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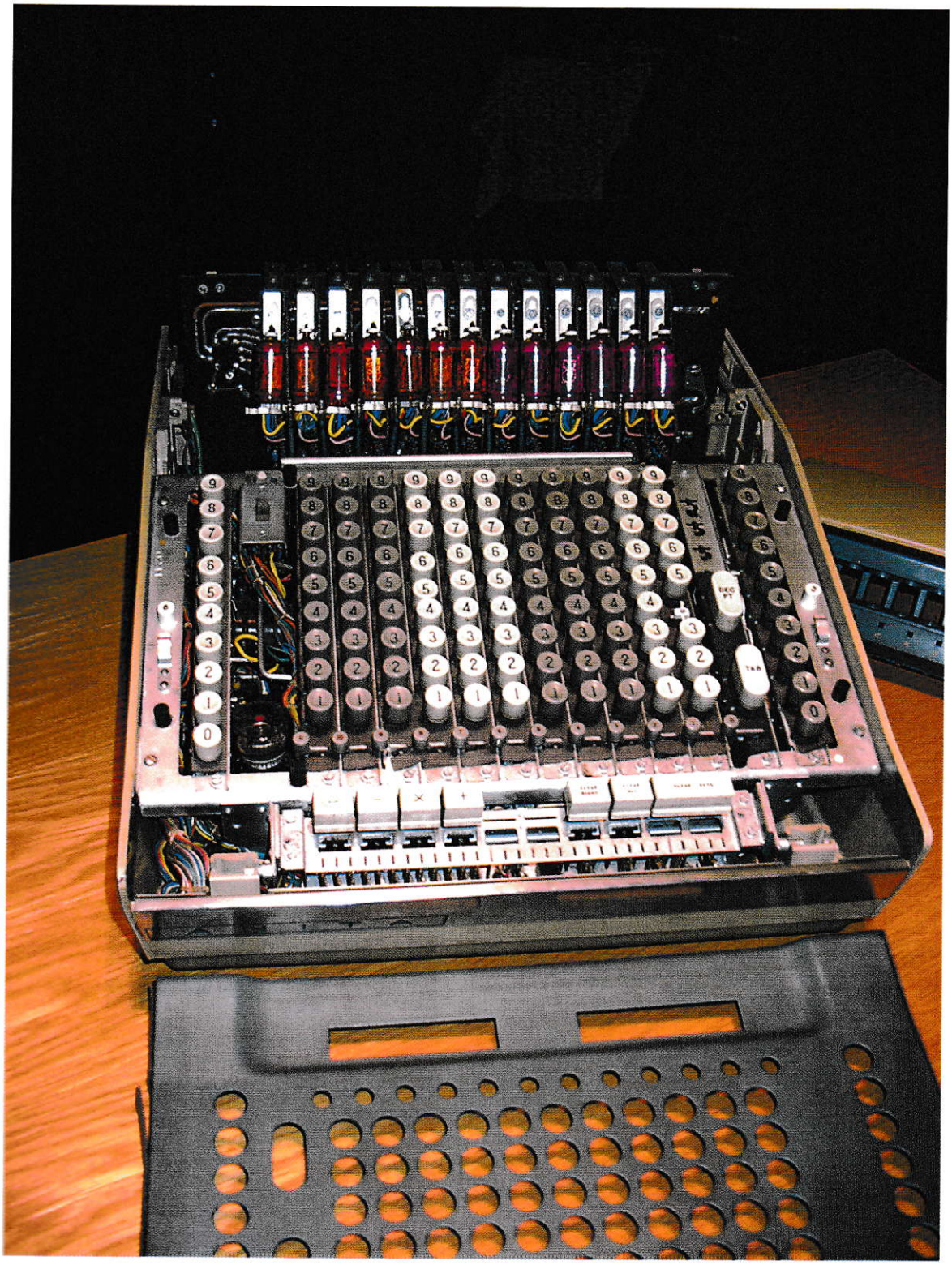

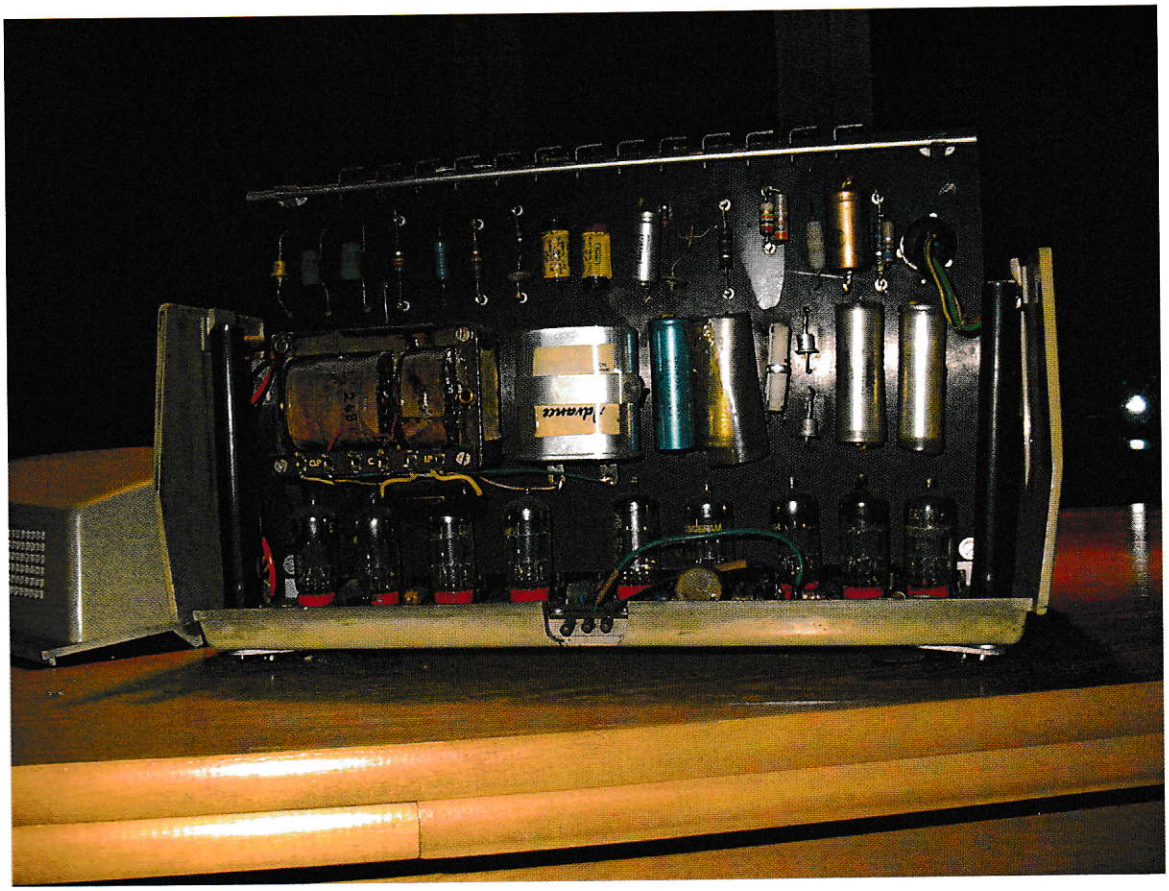

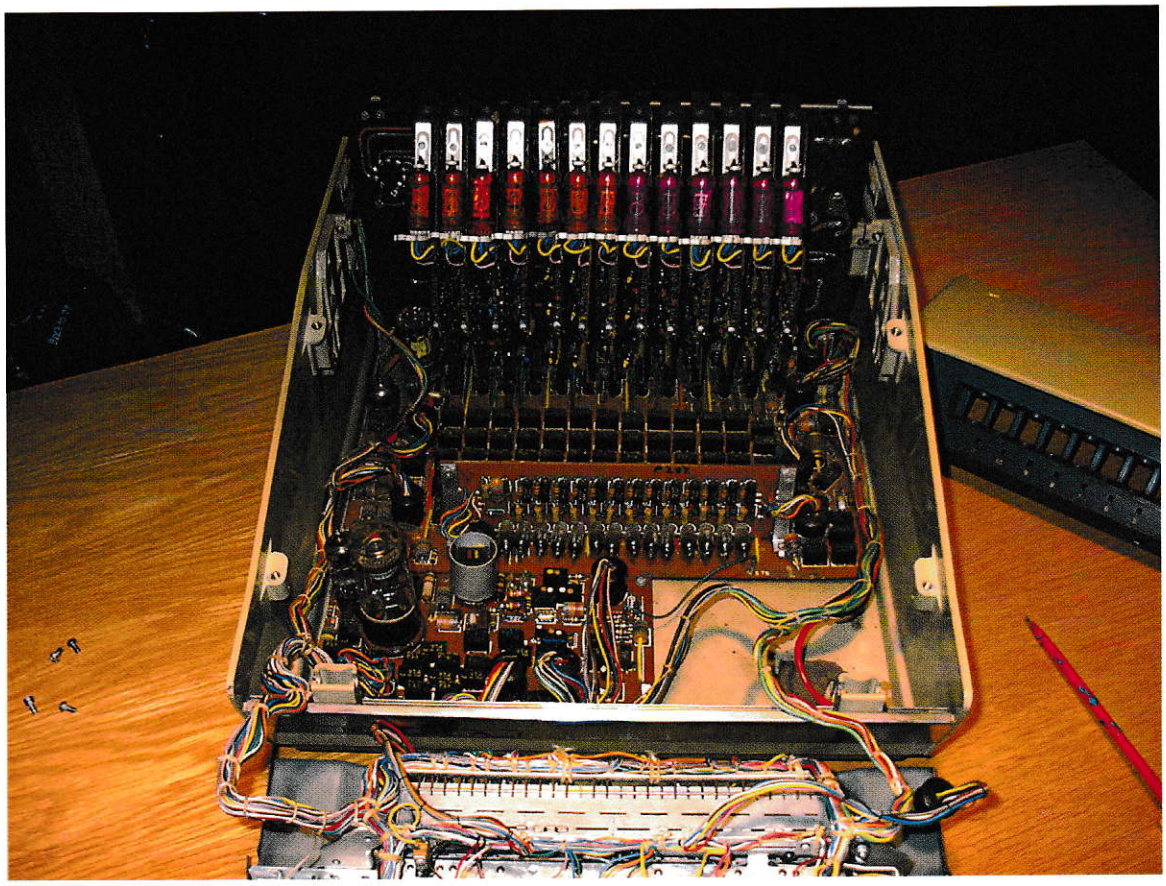

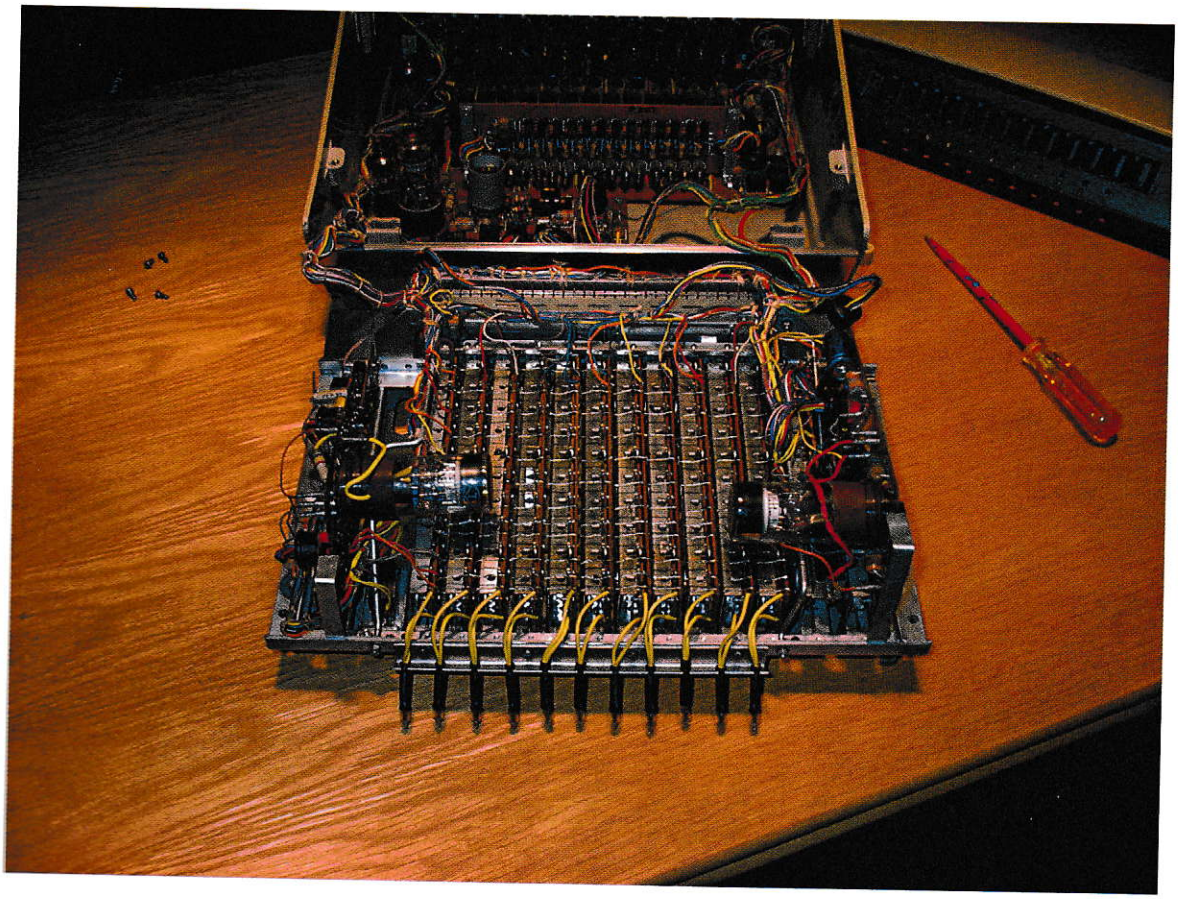

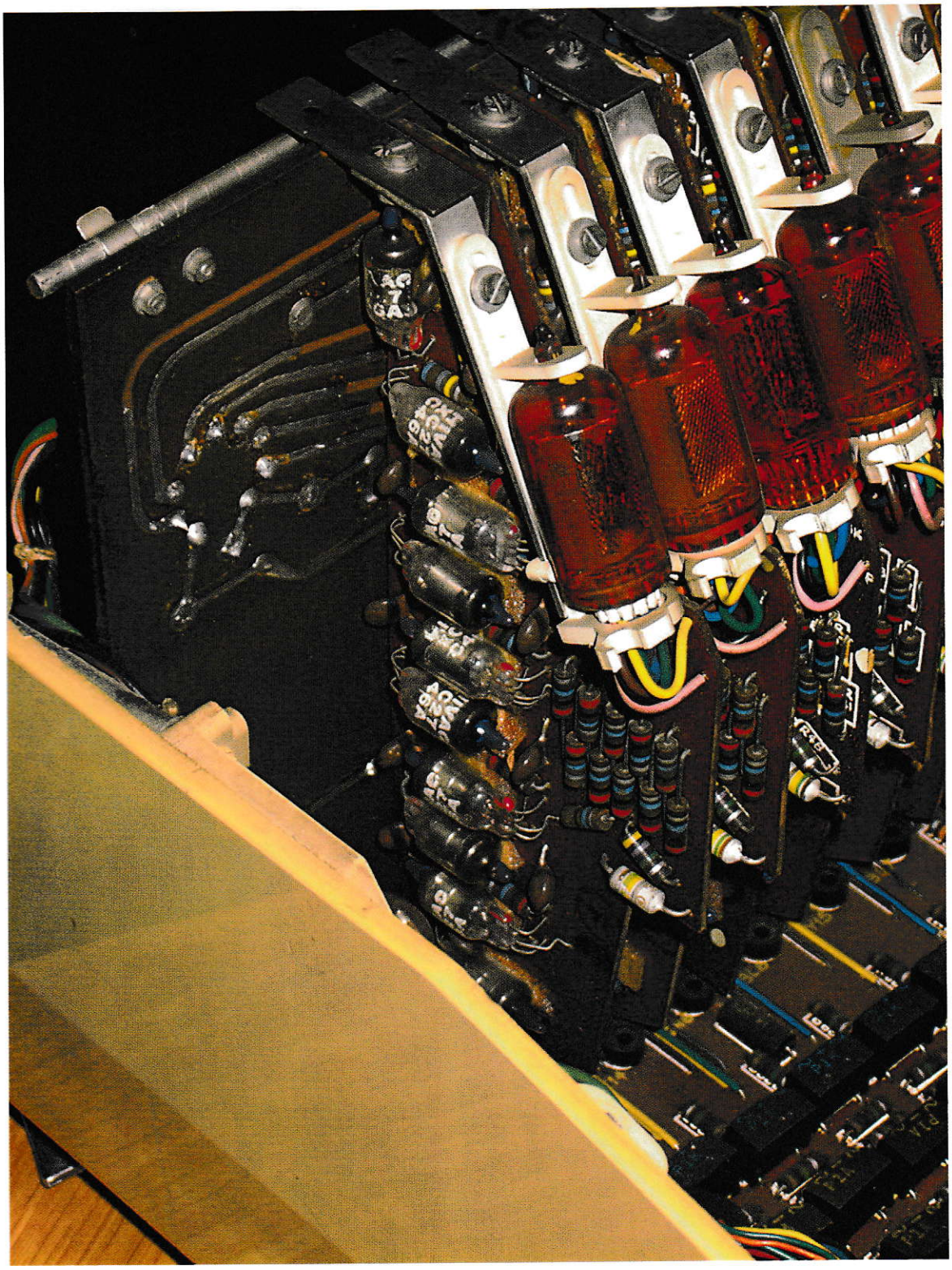

United States Patent Office

3,280,315

Patented Oct. 18, 1966

3,280,315

KEY CONTROLLED DECIMAL ELECTRONIC CALCULATING MACHINE

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Filed Dec. 29, 1961, Ser. No. 164,645
45 Claims. (Cl. 235—160)

This invention relates to calculating machines, and more particularly to digital calculating machines which may be constructed, in various forms all including important elements in common, to perform any one or more of the arithmetical operations of addition, subtraction, multiplication and division. The invention may be embodied in machines operating essentially by electromechanical means, as regards the development and accumulation together of digital pulses for delivery to storage means, and it may also be embodied in machines employing space discharge devices for the performance of those functions. The present invention is a continuation-in-part of my applications Serial Nos. 682,376, 682,394 and 682,396 filed September 6, 1957 and of my application Serial No. 819,068 filed June 9, 1959, all of which applications have been abandoned.

The invention will now be further described by reference to the accompanying drawings in which:

FIGURE 1 is a circuit diagram of an electronically controlled electromechanical key operated calculating machine according to the invention capable of effecting addition, subtraction, multiplication or division;

FIGURE 2 illustrates diagrammatically a multicathode stepping electronic tube which may be employed as a counting device in a machine constructed in accordance with the present invention;

FIGURES 3 and 4 are respectively plan and side elevation views of a key controlled calculating machine embodying the circuit arrangement illustrated in FIGURE 1 to effect addition, subtraction, multiplication or division;

FIGURES 5 and 6 are side and elevation views of one order of keys in the main keyboard of the machine of FIGURES 3 and 4;

FIGURES 7, 8, 9 and 10 illustrate a device whereby the numeral registered upon a multicathode counting tube of a key controlled office calculating machine can be registered upon a mechanically operated numeral wheel;

FIGURES 11 and 12 are respectively side elevations of the multiplier key and control key columns in the machine of FIGURES 3 and 4;

FIGURE 13 is a circuit diagram similar to that of FIGURE 1, but showing the components of the circuit of FIGURE 1 necessary to carry out the operations of addition and subtraction only;

FIGURE 14 is a block diagram of the electrical circuit of a calculating machine of electronic type according to the present invention;

FIGURE 15 illustrates the wave forms of the outputs T1, T2, T3 and T4 of the timing device of FIGURE 14;

FIGURE 16 is a simplified circuit diagram of the pulse generator PG and changeover switch 1S illustrated in FIGURE 14;

FIGURE 17 illustrates the wave forms on the terminals 1/8 to 9/0 in FIGURE 16;

FIGURE 18 is a circuit diagram of the gate circuit CG and the electronic changeover switch CS illustrated in FIGURE 14;

FIGURE 19 is a circuit diagram of the timing device T and its input amplifier TA illustrated in FIGURE 14;

FIGURE 20 is a circuit diagram of the control device C, its input amplifier CA, the gate circuits CGA and CGB, the bank of multiplier keys MK and the switching arrangement CM illustrated in FIGURE 14;

FIGURE 21 is a circuit diagram of the counting device 11R, its input amplifier 11A, the gate circuits 11GA, 11GB, 11GC and 11GF and the bank of keys 11K illustrated in FIGURE 14;

FIGURE 22 illustrates the plus and minus gate drive wave forms in the machine of FIGURE 14;

FIGURES 23 and 24 illustrate in sectional side elevation and in plan, respectively, the keyboard and phasing interlocks with which is provided the machine of FIGURE 25;

FIGURE 25 is a plan view of the exterior of a machine of electronic type according to the invention whose circuit is shown in FIGURE 14; and

FIGURE 26 is a circuit diagram of apparatus which may be incorporated into the machine of FIGURE 14 in order to permit the moving of numbers from one part of the register of that machine to another part of that register.

Referring to FIGURE 13 of the drawings, there is shown a circuit diagram of an electromechanical calculating machine constructed in accordance with the present invention, and adapted to perform the operations of addition and subtraction.

In the circuit diagram shown in FIGURE 13 there is diagrammatically illustrated a machine comprising twelve orders of keys. Each order of keys is provided with nine keys, each key being arranged to be manually operated and in so doing to close one pair of contacts associated with said key and open a second pair of contacts associated with the same key. The two pairs of contacts associated with each of these keys are hereinafter designated as S and K contacts and each pair of contacts is designated by a pair of index figures, the superscript indicating the order of keys with which the contacts are associated, the subscript representing the number of the key of the said order. Contacts S and K are respectively normally open and normally closed. Thus the contacts marked S^3_1 and K^3_1 comprise the contacts which are associated with the first key of the third order of keys. The contacts associated with any one order of keys are connected, in a manner hereinafter described, to nine studs arranged for example as a printed circuit or as a series of studs embedded in a suitable material or in any other suitable manner, in circular formation upon the face of a commutator plate.

The studs associated with the first order of keys are designated O_0 to O_8, those associated with the second order of keys as P_0 to P_8, those associated with the third order of keys as Q_0 to Q_8, those associated with the fourth order of keys as R_0 to R_8 and so on, for twelve orders of keys, so that the studs associated with the eleventh and twelfth order of keys are designated Y_0 to Y_8 and Z_0 to Z_8 respectively. Thus in a calculating machine constructed in accordance with the present invention in which there are twelve orders of keys designed to effect

calculations based upon the decimal system, a predetermined number of the nine studs associated with any one particular order of keys can be energized upon the actuation of a selected key of that order. The number of studs which are selected depend upon whether the machine is set to effect addition or subtraction. In the case of addition the number of studs selected is the same as the number which the actuated key represents whereas in the case of subtraction the number of studs selected is the nines complement of the number which the actuated key represents.

Considering the arrangement of S and K pairs of contacts illustrated in FIGURE 13 in connection with the first order of keys, it will be observed that the pairs of contacts S^1_1 to S^1_9 are connected in parallel with one another and that the pairs of contacts K^1_1 to K^1_9 are connected in series with one another and also in series with the parallel arranged S^1_1 to S^1_9 pairs of contacts.

The studs associated with the first order of keys are designated O_0 to O_8 and are so connected that the first stud O_0 is arranged in series with the pair of contacts S^1_1 and the remaining studs O_1 to O_8 are connected so that the stud O_1 is connected between the pairs of contacts K^1_1 and K^1_2, the stud O_2 is connected between the pairs of contacts K^1_2 and K^1_3, the stud O_3 between pairs of contacts K^1_3 and K^1_4, the stud O_4 between the pairs of contacts K^1_4 and K^1_5, the stud O_5 between the pairs of contacts K^1_5 and K^1_6, the stud O_6 between the pairs of contacts K^1_6 and K^1_7, whilst the stud O_7 is connected between the pairs of contacts K^1_7 and K^1_8 whilst the stud O_8 is connected between the pairs of contacts K^1_8 and K^1_9.

The pair of contacts K^1_9 is connected to one terminal CS^1_4 of a two-way switch CS_4 whilst the pairs of contacts S^1_1 to S^1_9 are connected in parallel to the other terminal CS^2_4 of the two-way switch CS_4.

When the anode T^3_1 of a valve T_1 is connected through the terminal CS^2_4 of the two-way switch CS_4 to the S pairs of contacts of the first order of keys and a key of the first order of keys is actuated the number of studs corresponding to the number which the actuated key represents will have a potential applied to them whereas when the anode T^3_1 of the valve T_1 is connected to the K pairs of contacts through the terminal CS^1_4 of the two-way switch CS_4 and a key of the first order of keys is actuated a number of studs corresponding to the nines complement of the number which the actuated key represents will have a potential applied to them. It will be observed that if CS_4 is set with the terminal CS^3_4 in contact with the terminal CS^1_4 and if none of the keys of an order of keys is actuated all the nine studs of the said order will have a potential applied to them whereas if the No. 1 key of that order of keys is actuated eight studs will have a potential applied to them, that is, one less than the number of studs.

The above arrangement enables both addition and subtraction to be effected by depressing a key indicative of the figure which has to be added or subtracted, thus avoiding the necessity of providing keys with two figures, one the complement of the other, in order to guide an operator in the case of a calculation where subtraction is required.

The arrangement described above applies to the studs associated with each order of the twelve orders of keys comprising the machine.

Associated with each batch of studs and arranged parallel thereto are commutator segments O_9, P_9, Q_9, R_9, etc., up to Y_9 and Z_9. Arranged between adjacent batches of nine studs O_0 to O_8, P_0 to P_8, Q_0 to Q_8 and so on up to Y_0 to Y_8 and Z_0 to Z_8 are three studs C, B and A. Each pair of studs C and B are arranged in alignment with corresponding pairs of studs C_1 and B_1, mounted in advance (that is to the right of the right-hand end when viewing FIGURE 13) of each of the commutator segments O_9, P_9, Q_9, R_9 and so on up to Y_9 and Z_9, whilst each of the studs A are arranged in line with the leading portion (that is, the right-hand end portion when viewing FIGURE 13) of each of the commutator segments O_9 to Z_9. Further, arranged in advance (that is to the right of the stud O_0 when viewing FIGURE 13) of the studs O_0 to O_8 and in line with the leading end (that is the right-hand end portion when viewing FIGURE 13) of the commutator segment O_9 of the first order of keys is a stud D to which is applied a negative potential when the switch CS_4 is set in the position indicated in the drawing where the machine is arranged to effect subtraction.

The commutator segments O_9 to Z_9 are each connected to a separate accumulator O_{10} to Z_{10}, operable as a result of electrical impulses, and each accumulator is connected through a separate diode O_{11} to Z_{11} or other unidirectional electronic device to a bus-bar J.

Mounted in advance of the batch of studs O_0 to O_8 and the associated commutator segment O_9 (that is to the right of the right-hand stud O_0, and to the right of the right-hand end of the commutator segment O_9 when viewing FIGURE 13) are a pair of studs E—E which are arranged to be swept by a rotatable brush F preferably arranged to rotate continuously and operable to short circuit any pair of contacts or a contact and a commutator segment which it may bridge. The brush F is arranged as it rotates to sweep over the batches of O_0 to O_8 up to Z_0 to Z_8 studs and the commutator segments O_9 to Z_9 of the various orders of keys so as to bridge associated studs and commutator segments. The brush F is also arranged to bridge the A studs and their associated commutator segments O_9 to H and also the B–B_1 and the C–C_1 studs associated with each order of keys.

The studs C and B mounted in advance of each batch of studs O_0 to O_8 up to Z_0 to Z_8 are connected respectively to the trigger electrode T^1_9 of the valve T_9 and to the cathode T^1_3 of the valve T_3 whilst the studs C_1 and B_1 mounted in advance of corresponding commutator segments O_9 to Z_9 and H are connected to a source of positive potential M.

The studs A mounted adjacent to the leading studs, namely the studs P_0, Q_0, R_0 and so on up to Y_0 and Z_0 and also following the stud Z_8 are connected to the anode T^1_4 of a valve T_4. The valves T_3 and T_4 are arranged as a two stage transfer store.

One of the studs E—E is connected to a "one shot device" which comprises a condenser U_4 arranged normally to be connected through a common contact U_1 and a contact U_2 of a two-wap switch U to a source of power designed to charge the condenser U_4. When the common contact U_1 breaks contact with the contact U_2 and makes contact with the contact U_3 the condenser U is connected to the upper one of tthe studs E—E above referred to and when the studs E—E are bridged by the brush F, a striking pulse is applied to the trigger electrode T^1_1 of the valve T_1.

The O_0 to O_8 up to the Z_0 to Z_8 studs and the corresponding commutator segments O_9 to Z_9 associated with the various orders of keys and also the commutator segment H associated with the stud A to the left of Z_0 to Z_8 are arranged in circular concentric paths upon a commutator plate 12 (FIG. 4) and the brush F is mounted concentrically with the said studs and commutator segments so that as the brush F rotates it successively bridges the O_0 to O_8 up to Z_0 to Z_8 studs and the associated commutator segments O_9 to Z_9 and the stud A to the left of the studs Z_0 to Z_8 and the commutator H.

The studs O_0 to O_8 up to Z_0 to Z_8 and the studs C, B and A, as also the commutator segments O_9 to Z_9 and H and the associated studs C_1, B_1 are illustrated in the drawing as lying in line with the brush F regarded as moving over the studs and commutator segments in a linear path from right to left.

It will be observed that when the brush F bridges the studs E—E with the contacts U_1 and U_3 connecting the condenser U_4 to one of the studs E, a positive pulse is applied to the trigger electrode T^1_1 of the valve T_1. The

valve T_1 is connected in circuit with a valve T_2 which is normally conducting. The cathode T^2_1 of the valve T_1 is connected to the cathode T^2_2 of the valve T_2 whilst the anodes T^3_1 and T^3_2 of the valves T_1 and T_2 are connected by a condenser U_5. The circuit arrangement of the valves T_1 and T_2 is such that when the valve T_1 is conducting the valve T_2 is non-conducting and vice versa.

The anode T^3_1 of the valve T_1 is connected to the common terminal CS^3_4 of the two-way switch CS_4. The two-way switch CS_4 is operable so that in one position with the contact CS^2_4 in engagement with the common terminal CS^3_4 a circuit is connected from the anode T^3_1 of the valve T_1 through the common terminal CS^3_4 and the contact CS^2_4, of the two-way switch CS_4, to all the pairs of S contacts of the various orders of keys. Whilst when the common terminal CS^3_4 of the two-way switch CS_4 is placed in engagement with the contact CS^1_4 the anode T^3_1 of the valve T_1 is connected directly to the K pairs of contacts of the various orders of keys.

It will be observed that all the O_0 to O_8 up to Z_0 to Z_8 studs associated with the various orders of keys are normally at zero potential whilst the pairs of CC_1 and BB_1 studs, when bridged by the brush F, successively apply a positive potential from M to the trigger electrode T^1_9 of the valve T_9 and the cathode T^1_3 of the valve T_3. The potentials applied to the cathodes of the valves T_1, T_2, T_3, T_4 and T_9 are as indicated, merely by way of example, in FIGURE 1 as -300 volts. The anode T^3_1 of the valve T_1 and the anode T^1_4 of the valve T_4 are provided with anode resistors T^4_1 and T^3_4 respectively which ensure that when the valves T_1 and T_4 are conducting a potential of -150 volts is applied to the studs to which they are connected.

An accumulator H_1 is connected to a commutator segment H with which there is not associated an order of keys, the function of the accumulator H_1 is merely to accept from the stud A disposed between the Z_0 to Z_8 and the O_0 to O_8 series of studs, any transfer that may be transmitted from the accumulator Z_{10}.

Arranged in advance (that is to the right-hand side when viewing FIGURE 1) of the studs E—E are a pair of studs G—G one of which is connected to a source of positive potential whilst the other is connected to the trigger electrode T^1_2 of the valve T_2.

When the machine is set for operation but none of the keys of the various orders of keys has been actuated, the valves T_2 and T_9 are conductive as is indicated by shade lines, whilst the valves T_1, T_3 and T_4 are non-conductive. The circuit arrangements of the valves T_1 and T_2 are such that when the valve T_2 is conductive the valve T_1 is nonconductive and vice versa.

The construction of the machine is such that, in the case of addition and subtraction, upon the depression of any one key of an order of keys a motor driving the movable parts thereof is automatically switched on. As a result of the operation of the motor the contacts U_1 and U_3 of the one shot device are closed and the condenser U_4 is connected to one of the studs E—E.

The brush F which is caused to rotate as a result of the switching on of the motor will be assumed to bridge firstly the contacts E—E and thereby apply a positive pulse to the trigger electrode T^1_1 of the valve T_1, thus causing the valve T_1 to be rendered conductive and the valve T_2 nonconductive. As hereinbefore stated, depending upon the position of the common terminal of the two-way switch CS_4 the potential from the anode T^3_1 of the valve T_1 is either applied directly to the S or K pairs of contacts of the various orders of keys.

As the brush F proceeds in its path it bridges and short circuits the studs C–C_1 the effect of which is to apply a positive potential from the terminal M to the trigger electrode T^1_9 of the valve T_9 but as the valve T_9 is normally conductive the application of this positive potential is noneffective. The further movement of the brush F causes it to bridge and short circuit the studs B–B_1 the effect of which is to apply a positive potential from the terminal M to the cathode T^1_3 of the valve T_3 but as the valve T_3 is at this stage nonconductive the application of the said positive potential is noneffective. It will be observed that at this stage of the operations the transfer device comprising the valves T_3, T_4 and T_9 has been cleared. The continued movement of the brush F causes it to bridge a contact D and the leading end (that is the right-hand end when viewing FIGURE 1) of the commutator segment O_9 which if the common terminal CS^3_4 of the two-way switch CS_4 is making contact with the contact CS^1_4 has a negative potential applied to it, whereas if the common terminal CS^3_4 of the two-way switch CS_4 is making contact with the contact CS^2_4 the stud D is dead.

The purpose of the stud D will be hereinafter explained when dealing with subtraction.

The further movement of the brush F over the studs O_0 to O_8 of the first order of keys transmits, in the form of an impulse or impulses, the potential, which has been applied to a stud or a selected series of studs of the first order of keys as the result of a key actuation, to the commutator segment O_9, whereupon the impulse or impulses are transmitted from the commutator segment O_9 to the accumulator O_{10} to register in the said accumulator a numeral which is related to the numeral of the actuated key of the first order of keys.

The continued movement of the brush F causes it to bridge studs C–C_1 which precede the studs P_0 to P_8 associated with the second order of keys. The bridging of the studs C–C_1 applies a potential to the trigger electrode T^1_9 of the valve T_9 which remains conductive or is returned to the conductive state depending upon whether or not a carry was being propagated. If there was such a carry T_4 will be turned on by T_3 clearing. When the brush F bridges the B–B_1 studs which precede the second order of studs P_0 to P_8, the effect is as with the first order that the valve T_3 remains nonconductive. As the brush F sweeps over the studs of the second order of studs P_0 to P_8 to which a potential has been applied from the anode T^3_1 of the valve T_1, an impulse or impulses is or are transmitted through the commutator segment P_9 to the accumulator P_{10} of the second order of keys to vary the value registered in the second accumulator by an amount related to the value of the actuated key. The further movement of the brush F over the succeeding orders of studs Q_0 to Q_8 up to Z_0 to Z_8 will vary the value in the succeeding accumulators Q_{10} to Z_{10} by numbers which are related to the keys which are actuated in the said orders.

When the brush F has made one complete revolution it will bridge the studs G—G and in so doing will apply a positive potential to the trigger electrode T^1_2 of the valve T_2, thereby rendering the valve T_2 conductive, and the valve T_1 nonconductive.

When the accumulator associated with any one order of keys reaches the maximum numeral that that accumulator is designed to register means are provided according to the present invention to transfer unity into the accumulator of the next higher order. This is in the main accomplished by the provision of a two stage transfer store which comprises, following each of the pairs of studs B–B_1 and C–C_1, the provision of a stud A arranged in line with the leading end of the associated commutator segment and capable of having a potential applied to it upon an accumulator of one order reaching the maximum capacity thereof and transferring an impulse as a result of such applied potential to the accumulator of the next higher order. The arrangement according to the present invention is that each A stud disposed between succeeding orders of studs O_0 to O_8 up to Z_0 to Z_8 has a potential applied to it when the accumulator of the preceding order has reached the maximum numeral that it is designed to register. Thus in the arrangement illustrated in FIGURE 13 it will be assumed that the accumulators O_{10} to Z_{10} are operable to register according to the decimal system. The accumulators are designed so that in changing from 9 to 0 an