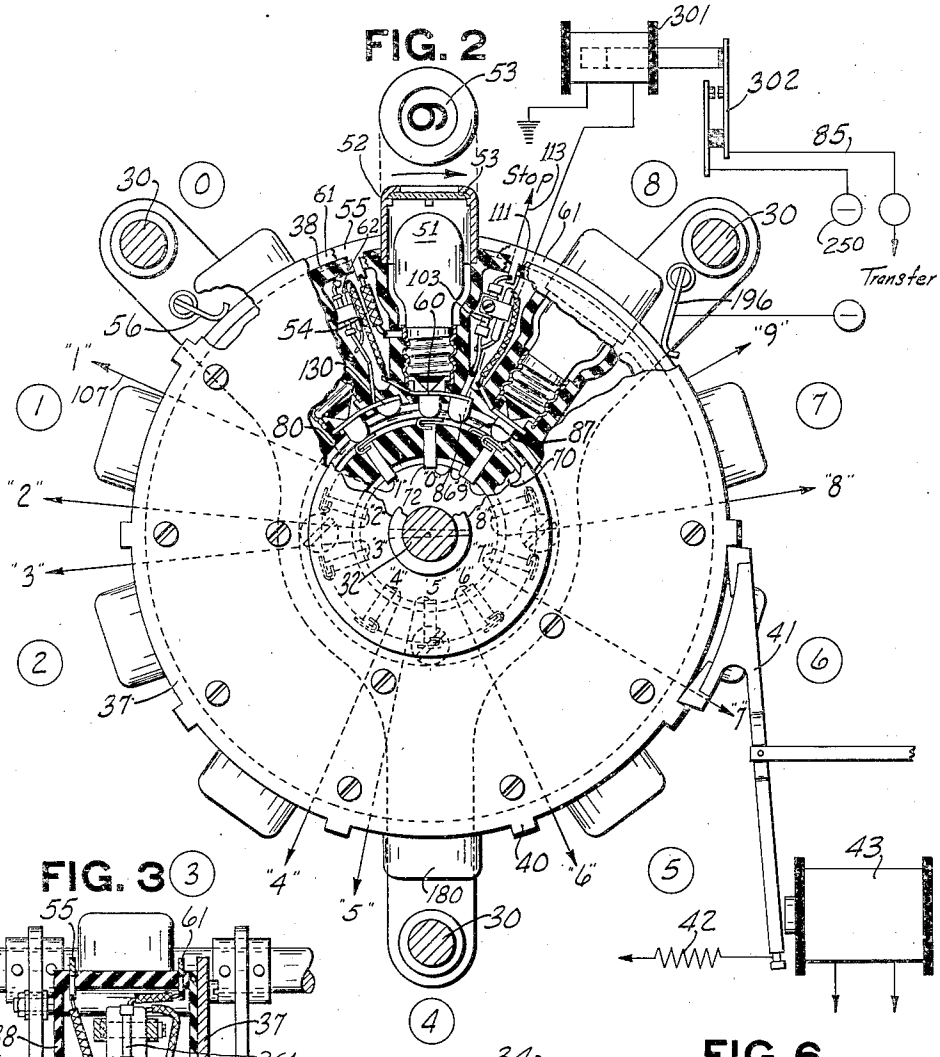
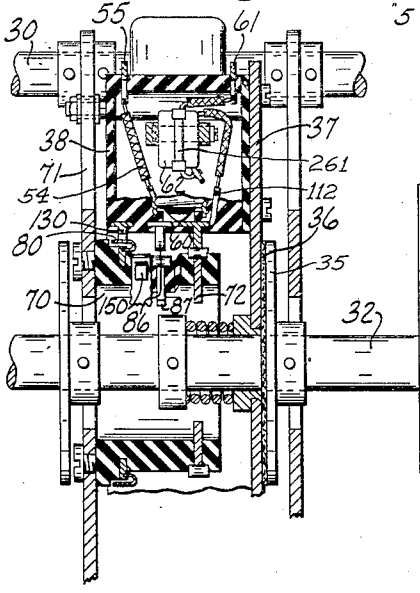


FIG. 3



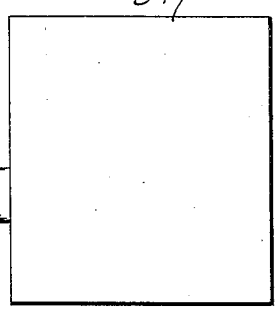
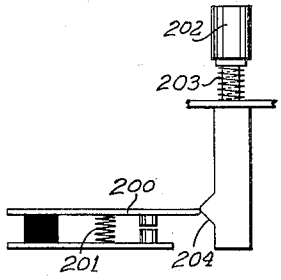


FIG. 6



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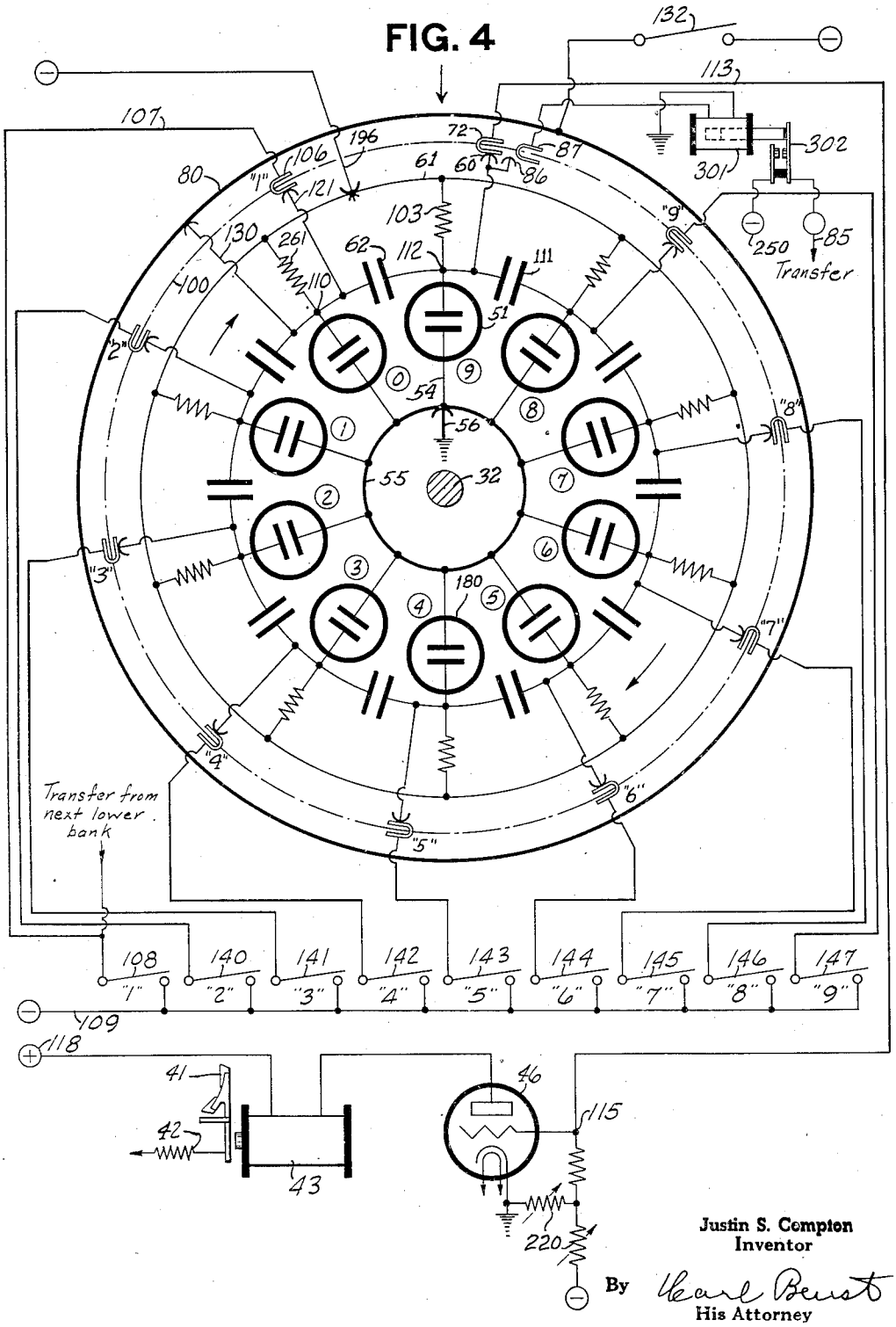
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CALCULATING DEVICE

Filed June 25, 1943 5 Sheets-Sheet 3

FIG. 4



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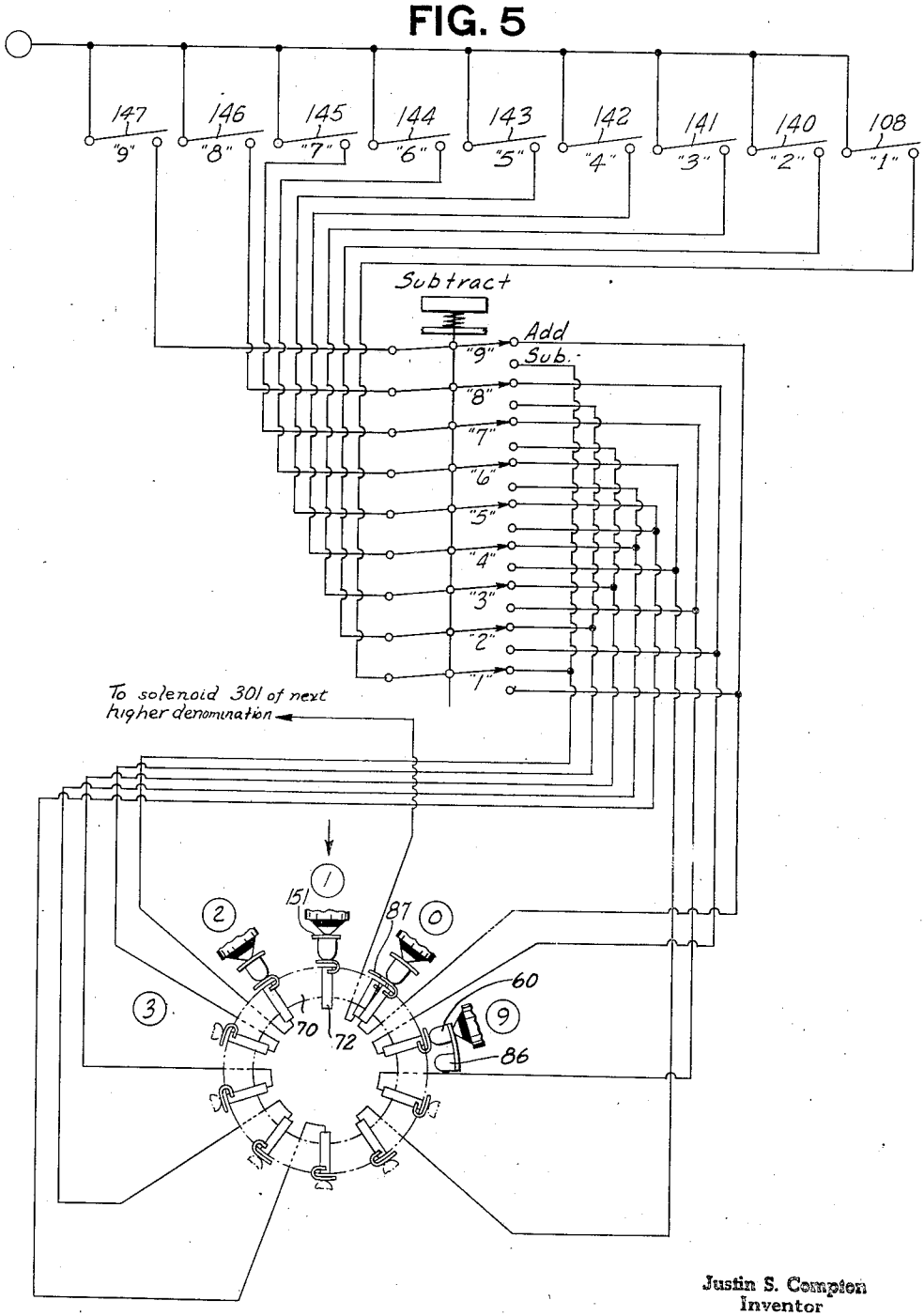
By Hearl Benest
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March 4, 1947. J. S. COMPTON 2,416,793

CALCULATING DEVICE

Filed June 25, 1943 5 Sheets-Sheet 4

FIG. 5



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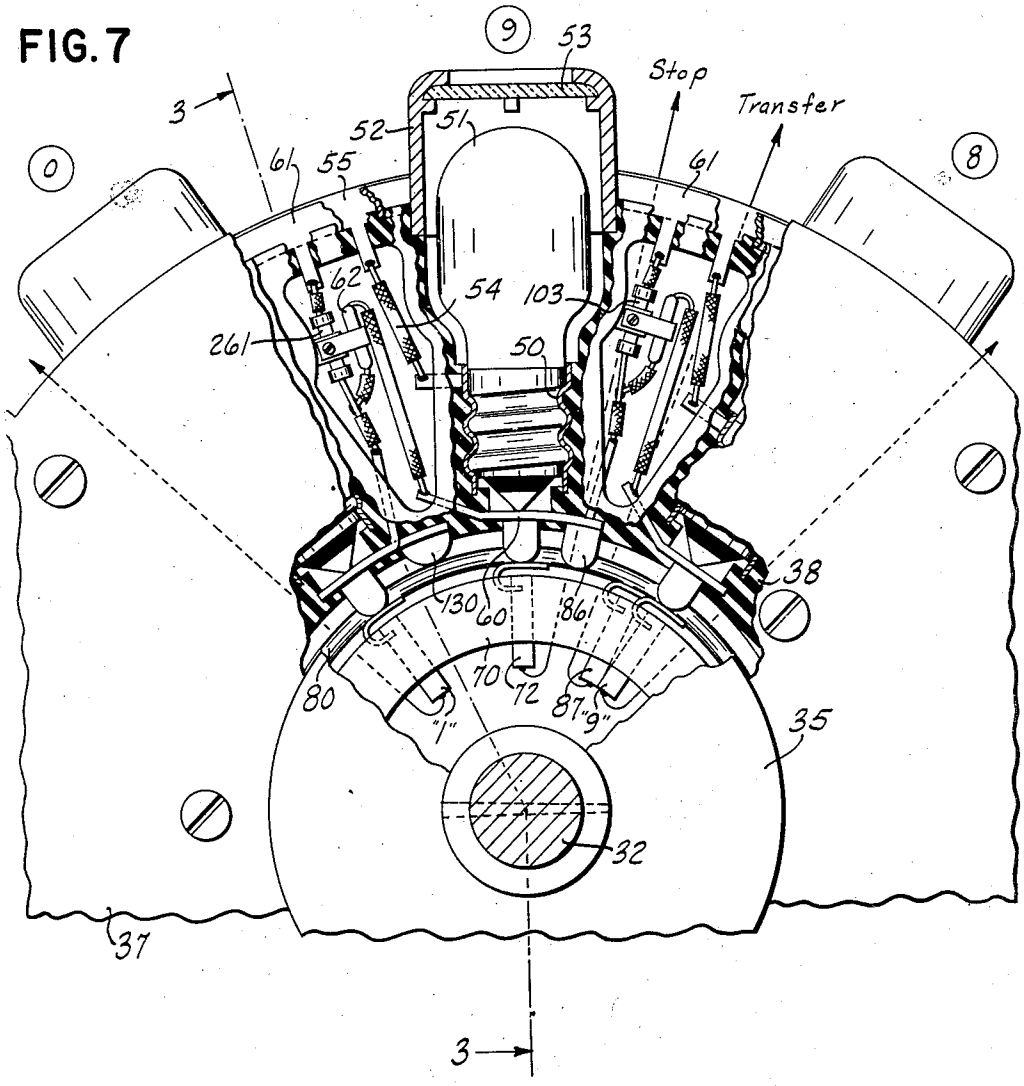
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CALCULATING DEVICE

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FIG. 7



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UNITED STATES PATENT OFFICE

2,416,793

CALCULATING DEVICE

Justin S. Compton, Lebanon, Ohio, assignor to The National Cash Register Company, Dayton, Ohio, a corporation of Maryland

Application June 25, 1943, Serial No. 492,299

21 Claims. (Cl. 235—61)

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This invention relates to a calculating machine in which the digit-representing elements are electron tubes which are moved by denominational carriers under differential control to registering and indicating positions.

The carriers are impositively driven reels, each representing a denomination, and each is provided with peripherally mounted digit-representing gaseous electron tubes of the glow type spaced in equal angular digit steps around the circumference. Each reel has a tube for each digit of the denomination, including zero. Data in a denomination is represented by one of the tubes on a reel being in a conducting condition, which condition causes the tube to be moved with the reel and to be stopped at a registering position. A value character associated with each tube is illuminated by the glow of the associated tube, when conducting, to render the registered data visible.

A group of digit keys are provided for each reel, there being in a group a key for each digit except zero, operable to enter data therein by causing the firing of a tube which is the desired number of digit steps away from registering position. In the decimal system, disclosed, the digit steps are thirty-six degrees apart around the denominational reel. The firing of a tube extinguishes the last conducting tube which has been stopped at the registering position, and the reel then moves, carrying the newly conducting tube to registering position, where, by its glow, the character associated with and carried by the reel over the tube is made visible.

Both adding and subtracting operations may be performed, the type of operation being determined by the direction of reel drive and by the selection of one of two possible switching arrangements to be selectively energized by the keys.

The invention is particularly novel in that the positioning of a denominational reel, when stationary, operates in conjunction with commutating contacts energized by selected digit keys to determine which is the next tube on the reel to become conducting. Such determined tube is the number of steps away from registering position which corresponds in number to the value of an operated digit key, and the direction of such steps from registering position depends on whether an adding or a subtracting operation is being performed.

Transfer means for denominational carry-overs is provided for both adding and subtracting operations.

Therefore, the principal object of the invention

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is to provide a calculating machine having electron tube digit elements moved differentially to a registering position.

Another object of the invention is to provide means to move a group of electron tubes differentially selected distances under key control.

Another object of the invention is to provide a multi-denominational calculating device having movable denominational elements with digit-representing electron tubes carried thereby.

Another object of the invention is to provide novel transfer means for the interdenominational carry-overs of such a device.

Another object of the invention is to provide a calculating machine with movable electron tubes as digit-representing and indicating elements, which tubes by their state of conduction also produce illumination of digit characters carried thereby.

Another object of the invention is to provide a group of electron tubes movable differential distances with respect to a contact commutator whereby an electrode of each tube in one cycle of operation over the commutator is connected to each contact in turn.

Another object of the invention is to provide a movable reel constantly urged to rotate impositively, the motion of which is started or stopped at selected points by the state of conductivity of electron tubes carried thereby.

Another object of the invention is to provide a calculating machine having glow discharge tubes which are carried on a carrier past a commutator, the state of conduction in a tube causing the carrier to stop with the conducting tube at a fixed registering point on the commutator.

The invention is not to be deemed limited by the numerical system used as an example, by the type of tubes used, or by any particular mechanical device or circuit elements for which obvious substitutes may be made.

With these and incidental objects in view, the invention includes certain novel features of construction, circuits, and combinations of parts, the essential elements of which are set forth in appended claims and a preferred form or embodiment of which is hereinafter described with reference to the drawings which accompany and form a part of this specification.

Of the drawings:

Fig. 1 is a perspective drawing, partly broken away, of the calculating device, showing the relative disposition of the main elements therein.

Fig. 2 is a side elevation of one of the denominational reels, partly broken away, and a plan

view of one of the character-bearing tube enclosures.

Fig. 3 is a cross section of a part of the reel of Figs. 2 and 7 on the line 3—3 as shown in Fig. 7.

Fig. 4 is a circuit diagram of one denomination of the calculating device, with the transfer means circuit and the reel drive control means circuit shown.

Fig. 5 shows the switching circuit for changing the device from an adding machine to a subtracting machine.

Fig. 6 shows a typical key switch.

Fig. 7 is an enlarged section of the upper part of a reel such as that shown in Fig. 2, with certain portions broken away.

General description

The framework of the device consists of a fabricated base 29 (Fig. 1) having supported therein, by cross members 230, vertical frame plates, like plate 31, in which is journaled a drive shaft 32, which is driven by a reversible motor, shown diagrammatically by box 34, having a normal forward rotation for adding operations, as shown by the arrow on a disc 35. To shaft 32 are pinned three discs, like disc 35 (see also Fig. 7), each having a friction surface 36, which engages a driven plate, like plate 37, journaled on shaft 32. Each of the plates like plate 37 supports a denominational reel, like reel 38, on which reel are mounted ten peripherally mounted gas discharge tubes like tube 51 (Fig. 2). Three such impositively driven reels are disclosed in this embodiment, representing the units, tens, and hundreds denominations of the decimal system. In Fig. 1, the hundreds reel is exposed, and the tens and units reels are positioned in the cabinet as indicated thereon. The principle of the invention is applicable to an embodiment of as many denominations of any number system as is desired.

Each of the driven plates, corresponding to plate 37 (Fig. 1) of the hundreds bank, has on its periphery teeth, like teeth 40 (see also Fig. 2) engageable by a pawl, like pawl 41, which, when in the actuated position, shown, holds the plate 37 against rotation in either direction without disturbing the drive of the other like plates, the angular position of a plate and associated reel with reference to a registering point being determined by which tooth on the plate 37 is so engaged. There is a tooth associated with each tube on a reel.

A spring, like spring 42, for each pawl 41 normally holds the pawl disengaged, and a solenoid, like solenoid 43, when energized, overcomes the spring tension and throws the pawl into engagement with the toothed plate 37, causing the driven plate and the associated reel carried thereby to be stopped at a definite place with reference to a viewing aperture, like apertures 44 associated with the unit and tens reels, cut in the cabinet 28. The viewing apertures are alined with the registering point of the reels, so as to give a visible indication of what is registered.

A group of digit keys 45 for each denomination is provided, each key being associated with one contact on the commutator of the associated reel, to switch electric potential to fire and render conducting the tube resting on the contact at that time.

As is well known, a gaseous discharge electron tube will continue conducting on much less potential difference between the anode and the cathode thereof than is necessary to start conduction

therein. This characteristic is used to fire a selected tube from among a number of non-conducting tubes which normally have applied thereto anode-cathode potential only sufficient to maintain conduction. The selected tube is given a potential boost temporarily by depression of a key, so as to fire it.

An amplifier vacuum electron tube, like tube 46 (see also Fig. 4), is provided for each reel. The anode-cathode circuit of the tube 46, when conducting, energizes an associated solenoid, like solenoid 43. Whenever a conducting digit tube of the denomination is moved with the reel to contact the registering position contact located on the commutator to be described, the associated amplifier tube 46 is caused to conduct, throwing the pawl 41 into effective position, so that the reel will be stopped with the conducting tube at the viewing aperture.

The hundreds denominational reel 38 (Figs. 2, 3, and 7), shown as typical, has ten tube sockets, like socket 50 (Fig. 7), arranged around the periphery thereof, each socket holding a digit representing diode gaseous glow discharge tube, preferably of the small type firing at about 100 volts and conducting on 60 volts, like tube 51. Each of the sockets is capped by an enclosure 52 having a transparent character-bearing disc 53 in the outer end thereof, so that the glow from a conducting tube renders the character visible, as shown in the plan view of disc 53 in Fig. 2. The tubes are designated around the periphery of the reel "1," "2," "3," "4," "5," "6," "7," "8," "9," and "0" as shown in Fig. 2. Each of the sockets 50 (Fig. 7) is connected to the anode of the tube held therein and is grounded by being connected by a conductor, like conductor 54 (see also Fig. 4), to a ring contact 55 clamped on and partially embedded in the periphery of the reel (Figs. 2, 3, 4 and 7), which ring contact is connected to the grounded base of the machine through wiper arm 56 (Fig. 2). In the bottom of each socket is a cathode connected electrode contact, like contact 60 (Figs. 2, 3, 4 and 7), which is connected through a resistance, like resistance 103, to a ring contact 61, similar to ring 55 (see Fig. 3), which, through wiper arm 196 (Figs. 2 and 4) is supplied with negative potential sufficient to maintain conduction in any of the tubes but insufficient to fire any such tube. Each cathode contact 60 is connected to the next adjacent cathode contact in one direction through a capacitor, like capacitor 62, and in the other direction through a capacitor like capacitor 111.

For each reel there is provided a stationary commutator element, such as element 70 (see especially Figs. 3 and 7), mounted on a plate, such as plate 71 (Fig. 3) supported by the cross members 30.

Each commutator has nine firing contacts (Fig. 2), represening the nine digits which it is possible to enter, and one registering contact for sensing conduction in a tube passing thereover. The firing contacts are spaced around the periphery of the commutator from a registering point determined by the position of registering contact 72 (see Figs. 2 and 7). The commutator contacts for firing the selected tube as shown in Figs. 2 and 4, are designated in a clockwise manner (the direction of rotation in adding operations), beginning from the registering contact 72, "9," "8," "7," "6," "5," "4," "3," "2," and "1." Each firing contact can be coupled to a source of negative firing potential by closing an associated denominational digit key of the same designation. When

a contact is so energized, the tube at that time resting thereon becomes conducting.

The disclosed position of the reel as shown in Figs. 2, 4, and 7 is such that the tube bearing the designation "9" is at the registering point, which tube is assumed to be in a conducting state. If, for example, it is desired to add five units of data into the hundreds denomination, the "5" digit key 143 (Figs. 1 and 4) is operated, which, by closing a circuit to a source of negative potential temporarily, will cause the tube bearing the character 4 covered by enclosure 180 (Fig. 2), to become conducting and will cause the tube covered by the enclosure 52 bearing the character "9" to be extinguished, in a manner to be described. Under these circumstances, when the "9" tube is extingushed and its cathode potential drops, amplifier tube 46 ceases to conduct and pawl 41 will be retracted under action of spring 42 and the reel will be driven by the friction drive until, just as the conducting tube under enclosure 180 reaches the registering point, registering contact 72 designated "0" is energized by the raised potential of the cathode of the conducting "4" tube, which causes conduction in the amplifier tube 46 energizing solenoid 43, and thereby causes engagement of pawl 41 with toothed plate 37, stopping the reel. The character "4" on top of enclosure 180 will thereupon be in registering position, indicating the addition of five units of data.

When it is desired to have a denominational reel register zero, negative firing potential is applied, through an ever ready circuit, to the base contact of the "0" tube, no matter in what position relative to the registering contact 72 the "0" is at that instant. This zeroizing is accomplished by the use of a ring contact 89 (Figs. 2, 3, 4, and 7) mounted on the commutator, which ring is constantly ridden by contact 139 carried by the reel and connected to the cathode of the "0" tube. The "0" tube, thus, can be fired wherever it is, by the application of negative voltage to ring contact 89, and the "0" tube will move to registering position.

The transfer of denominational carry-overs, represented in Figs. 2 and 4 as though there were a thousands order to transfer carry-over data to, is accomplished by the utilization of the cathode supply potential of the "9" tube as tube "9" is passing out of registering position to operate a solenoid-controlled source of negative potential. Thus, when contacts 86 and 87 meet, it energizes a solenoid 301 to close a switch 302 connecting a source of negative potential to supply negative firing energy by way of conductor 85 to the "1" digit firing conductod of the next higher bank, which will advance the reel of the next higher bank one step. Contact 86 of the lower order brushes its transfer contact 87 mounted on the commutator between contacts 72 and "9," as the "0" tube comes into registering position. The potential of the transfer conductor 85 (Fig. 4) is momentarily applied to the "1" key input conductor to the next higher bank to cause a single unit of data to be added therein. The digit keys of the device are operated by denominations from the highest order to the lowest order, as in reading a number, and consequently no interference will be experienced in the entry of transfer data and the entry of key selected data.

The input conductors "1," "2," "3," "4," "5," "6," "7," "8," and "9" of Fig. 2 are energized by switches similarly designated in Fig. 4, to which

reference will now be made for explanation of the electrical circuits of a denomination. For convenience, the tubes are shown with their reel-borne interconnecting elements on the inside of broken circle 100, and all of the elements completely inside circle 100 and conductor ring 55 are considered to move about axle 32. Contact 130 also moves about axle 32. All of the tubes have their anodes connected to ring 55 grounded through contact 56. Each tube—as, for instance, the "9" tube—has its cathode connected through a resistance, like resistance 103, of several thousand ohms, to a 60-volt negative potential conductor ring 61 supplied with potential through brush contact 196 connected to a source. The cathodes are coupled in a ring for extinguishing purposes by having a small capacitor of .005 microfarad between the cathodes of each two adjacent tubes like capacitors 62 and 111. The cathode of each tube is connected to a wiper contact, like wiper contact 60, which wipes one of the contacts, like contact 72, for each position of the reel. As before stated, these contacts are ten in number and are shown as "1," "2," "3," "4," "5," "6," "7," "8," "9," and 72. The registering position is assumed to be at the contact 72 where the tube "9" is shown and the adding rotation is in the direction of the arrows. Contact 106 represents, and is connected by the "1" firing conductor 107 to, the associated "1" digit key 108, which, when closed, connects conductor 107 to negative potential supply source 109, which source is adjusted to supply sufficient potential to fire a tube. If the "1" key is operated, the potential rise of point 110 as tube "0," resting on contact 106, fires will be conveyed as a positive impulse through capacitor 62. As the cathode of conducting tube 51 is, by reason of the high cathode resistance 103, at a potential of only about 15 volts negative with respect to the grounded anode, the added positive potential impulse through charged capacitor 111 causes the said cathode to become more positive than the anode for an instant, extinguishing the tube. The contact 72 is the registering contact, as has been mentioned. The lowering of potential of point 112 as tube "9" is extinguished is conveyed through contacts 60 and 72, and conductor 113 to the grid point 115 of vacuum electron amplifier tube 46. Biased through variable resistance divider 220 to conduct when contact 72 is energized by the potential of the cathode of a conducting glow tube and to become non-conducting when contact 72 is energized by the cathode of a non-conducting glow tube or energized by no tube at all as in between stations. The cathode of tube 46 is grounded, and the anode obtains its potential through the windings of solenoid 43 from source 118. Consequently, when the "9" glow-tube becomes non-conducting, tube 46 becomes non-conducting as the grid becomes more negative and pawl 41 is moved to ineffective position by spring 42 as solenoid 43 has become de-energized, and the reel is then free to move in response to the friction drive. As the reel moves, the now conducting "0" tube's contact 121 having a higher than normal potential reaches registering contact 72 and the tube 46 commences to conduct, which causes pawl 41 to be moved to effective position, stopping the "0" tube in registering position.

Contact 130, constantly in contact with contact ring 89, is given a negative potential sufficient to fire the zero tube whenever zeroizing switch 132 is closed. As contact 130 is always connected to

the cathode of the "0" tube, the zero tube may be brought to registering position by firing it, no matter in what location it may be, simply by closing switch 132 temporarily.

Each of the digit key switches 103, 140, 141, 142, 143, 144, 145, 146, and 147 is connected to the commutator contact the number of stations away, counter-clockwise as shown in Fig. 4, from the registering position contact 72 as the digit value of the key designates.

The normal potential of the cathode of the "9" tube is given through contact 86 to contact 87 as the registering point is passed, and serves to energize solenoid 301 temporarily, which closes switch 302 temporarily to supply firing energy from a negative source 250 to the "1" input line of the next higher bank, if any. Such transfer input line from the lower denominational order is shown connected to conductor 107 in Fig. 4.

As the capacitors coupling the cathodes of the tubes on a reel are in series, the impulse from any fired tube will extinguish any other tube on the reel.

Fig. 5 shows a switching unit for converting the disclosed device into a subtracting machine. In subtraction, the motor must be reversed and the digit keys in a denominational row must be connected with the input conductors to the commutator in a reverse manner. The commutator 70 of Fig. 5 is viewed from the same direction as seen in Figs. 2 and 4 and is shown registering the accumulation of one.

The key switches of Fig. 5 bear the same digit values and reference numbers as in Fig. 4. The denominational "Substract" key, in the upper position shown in Fig. 5, makes the connections with the commutator for an adding operation such as that shown in Fig. 4, the transfer being taken from contact 87 as energized by contact 86, as has been explained, as the "9" tube passes from registering position indicated by the arrow in a clockwise direction. In the lower position of the "Subtract" key, the "9" key 147 is connected in a circuit to the first position counter-clockwise of the registering position indicated by the arrow, which contact, when energized by the "9" key, causes the reversely moving reel to move nine positions in a counter-clockwise manner. The remainder of the digit key circuits are connected by operation of the subtract key in such reverse manner. The transfer occurs in the passing of the "0" tube out of registering position in a counter-clockwise direction.

Any known motor-reversing means may be used and controlled by the "Subtract" key.

The add-subtract switches of all the denominational banks may be operated by a single key, represented by "S" on the keyboard (Fig. 1).

Fig. 6 shows a typical digit key switch designed to assure but momentary application of firing potential to a commutator contact even though the key be held depressed after the associated tube is fired and the reel has commenced to move.

Switch 200, representing a digit of a denomination, is normally held open by a spring 201 but is closed upon depression of a key 202, against the action of key return spring 203, as camming surface 204 rides against the edge of the upper switch blade. The parts are positioned so that the camming surface may bend the end of the upper switch blade at the moment the switch is closed and ride past the blade, allowing the switch to immediately open in response to the action of spring 201. On the return of key 202 to normal, the camming portion of the key springs past the upper switch blade. The key switch shown may be replaced with any other kind of switch which momentarily closes.

In the operation of the machine, the digit keys are operated one at a time, preferably from the highest order to the lower orders. A subtract operation may be made of any desired entry without clearing the machine. When it is desired to clear the machine, the zero tubes of all the reels are fired as by energizing them through operation of a zero key switch, represented as "Z" (Fig. 1), which brings all the "0's" to registering position. The key "Z" may be used to operate all the zero switches such as switch 132 (Fig. 4).

While the form of the invention herein illustrated and described is admirably adapted to fulfill the objects primarily stated, it is to be understood that it is not intended to confine the invention to the one form or embodiment herein disclosed, for it is susceptible of embodiment in various forms all coming within the scope of the claims which follow.

What is claimed is:

1. A rotatable member; means to rotate the member; means to stop the rotation; a plurality of electrically energizable stop control means carried by the member, said energization consisting in providing an electric potential on any one of said control means that is distinctive from the electric potential on all the others of said control means, each control means when energized controlling the stop means, by the effect of the distinctive potential, to stop the rotation at an associated point in the rotation; and a plurality of keys to energize any selected one of the non-energized control means when the member is stopped, any selected key always stopping the rotation of the rotatable member after a fixed number of degrees of movement regardless of the then angular disposition of it.

2. A movable carrier normally moved cyclically; means, rendered active by a distinctive electric potential applied thereto, to stop the carrier at any one of a plurality of positions in the cycle; a conditionable electric means for each position carried by the carrier, the conditioning of any one of said conditionable means by causing it to have a distinctive electric potential, actuating the stop means to stop the carrier at the associated position; means to condition any selected electric means; and means connecting the electric means so that the conditioning of one electric means deconditions any other then conditioned electric means and causes movement of the carrier accordingly.

3. A plurality of gaseous discharge diode electron tubes mounted on a carrier; means to supply operating potential to all of said tubes sufficient to maintain conduction therein, said supply means including a resistance in an electrode supply for each tube; means to move the carrier past a registering point; means to render a tube conducting; and means energized by the potential change of the electrode of a conducting tube due to the associated resistance for stopping the carrier with the conducting tube at said point.

4. A plurality of gaseous discharge electron tubes mounted on a carrier; means supplying potential energy to said tubes sufficient to maintain conduction therein, there being a resistance

in the supply circuit of an electrode of each tube; means to render a tube conducting; means to impositively move the carrier; energizable means to stop the carrier when energized by the application of potential equivalent to the potential of the resistance-supplied electrode of a tube when conducting; and a circuit connecting the stop means and the resistance-supplied electrode of each tube in succession as the carrier moves, so as to cause the carrier to stop as a conducting tube energizes the stop means.

5. A movable carrier; means to move the carrier cyclically with reference to a registering point associated with a viewing aperture which the tubes pass successively in the cycle of movement; a plurality of electron tubes arranged on the carrier; means to cause a selected one of said tubes to become conducting; and means controlled by the conducting tube to stop the carrier so that the conducting tube will be stopped at the registering point so that it may be viewed through the aperture.

6. A rotatable member having engageable means to stop it at any one of a plurality of positions in its cycle of rotation; means to rotate the rotatable member; stop means which, when energized, actuates the engageable means to stop the rotation at its then angular position; a plurality of electronic devices carried by the rotatable means at angularly disposed intervals, each of which devices is associated with a stopping position of the rotatable means; means for rendering an electronic device conducting; and means for connecting each electronic device in succession to the stop means once each cycle of rotation, any one of which connections energizes the stop means if the associated electronic device is in a conducting condition.

7. A cyclically moving carrier; stop means which, when actuated, stops the carrier at a position corresponding to the carrier's position in the cycle at the time when the stop means is actuated; a plurality of electron tubes mounted on the carrier; circuits supplying operating potential to the tubes in such a manner that a sensing electrode of each tube is caused to have a change of potential as such tube becomes conducting, said change in potential being sufficient to actuate the stop means; means interconnecting the tubes so that, when a tube becomes conducting, it stops conduction in any other conducting tube; selective means operable to cause conduction to commence in any non-conducting tube; and means connecting the sensing electrode of each tube in succession in a cycle to the stop means, said stop means being thereby actuated or not according to whether the sensed tube is conducting or not.

8. A plurality of gaseous electron tubes each having at least an anode electrode and a cathode electrode; a rotatable device upon which said tubes are mounted; means to supply current maintenance anode-cathode potential to said tubes but insufficient to initiate a discharge therein, said circuits including a resistance in series with one of the electrodes of each tube so as to cause a potential change in said electrode if the tube commences to conduct; means to render a tube conducting; means to rotate the device impositively cyclically; a toothed wheel on the device, there being a tooth at least for each tube; a pawl engageable with the wheel in any of its teeth to stop rotation of the device; means actuable by a potential change to engage the pawl; and a circuit connecting the actuable means with the resistance-supplied electrode of each tube once each cycle so as to actuate it if a tube be conducting.

9. A plurality of gaseous electron tubes each having at least an anode electrode and a cathode electrode; a rotatable device upon which said tubes are mounted; means to supply current maintenance anode-cathode potential to said tubes but insufficient to initiate a discharge therein, said circuits including a resistance in series with one of the electrodes of each tube so as to cause a potential change in said electrode if the tube commences to conduct; means to cause a tube to conduct; means to rotate the device impositively cyclically; a toothed wheel on the device, there being a tooth at least for each tube; a pawl engageable with the wheel in any of its teeth to stop rotation of the device; means actuable by a potential change to engage the pawl; a circuit connecting the actuable means with the resistance-supplied electrode of each tube once each cycle so as to actuate it if a tube be conducting; and means electrostatically connecting the resistance associated electrodes of the tubes, so that conduction commencing in one tube extinguishes any other conducting tube.

10. A plurality of gaseous electron tubes each having at least an anode electrode and a cathode electrode; a rotatable device upon which said tubes are mounted; means to supply current maintenance anode-cathode potential to said tubes but insufficient to initiate a discharge therein, said circuits including a resistance in series with one of the electrodes of each tube so as to cause a potential change in said electrode if the tube commences to conduct; means tending to rotate the device impositively cyclically; a toothed wheel on the device, there being at least a tooth for each tube; a pawl engageable with the wheel in any of its teeth, which pawl, when so engaged, stops rotation of the device; means actuable by a potential change to engage the pawl; a circuit connecting the actuable means with the resistance-supplied electrode of each tube once each cycle so as to actuate it if a tube be conducting; means to disengage the pawl when the engaging means is no longer actuated by the potential change permitting the rotatable device to rotate; and means to furnish firing potential to any selected tube not conducting.

11. A plurality of gaseous electron tubes each having at least an anode electrode and a cathode electrode; a rotatable device upon which said tubes are mounted; means to supply current maintenance anode-cathode potential to said tubes insufficient to initiate a discharge therein, said circuits including a resistance in series with one of the electrodes of each tube so as to cause a potential change in said electrode if the tube commences to conduct; means to rotate the device impositively cyclically; a toothed wheel on the device, there being at least a tooth for each tube; a pawl engageable with the wheel in any of its teeth to stop rotation of the device; means actuable by a potential change to engage the pawl; a circuit connecting the actuable means with the resistance-supplied electrode of each tube once each cycle so as to actuate it if a tube be conducting; means electrostatically connecting the resistance-associated electrodes of the tubes so that conduction commencing in one tube extinguishes any other conducting tube; means to disengage the pawl when the pawl-engaging means is no longer actuated by a potential

change; and means to fire any selected non-conducting tube.

12. A wheel; means to frictionally rotate the wheel; a toothed member attached to the wheel; a pawl engageable with the toothed member to stop the wheel in any one of a plurality of angular positions; a gaseous diode electron tube associated with each tooth, said tube being mounted on the wheel; fixed circuits supplying current maintaining potential to all the tubes but less than that required to fire a tube, said circuits including a resistance associated with the supply of a particular electrode of each tube; a plurality of firing circuits equal to the number of tubes less one; commutator means for engaging each firing circuit and the particular electrode of each tube one at a time each rotation of the wheel; means to energize any selected firing circuit; a means to sense the resistor-associated electrode of each tube once each cycle; means actuated by the change in the potential of the resistor-associated electrode of a conducting tube when sensed to engage the pawl; means to disengage the pawl when the potential change subsides; and means to extinguish any conducting tube when another tube is fired.

13. A plurality of gaseous electron tubes each having at least an anode electrode and a cathode electrode; a rotatable device on which said tubes are mounted; means to supply current maintenance anode-cathode potential to said tubes insufficient to initiate a discharge therein, said circuits including a resistance in series with one of the electrodes of each tube, any of said electrodes therefor having a change in potential as the associated tube is rendered conducting; means to initiate rotation of the device by rendering one of the tubes conducting; means to sense the resistance-associated electrode of each tube once each cycle serially one at a time; means rendered effective to stop the device when a conducting tube is sensed and rendered ineffective when said conducting tube is extinguished; means coupling the tubes so that, as one becomes conducting, all other conducting tubes are extinguished; and means to render a selected non-conducting tube conducting.

14. A plurality of gaseous electron tubes each having at least an anode electrode and a cathode electrode; a rotatable device on which said tubes are mounted; means to supply current maintenance anode-cathode potential to said tubes insufficient to initiate a discharge therein, said circuits including a resistance in series with one of the electrodes of each tube, any of said resistance-associated electrodes therefor having a change in potential as the associated tube is rendered conducting; means to initiate rotation of the device by rendering one of the tubes conducting; means to sense the resistance-associated electrode of each tube once each cycle serially one at a time; means rendered effective to stop the device when a conducting tube is sensed, and rendered ineffective when said sensed conducting tube is extinguished; means coupling the tubes so that, as one becomes conducting, all other conducting tubes are extinguished; and selectively operable means for causing any one of the non-conducting tubes to fire while the device is stationary.

15. A plurality of gaseous electron tubes each having at least an anode electrode and a cathode electrode; a rotatable device on which said tubes are mounted; means to supply current maintenance anode-cathode potential to said tubes insufficient to initiate a discharge therein, said circuits including a resistance in series with one of the electrodes of each tube, any of said electrodes therefor having a change in potential as the associated tube is rendered conducting; means to initiate rotation of the device by rendering one of the tubes conducting; means to sense the resistance-associated electrode of each tube once each cycle serially one at a time; means rendered effective to stop the device against the urge to rotate, when a conducting tube is sensed at a position associated with said tube and rendered ineffective when such a conducting tube is extinguished; means coupling the tubes so that, as one becomes conducting, all other conducting tubes are extinguished; selectively operable means for causing any one of the non-conducting tubes to fire while the device is stationary; and means operable to fire a particular one of the tubes whether the device is stationary or rotating to bring the device to a stop at a fixed position.

16. A reel impositively driven cyclically past a registering point; a plurality of gaseous electron tubes arranged around the reel; means for causing a tube selected for its angular position from the registering point to become conducting; means coupling the tubes so that, when one becomes conducting, any other conducting tube is extinguished; and stop means rendered effective by a conducting tube to stop the rotating member with the conducting tube at registering position, said stop means being rendered ineffective when said conducting tube is extinguished by reason of another selected tube being rendered conducting.

17. An electron tube for each digit of a numerical denomination including zero, each tube having at least an anode and a cathode; a rotatable body on which the tubes are mounted serially; means to rotate the body adjacent a registering point; means operable when actuated for stopping the body with any tube at the registering point; means supplying anode-cathode potential to said tubes sufficient to maintain conduction therein but insufficient to initiate conduction therein, said supply means including means to cause the cathode of a tube to rise in potential as the tube becomes conducting; a conduction-initiating contact for each digit except zero, which contacts are coupled to each cathode each cycle serially one at a time, said couplings being made when one or another of the tubes is at the registering point, each of said initiating contacts being assigned a value equivalent to the number of tubes it is removed from the tube at the registering position; a digit key for each initiating contact, a key when operated temporarily energizing the associated contact to initiate conduction in the tube coupled thereto; a contact at the registering position for scanning the potential of the cathodes of tubes reaching that position; means connecting the register contact and the stop means to convey the potential of a conducting cathode thereto to actuate said stop means and halt the conducting tube at registering position; and means connecting the tubes so that when a tube becomes conducting through selective key operation any other conducting tube is extinguished, rendering the stopping means ineffective.

18. An electron tube for each digit of a numerical denomination including zero, each tube having at least an anode and a cathode; a rotatable body on which the tubes are mounted serially; means to rotate the body adjacent a reg-

istering point; means when actuated for stopping the body with any tube at the registering point; means supplying anode-cathode potential to said tubes sufficient to maintain conduction therein but insufficient to initiate conduction therein, said supply means including means to cause the cathode of a tube to rise in potential as the tube becomes conducting; a conduction-initiating contact for each digit except zero, which contacts are coupled to each cathode each cycle serially on at a time, said couplings being made when one or another of the tubes is at the registering point, each of said initiating contacts being assigned a value equivalent to the number of tubes it is removed from the tube in registering position; a digit key for each initiating contact, a key when operated temporarily energizing the associated contact to initiate conduction in the tube coupled thereto; a contact at the registering position for scanning the potential of the cathodes of tubes reaching that position; means connecting the register contact and the stop means to convey the potential of a conducting cathode thereto to actuate said stop means and halt the conducting tube at registering position; means to render the zero tube conducting in whatever angular position with reference to the registering point it may be; and means connecting the tubes so that when a tube becomes conducting through selective key operation any other conducting tube is extinguished, rendering the stopping means ineffective.

19. A gaseous discharge electron tube for each digit of a numerical denomination including zero, each tube having at least an anode and a cathode; a rotatable body on which the tubes are mounted serially; means to rotate the body adjacent a registering point; means when actuated for stopping the body with any tube at the registering point; means supplying anode-cathode potential to said tubes sufficient to maintain conduction therein but insufficient to initiate conduction therein, said supply means including means to cause the cathode of a tube to rise in potential as the tube becomes conducting; a conduction-initiating contact for each digit except zero, which contacts are coupled to each cathode each cycle serially one at a time, said couplings being made when one or another of the tubes is at the registering point, each of said initiating contacts being assigned a value equivalent to the number of tubes it is removed from the tube at registering position; a digit key for each initiating contact, a key when operated temporarily energizing the associated contact to initiate conduction in the tube coupled thereto; a contact at the registering position for scanning the potential of the cathodes of tubes reaching that position; means connecting the register contact and the stop means to convey the potential of a conducting cathode thereto to actuate said stop means and halt the conducting tube at registering position; and means connecting the tubes so that when a tube becomes conducting through selective key operation any other conducting tube is extinguished, rendering the stopping means ineffective.

20. A gaseous electron tube for each digit of a numerical denomination including zero, each tube having at least an anode and a cathode; a

rotatable body on which the tubes are mounted serially; means to rotate the body adjacent a registering point; means when actuated for stopping the body with any tube at the registering point; means supplying anode-cathode potential to said tubes sufficient to maintain conduction therein but insufficient to initiate conduction therein, said supply means including means to cause the cathode of a tube to rise in potential as the tube becomes conducting; a conduction-initiating contact for each digit except zero, which contacts are coupled to each cathode each cycle serially one at a time, said couplings being made when one or another of the tubes is at the registering point, each of said initiating contacts being assigned a value equivalent to the number of tubes it is removed from the tube at registering position; a digit key for each initiating contact, a key when operated temporarily energizing the associated contact to initiate conduction in the tube coupled thereto; a contact at the registering position for scanning the potential of the cathodes of tubes reaching that position; means connecting the register contact and the stop means to convey the potential of a conducting cathode thereto to actuate said stop means and halt the conducting tube at registering position; means connecting the tubes so that when a tube becomes conducting through selective key operation any other conducting tube is extinguished, rendering the stopping means ineffective; and means to render the zero tube conducting in whatever angular position with reference to the registering point it may be.

21. A rotating body; a plurality of glow discharge electron tubes carried by the body; a cover over each tube bearing a character made visible by the glow in a conducting tube; means to render a tube conducting; a shield having a viewing aperture past which the covered tubes move; and means to stop the body so that any selected conducting tube and its cover are visible through the viewing aperture.

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Certificate of Correction

March 4, 1947.

Patent No. 2,416,793.

JUSTIN S. COMPTON

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 4, line 61, for "represening" read *representing*; column 5, line 37, after "O" insert *tube*; line 57, for "conductod" read *conductor*; column 7, line 36, for "Substract" read *Subtract*; column 8, line 51, claim 2, after "means" insert a comma; column 12, line 11, claim 15, strike out the comma after "rotate"; column 13, line 11, claim 18, for "serially on" read *serially one*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of May, A. D. 1947.

[SEAL]

LESLIE FRAZER,
First Assistant Commissioner of Patents.

Certificate of Correction

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[SEAL]

LESLIE FRAZER,
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