May 20, 1952 K. A. KNUTSEN 2,597,647

STORING AND COMPARING ARRANGEMENT FOR COLLATING AND THE LIKE MACHINES

Filed Dec. 16, 1950 6 Sheets-Sheet 1

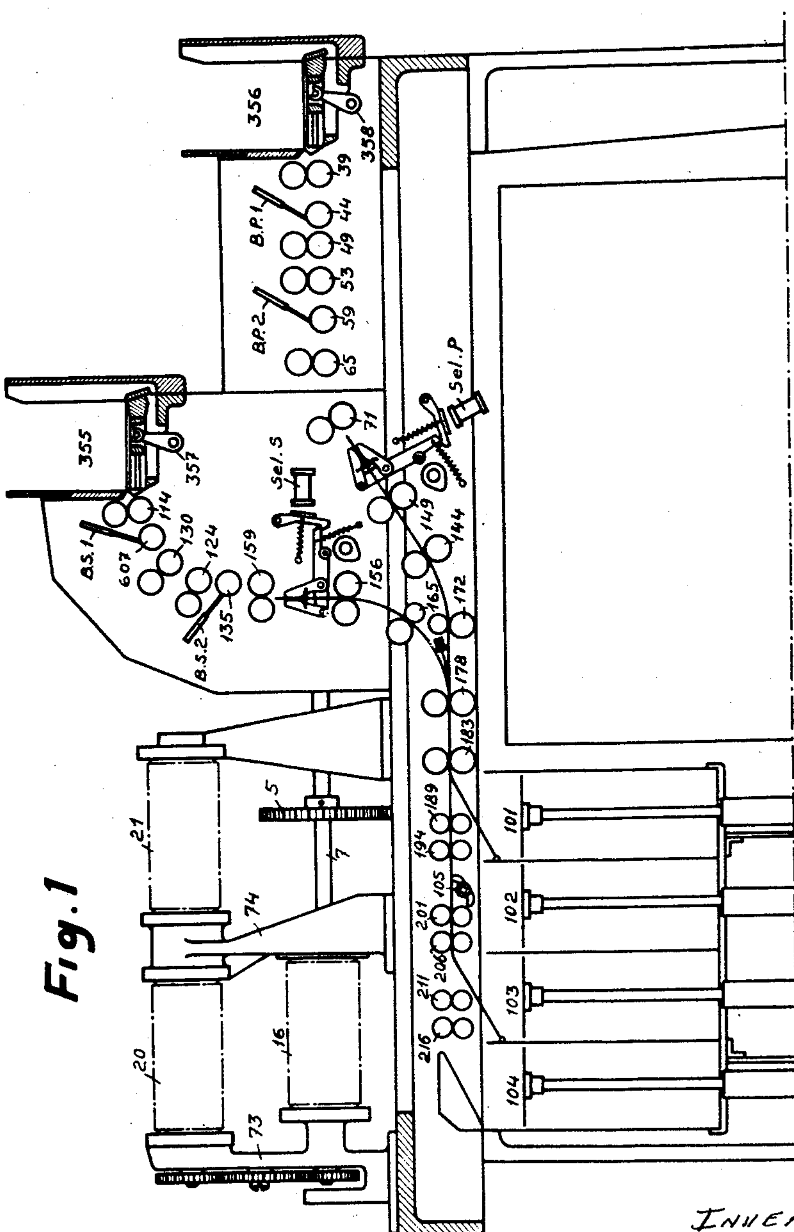
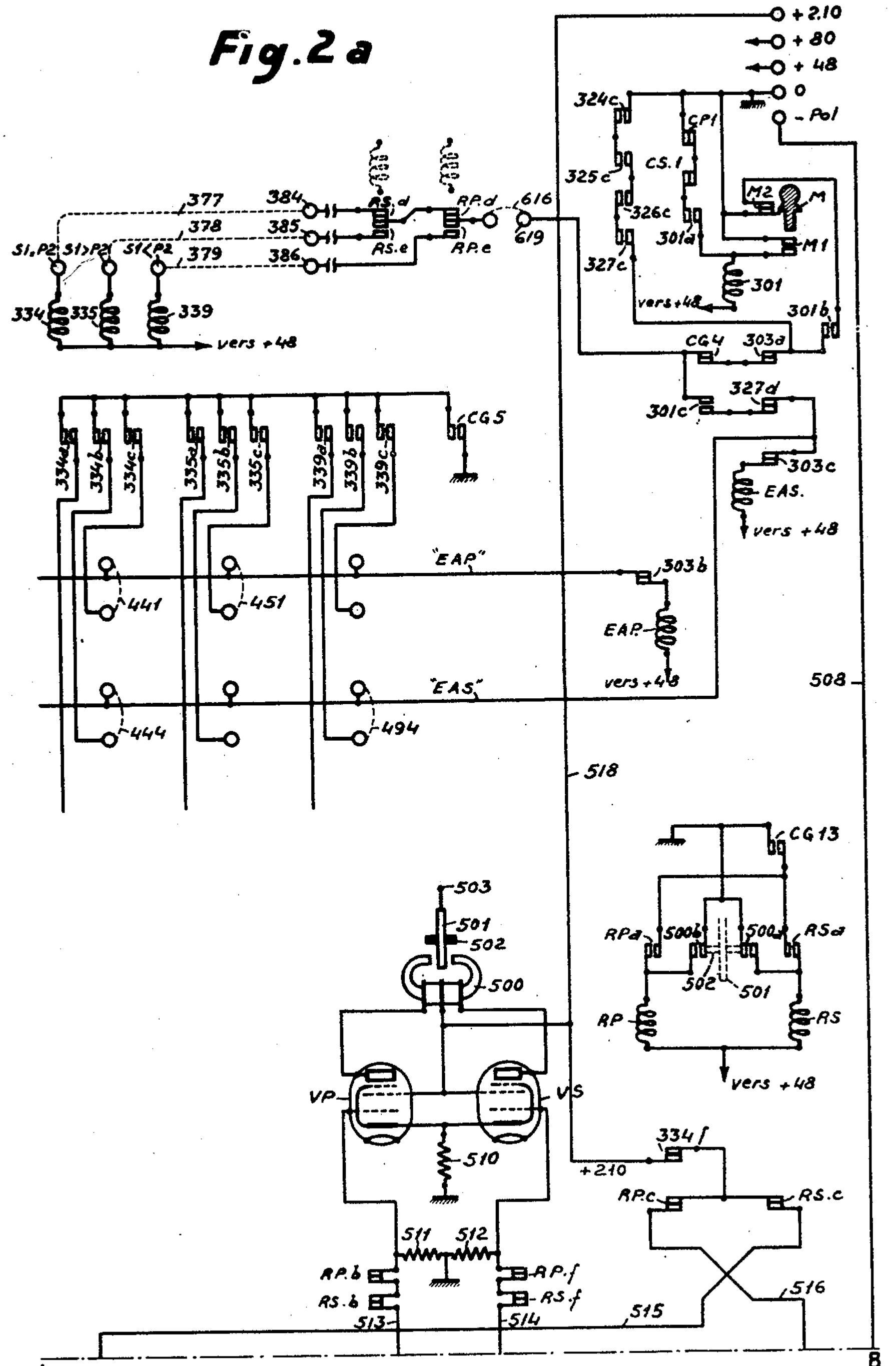


Fig. 1

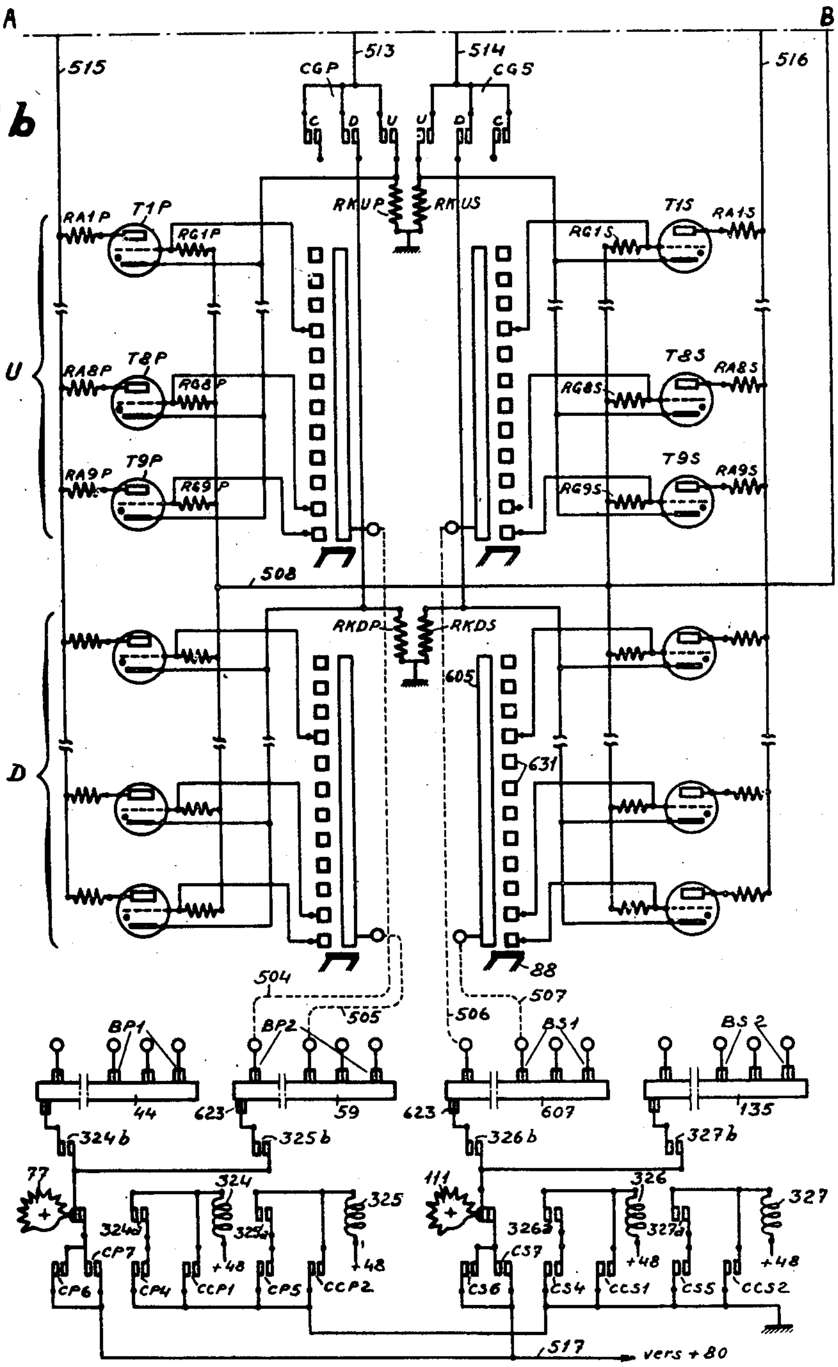
INVENTOR
KNUT ANDREAS KNUTSEN
By: Haseltine, Lake & Co.
AGENTS

Fig. 2a



INVENTOR
By: KNUT ANDREAS KNUTSEN
Haseltine, Lake & Co.
AGENTS

Fig. 2b



INVENTOR
KNUT ANDREAS KNUTSEN

By: Haseltine, Lake & Co.
AGENTS

May 20, 1952

K. A. KNUTSEN

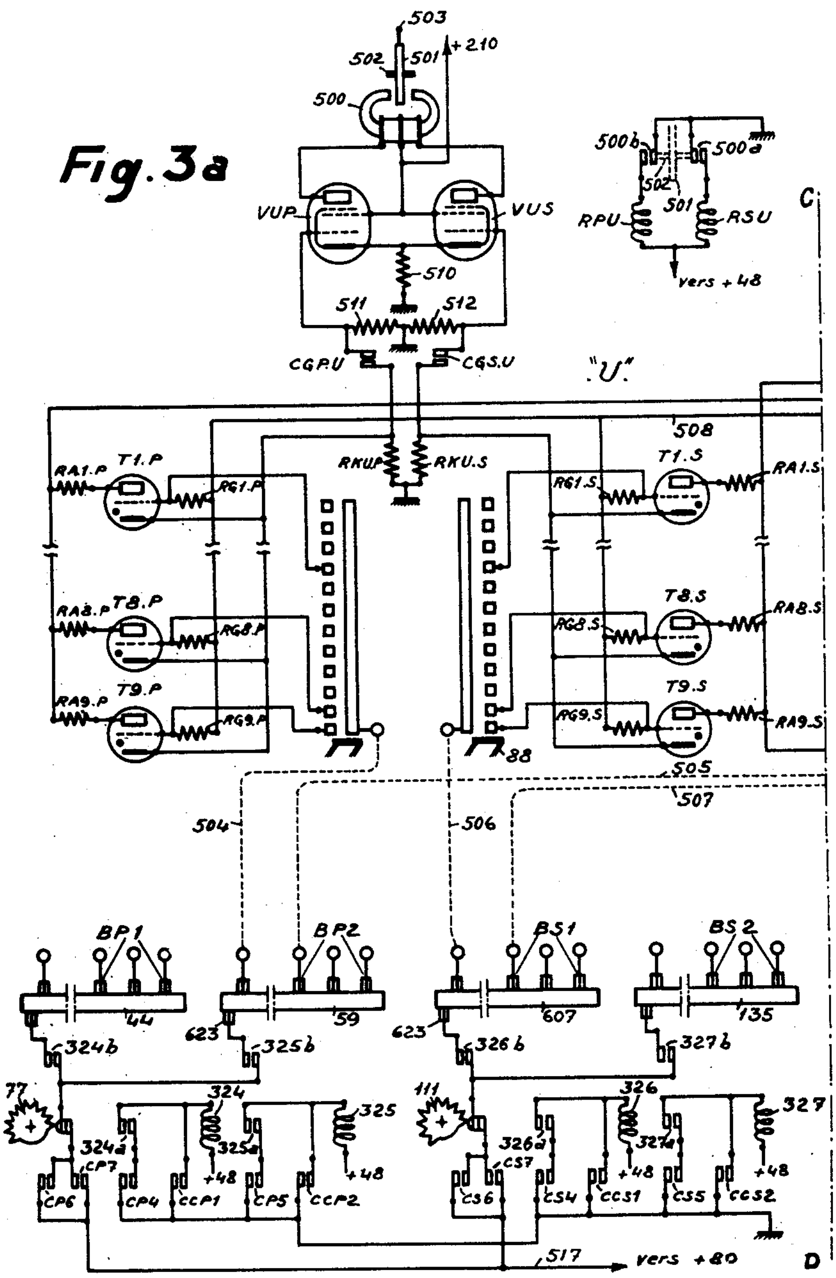
2,597,647

STORING AND COMPARING ARRANGEMENT FOR COLLATING AND THE LIKE MACHINES

Filed Dec. 16, 1950

6 Sheets-Sheet 4

Fig. 3a



INVENTOR
KNUT ANDREAS KNUTSEN

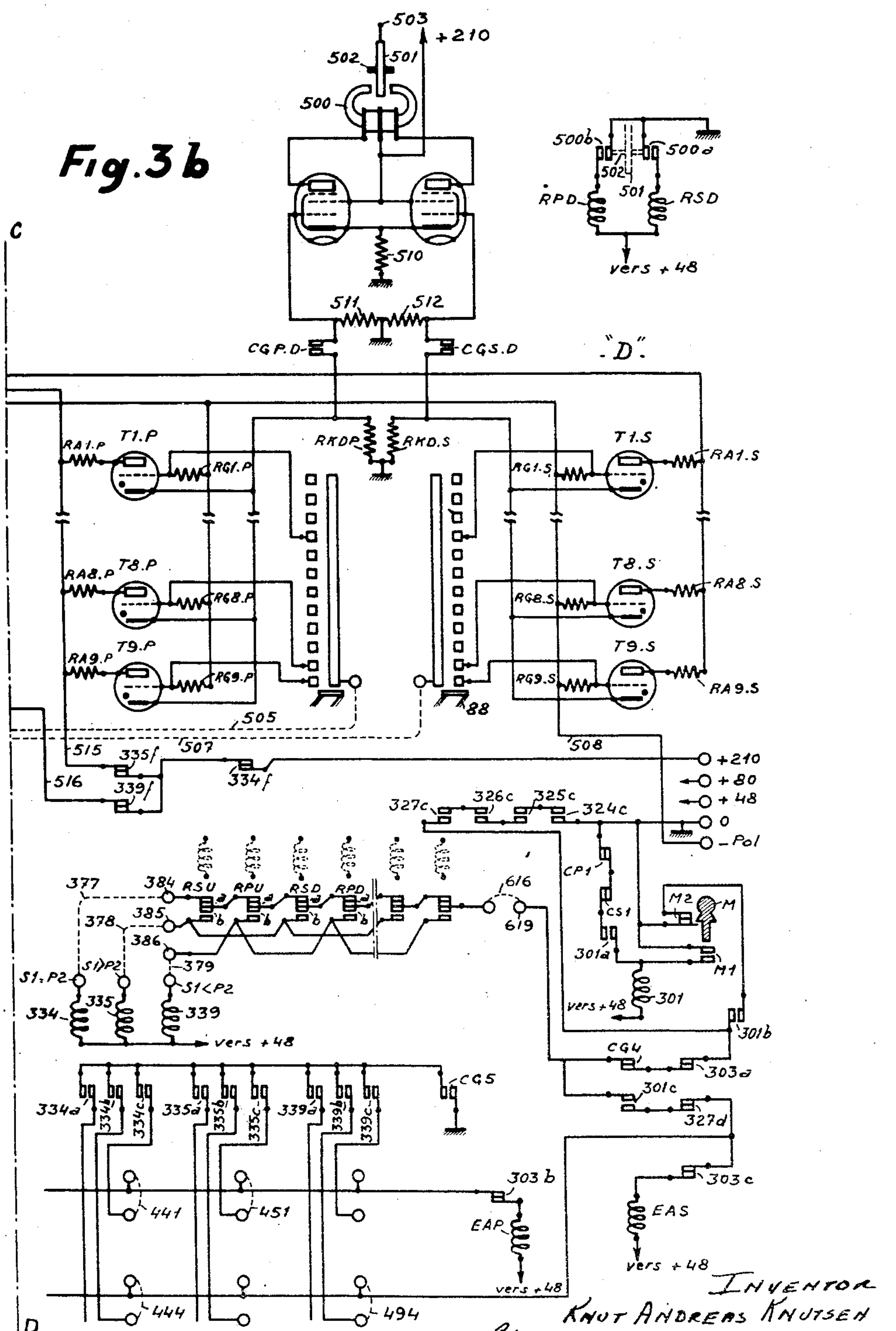
By: Haseltine, Lake & Co.
AGENTS

May 20, 1952 K. A. KNUTSEN 2,597,647

STORING AND COMPARING ARRANGEMENT FOR COLLATING AND THE LIKE MACHINES

Filed Dec. 16, 1950 6 Sheets-Sheet 5

Fig. 3b



Inventor
Knut Andreas Knutsen
By: Haseltine, Lake & Co.
Agents

Fig. 4

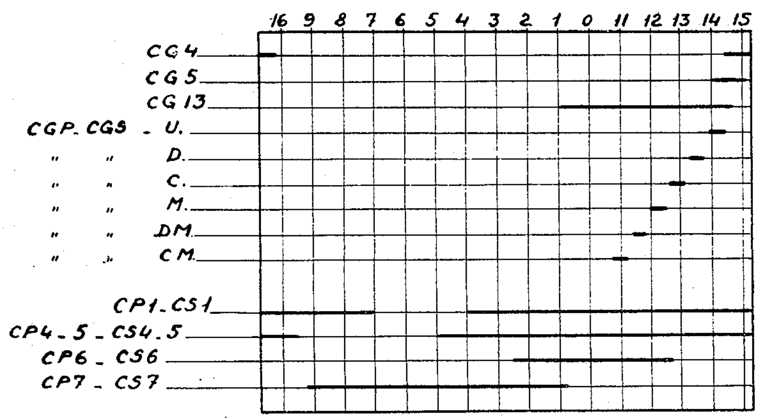


Fig. 5

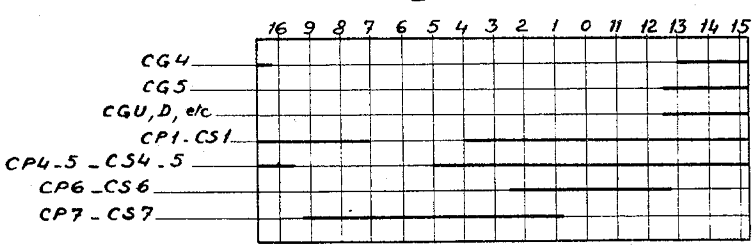


Fig. 6

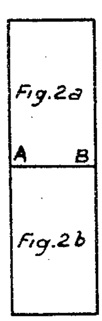
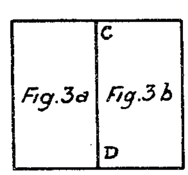


Fig. 7



INVENTOR
KNUT ANDREAS KNUTSEN
By: Haseltine, Lake & Co.
AGENTS

Patented May 20, 1952 2,597,647

UNITED STATES PATENT OFFICE

2,597,647

STORING AND COMPARING ARRANGEMENT FOR COLLATING AND THE LIKE MACHINES

Knut Andreas Knutsen, Paris, France, assignor to Compagnie des Machines Bull (Societe Anonyme), Paris, France, a company of France

Application December 16, 1950, Serial No. 201,142
In France December 29, 1949

7 Claims. (Cl. 235—61.7)

1

This invention relates to storage and comparing arrangements for collating and the like machines, and more particularly to electronic arrangements for the storage and comparing of record cards for re-sorting the cards in said machines.

Such machines are well known and are employed especially to re-constitute a card index when some of the cards have been extracted therefrom. In such cases there are two stacks of cards respectively according to the index numbers which the cards bear, these cards being designated primaries (P) and secondaries (S), respectively. A collating machine therefore comprises a hopper and a feed track for the primary cards and similar elements for the secondary cards. The means for feeding forward the primary and secondary card tracks are started by electromagnetic clutches, either separately or simultaneously, as a function of the comparison or data or indices on the cards, The cards then pass through forward feed members which lead the cards to a common receptacle.

Generally, the known storage and comparing devices comprise relays co-operating with distributors or commutators. They have a certain inertia owing to the relays and necessitate control of relatively great energy. This results in a limitation of the speed of operation of the machine, and wear on the different contacts, distributors and the like, necessitating appreciable maintenance work.

One object of the present invention is to obviate these disadvantages by replacing the storage or registering relays by gas-filled electron tubes and by replacing the comparison relays by high-vacuum electron tubes, a limited number of relays being provided to control the operating members. Such an arrangement permits of a reduction in the overall dimensions of the storage and comparing devices, and in the cost of production, by reason of the fact that the electron tubes replacing the relays are actually much smaller in number than the relays, while being substantially equivalent in cost per element.

According to the invention there is provided a storage and comparing arrangement applicable to a collating machine for re-sorting record cards bearing data or index numbers in the form of perforations or marks representing by their position the numerical value of the said indices, the storage circuits comprising thyratrons and being adapted to translate the time-controlled impulses resulting from the reading of the indices, into momentarily stable electric parameters representing the numerical value of the indices read. (The expression "momentarily stable" must be understood as meaning that the electric parameters obtained remain sufficiently constant for sufficient time to permit the subsequent operation of the machine.) For this purpose, in accordance with the preferred embodiments of the invention, a storage circuit comprises a rotary multiple switch or the like controlling a thyratron corresponding to the digit in question read from the index, said thyratron being one of a series of identical thyratrons having different anode resistances of graded values, or of any equivalent thyratron arrangement providing a parameter (voltage or current) of variable value and preferably proportional to the said read digit corresponding to the said storage circuit.

2

Another object of the invention is to provide a storage and comparing arrangement, as above, which is applicable to collating machines (functioning cyclically) which deals with cards separated into primary and secondary stacks, in which arrangement the electric parameters representing the primary and secondary indices are transmitted to the comparing circuits comprising high-vacuum electron tubes associated in groups of two with a member having a differential electromagnetic action, so as to actuate the primary and secondary feed members differently according to whether the primary parameters are greater than, lower than or equal to the secondary parameters.

A further object of the invention is to provide a storage and comparing arrangement of the type referred to, in which the two tubes of one comparing group have their cathodes connected to a common impedance which supplies the polarising voltage in the inoperative position and effects a limitation of the total anode current of the two tubes by a total negative feedback and balancing effect regardless of the relative values of the parameters applied separately to the control grids of the said tubes.

For a better understanding of the invention and to show how it may be carried into effect, two embodiments will hereinafter be described with reference to the accompanying drawings, given by way of non-limitative example, the embodiments each being applicable to a collating machine suitably modified and of the type described in the specification of United States patent application No. 716,796 filed December 17, 1946.

In the accompanying drawings—

Figure 1 shows diagrammatically a machine to which the invention may be applied, the card receptacles, the feed devices and the reading devices, being illustrated,

Figures 2*a* and 2*b*, when assembled along the lines A—B, show one form of the circuit diagram according to the invention,

Figures 3*a* and 3*b*, when assembled along the lines C—D, show an alternative form of circuit diagram according to the invention.

Figures 4 and 5 show control tables for the cam-operated contacts of the machine, corresponding to the first and second embodiments respectively, and

Figures 6 and 7 show how Figures 2*a*, 2*b* and 3*a*, 3*b* respectively are to be assembled.

Before the storage and comparing arrangement is described, it is necessary to recall clearly how the machine is started and the cards are read. The members necessary for these operations will only be briefly described since a complete and detailed description thereof has been given in the afore-mentioned prior patent specification. The values of the voltages or other practical values indicated are given merely by way of illustration.

It will first be noted that in the accompanying drawings these parts or circuits which are also illustrated in the drawings of the said prior patent specification, have not been modified and have retained similar reference numerals. However, since none of the original elements bearing the numerals 500 to 599 is shown in the accompanying drawings, these numerals are employed for the new parts and circuits necessary for carrying the present invention into effect.

The right-hand part of Figure 1 shows a hopper **356** for the primary cards. **358** is a picker mechanically coupled to the primary shaft which also actuates feed rollers **39**, **49**, **53**, **65**, **71** with their associated pressure rollers, and contact cylinders **44** and **59**.

When a primary cycle is to be started, an electric impulse actuates an electromagnetic clutch which thereupon couples the primary shaft to a main shaft **7** (Figure 1) for one revolution of the latter shaft. The picker **358** feeds a card through the outlet of the hopper; the card is then driven by the rollers **39** and is stopped first before reaching the reading brush BP1. The extent of this movement constitutes what will be referred to as a "cyclic space." If a second impulse is fed to the clutch, another primary cycle is started. The first card, carried along by the rollers, passes under the reading brush BP1 and is stopped shortly before reaching the reading brush BP2 while a second card takes the place of the first. If a third impulse actuates the electromagnetic clutch, the first card passes under the reading brush BP2, while the following cards are also advanced through one cyclic space. After the third primary cycle, the first primary card is stopped between the rollers **65** and **71**. A fourth cycle is required to enable this card to reach the rollers **149**, **144**, **172**, etc. (Figure 1) which rotate constantly, being driven by the main shaft **7**, and which drive the said card into receptacle **103**, the card being guided by a number of deflectors which need not be described here.

The elements of the seconary track are identical with those of the primary track, but may differ in number. There is one secondary card hopper **355**, and one picker **357**, but only three driving rollers **114**, **130**, **124**, with cooperating pressure rollers. Contact rollers **607** and **135** cooperate with the reading brushes BS1 and BS2. The secondary track is continued by feed rollers **159**, **156**, **165**, etc. controlled by the main shaft. It will therefore be seen that as soon as a secondary card has passed the reading brush BS2, it is taken up by the roller **159** and immediately conducted to a receptacle which may, in this case, be the compartment **103**.

In this machine, means are provided to ensure that during the comparison of data or indices on a primary card and secondary card the card bearing the index of lower denomination is advanced during the following cycle, while the other card remains in position until the arrival of a card having a higher index. In this way, a stack of cards sorted in numerical order, is collected in the receptacle **102**. When two cards of similar index are compared, they are simultaneously fed forward in the following cycle, so that they are situated one above the other in the general track. (It will be noted that the record cards dealt with here have a single perforation situated in different indicating positions "9" to "0," to represent the numerical value of a digit.)

The reading circuits of the machine can be seen in the lower part of Figure 2*b*, which shows the contact rollers **44**, **59**, **607** and **135**, against which bear the brushes of the reading contacts BP1, BP2, BS1, and BS2. Two distributors **77** and **111**, constantly driven by the main shaft, close their contacts as the perforations of the cards pass below the reading brushes. The cam-operated contacts CP6, CP7, CS6 and CS7 only permit closing of the reading circuits at those points of the cycle at which analysis of a perforation may take place. Contacts CCP1 and CCS1 and 2 are controlled by card levers situated at the first and second stations of the primary and secondary reading tracks respectively. The latter contacts are intended to indicate, by energising the relays **324**, **325**, **326** and **327**, when one of them is closed, that a card is passing or is about to pass the correponding reading station.

The operation of the members for starting the machine and for effecting the comparison, will now be described with reference to the upper part of Figure 2*a*. These members are exactly the same as those described in the above-mentioned prior patent specification. It is to be recalled that, for the primary-secondary comparison, use is made of the reading stations BS1 and BP2 (the reading stations BS2 and BP1 serving purposes other than those envisaged in the present description). This arrangement has been retained for the purposes of the present description and can be seen from Figure 2*b* by the plug connections **504**, **505**, **506**, **507** to the sockets of the reading brushes BS1 and BP2.

It will be seen that during a primary-secondary comparison the reading of a pair of primary and secondary cards, fed simultaneously from their respective hoppers, is effected with a displacement of one cyclic space. That is to say, of two cards passing simultaneously to the stations BP1 and BS1, only the secondary card is read and stored, and of two cards passing at the same time to the stations BP2 and BS2 only the primary card is read and stored.

Referring again to Figure 2*a*, there will be seen the coils EAP, EAS of the primary and secondary clutch electromagnets. When the motor of the machine is in operation and is driving the general shaft, the feeding of the cards is started by an initial depression of button M. The depression of this button has the effect of closing the following circuit:

Terminal O or earth, contact M1, relay 301, terminal +48. The relay 301, being energised, closes its holding contacts 301a, whereby a holding circuit is made for the said relay in conjunction with the cam-operated contacts CP1 and CS1 (closed upon stopping of the corresponding primary and secondary shafts). Relay 301 also closes its contacts 301b, 301c. When the button M is released, the contact M2 (which had been open) is closed again and establishes circuits for simultaneously energising the electromagnetics EAS and EAP. The first circuit is as follows: terminal O connected to earth, contacts M2, 301b, 303a, CG4, 301c, 327d, 303c, electromagnet EAS, terminal +48. CG4 is closed on stopping of the feed at the point 15½ of the cycle (see Figure 4), 327d is closed since there is still no card under the reading brush BS2, and the control of the contacts 303a, b and c is of no interest at present. The second circuit comprises: terminal O, contacts M2, 301b, 303a, CG4, socket 619, rider 616, contacts RPd, RSd, socket 384, plug connection 377, relay 334, and terminal +48. Energisation of relay 334 causes the closing of the contacts 334a, 334b and 334c and permits energisation of the electromagnet EAP by the following circuit: earth, cam-operated contact CG5, contact 334c, rider 441, line "EAP," contact 303b, electromagnet EAP, terminal +48.

Thus a primary card and a secondary card are simultaneously fed forward through one cyclic space and stopped short off their first reading brushes. In fact, CP1 and CS1 have been opened during the course of this cycle, and this has broken the holding circuit of the relay 301 and prevented the cam-operated contacts CG4 and CG5 from again feeding the clutch electromagnets. Further depression of the button is therefore necessary. By the same processes as before, energisation of the clutch electromagnets brings about the movement of the first pair of primary and secondary cards to a position short off the reading brushes BP2, BS2, while another pair of cards is also fed forward through one cyclic space. In the course of this cycle, the reading of the first secondary card is effected by BS1; the storage of the index read is effected and a comparison, the process of which will later be seen, takes place at the end of the cycle. Owing to the fact that the first primary card has not yet been read and its index stored, the secondary index is necessarily higher (the case of the index 0 being excluded). It is sufficient to know for the moment that this comparison will result in the opening of the contact RSd and the closing of RSe. On release of the button M, a single circuit will be formed, namely: terminal O, M2, 301b, 303a, CG4, 619, 616, RPd, RSe, 385, 378, relay 335, and terminal +48. The closing of the contacts 335c permits the feeding of the electromagnet EAP by CG5 and the rider 451, while the circuit for EAS cannot be made by the opening of the contacts 327d resulting from the presence of a secondary card just in front of BS2. Thus, in the following cycle only the primary feed will be actuated, and the first primary card will be read and its index stored and then compared with the secondary index stored in the second cycle. From this instant, the feed cycles can automatically succeed one another owing to the simultaneous closing of the contacts 324c, 325c, 326c and 327c, as long as there are cards in the reading positions.

The first form of the storage and comparing arrangement will now be described with reference to Figures 2a and 2b. Figure 2b shows, in addition to the reading circuits (at the bottom of the figure), the storage or registering circuits (at the top). The storage circuits have only been shown for indices comprising two digits, namely a row of units and a row of tens. Actually, the operation of the machine envisaged in the first embodiment allows of the dealing with indices containing a greater number of digits, limited by the process of comparison provided. It is sufficient to add an adequate number of storage or registering circuits to have as many such circuits as unit orders which can be employed in the machine.

Each of the storage or registering circuits U (units) and D (tens) is composed of two groups of members, namely one group for the primary indices (P) and one identical group for the secondary indices (S). For this reason, the description of one group will be applicable to both.

A group comprises a multiple switch or commutator connected by means of a plug connection to a reading brush or corresponding order, and a series of thyratron circuits. The multiple switch or commutator may be of any convenient form and, more particularly, in accordance with the construction described in the prior patent specification already referred to. In any case, the switch must comprise a common segment 605 (Figure 2b), preferably of circular form, a series of contact studs 631, and a rotary member or brush 88 which establishes a connection between the common segment and each of the studs successively, when it is in motion.

The brush must be driven synchronously, on the one hand with the distributors 77 and 111, and on the other hand with the card-feed rollers so that when a perforation "9" is analysed, the brush is situated on a stud representing the value "9" and so on for the other values of the perforations. During one feed cycle, the brush describes a complete revolution.

The common segment of the units of the primary cards (Figure 2b) is connected by the plug connection 504 to the reading brush BP2 for the units.

The thyratrons of each group are employed to convert the time-controlled impulses resulting from the reading of the indices into electric parameters representing by their magnitude the numerical value of the said indices and to preserve the parameters throughout the time necessary for the subsequent comparison or comparisons.

It will be recalled that a thyratron is a gas-filled electron tube having at least one cathode, a control grid and an anode and that when the state of conduction is initiated, for a certain range of voltage values, the control grid no longer acts on the anode current, which can only be cut off by suppressing the anode voltage or by breaking the anode circuit. Moreover, during conduction the voltage drop across the anode-cathode space is constant for a given type of thyratron and the current delivery depends only on the external circuits.

A group comprises nine thyratrons to which are allocated the values 1 to 9. (Certain only of the thyratrons are shown in Figure 2b for the sake of clarity.) For example, the primary storage group comprises thyratrons T1P to T9P. Their cathodes are connected to earth through a common resistance RKUP. Each of the grids is connected directly to one contact stud of the associated multiple switch, each stud controlling an impulse, the numerical value of which corresponds to that of the thyratron. Thus, the grid of the thyratron T9P can receive a time impulse "9," the grid of T8P a time impulse 8, and so on. If it be assumed that the zeros are not punched on the cards, there are no thyratrons for this value. In the inoperative position, that is to say, during the non-conductive state of all the thyratrons of the group, the potential of the grids is fixed at a negative value with respect to the cathodes which are at this instant at zero potential. For this reason, each of the grids is connected to terminal Po1 (Figure 2a) through individual resistances RG1.P, RG2.P, etc., each of which resistances is connected to a common connection 508.

High tension voltage is applied to the anodes through the conductor 515 (Figure 2b) and resistances RA1.P, RA.P etc. The values of these resistances are unequal and are so selected that they determine, in each of the thyratrons which they control, different current deliveries which are a function of the numerical value allocated to the associated thyratron. For example the resistance RA9.P can be made the weakest of the group; the resistance RA1.P will then be the highest. When T9.P is rendered operative, the anode current delivered is greater than that delivered by T8.P which is greater than that delivered by T7.P and so on up to T1.P when the latter is rendered operative. When any one of the thyratrons of the group is conductive, a potential difference is set up across the terminals of the resistance RKU.P, the positive pole being opposite to earth. It is clear that when T9.P is conductive, the voltage set up across the terminals of RKU.P is higher than when T1.P is conductive. The resistances RA2.P to RA8.P have values intermediate between those of RA1.P and RA9.P. Consequently, owing to the selection of the thyratrons effected by the associated multiple switch and owing to the anode resistances of different values, it is possible to obtain a stable direct current voltage across the terminals of the resistance RKU.P and to make the different possible values of this voltage represent a predetermined function of the numerical values of the recorded impulses.

The setting in operation of one of the thyratrons of a group takes place in the following manner. The reading circuits of the machine described in the aforesaid patent specification are so modified that they include a voltage source other than that of the relays. For this purpose, the cam-operated contacts CP6, CP7, CS6 and CS7 (lower part of Figure 2b), are fed independently of the relays by the connection 517 to the positive terminal 80. It will be assumed that a primary card is analysed at the position BP2, when a perforation passes under the reading brush of the units order, for example, the voltage +80 is transmitted to the grid of one of the primary thyratrons through the circuit: positive terminal 80 (Figures 2a–2b), connection 517, cam-operated-contact CP6 or CP76, contact of the distributor 77, contact 325b, general brush 623, contact cylinder, hole of the card, units brush, plug connection 504, multiple switch (common segment, brush contact stud corresponding to the perforation) and grid of one of the thyratrons thus selected. The making of this circuit corresponds to the sending of a positive impulse and during this impulse the thyratron selected becomes conductive and remains conductive as long as the anode circuit is not broken.

The appearance of a positive continuous voltage (across the terminals of RKU.P) proportional to the numerical value of an analysed perforation constitutes, therefore, the storage of the said value. The storage of the perforations by the secondary units group takes place identically and it will be appreciated that if the elements of the secondary group have exactly the same values as the corresponding elements of the primary group the analysis of equivalent perforations at the positions BP2 and BS1 must set up equal voltages across the terminals of the resistances RKU.P, RKU.S, etc., and that comparison of these voltages is possible for detecting which is the largest in the case of inequality. The storage of the value corresponding to the perforations by the groups of the other orders of units takes place identically and simultaneously for each unit order.

It therefore remains to consider the comparison circuits. These are composed essentially (see Figure 2a) of two high-vacuum electron tubes VP and VS, a differential polarised relay 500, two comparison relays RP and RS and finally change-over devices CGP and CGS (upper part of Figure 2b).

The two tubes VP and VS are pentodes having similar characteristic curves. Triodes or tetrodes could also be employed for this purpose. The control grids are, during the inoperative period, at earth or zero potential owing to their respective connection to the resistances 511 and 512, the other end of which is earthed. The grids are also each connected by a wire 513 and 514 to the change-over devices CGP and CGS (see Figure 2b), the contacts of which are all open in the inoperative position. The anodes of the pentodes VP and VS receive the high tension of the connection 518 (leading to the positive terminal 210) through the respective coils of the differential relay 500. These two coils must be so constructed that when they are traversed by equal currents (which is the case when VP and VS are inoperative) the magnetic fluxes produced cancel one another out so that the armature 501 remains in its position of equilibrium. The sensitivity of the system must be such in practice that a difference of a few mA is sufficient to produce the attraction of the armature 501 in one direction or the other.

The screens of VP and VS receive the high tension directly through the connection 518. The cathodes are connected together and the cathode circuit is closed on a common resistance 510 connected to earth. This resistance produces in well known manner that negative polarisation of the grid which determines the anode delivery of the valves VP and VS in the inoperative position. However, this self-polarising system applied to two direct-current amplifier valves in opposition is somewhat special, since it superposes effects of total negative feedback and balancing and affords advantages which will later become apparent. Moreover, the polarised differential relay 500 is provided with an armature 501 having a fixing point 503 connected to the relay. The armature carries an insulating rod 502 which extends transversely across the said armature to control contacts 500a and 500b. When the anode current VP is greater than the anode current supplied by VS, the armature 501 is attracted to the left (as viewed in Figure 2a). It is attracted to the right in the contrary case. These are the movements of the said armature which produces the result of the comparison which is effected in the following manner:

It has already been stated that the grids of the tubes VP and VS are connected respectively to the change-over systems CGP and CGS. These are composed of cam-operated contacts equal in number to the unit orders of the indices to be compared. The cams which control them are actuated by the general shaft of the machine in synchronism with the other distributing and feeding parts. These cams are so adjusted as to obtain the closing times indicated by the table of Figure 4, lines CGP, CGS—U—D—C—M—DM—CM (representing the different unit orders, extending from the units to the hundred thousands). On the machine in question, owing to the division of the cycle into sixteen points or intervals it is scarcely possible in practice to effect more than six successive comparisons between the end of the reading phase and the exploitation of the comparison. It will be seen from the upper part of Figure 2*b*, that the fixed blades (for example) of the cam-operated contacts CGP are connected together and by the connection **513** to the control grid of VP (Figure 2*a*). The opposite blades are individually connected to the resistances located in the cathode return circuits of the groups of thyratrons, namely CGP.U to the upper terminal of KRU.P, CGP.D to the upper terminal of RKD.P, and so on to CGP.CM (not shown) corresponding to the hundred thousands. The connection of the cam-operated contacts CG.S to the tube VS and to the cathode resistances of the secondary thyratrons is identical.

The table of Figure 4 shows that the cam-operated contacts U, D, C, M, DM, CM are successively closed in accordance with decreasing unit orders, CM being closed first and U last. In this way, priority of comparison is granted to higher unit orders.

The members for exploiting the comparison comprise the comparison relay RP (Figure 2*a*) which is energised by the closing of the contact **500*b*** when the armature **501** is moved to the left (in the case of primary superiority) and the relay RS which is energised by the closing of the contact **500*a*** when the armature **501** is moved to the right (in the case of secondary superiority).

Since the energisation of each of the relays must be maintained, they control their respective holding contacts RP*a* and RS*a* both of which are connected in series with the cam-operated contact CG**13** which opens at the end of each cycle.

The comparison relays also control the following contacts:

RPB and *f* and RSB and *f* (Figure 2*a*, lower part) inserted respectively in the connections **514** and **513**, thus controlling the grids of the tubes VS and VP. Thus, priority of the higher order is complete, since, assuming, for example, that when the contact CM of CGP and CM of CGS is closed (Figure 2*b*), a primary card P is of higher index than a secondary card S, the energisation of RP (Figure 2*a*) produces the opening of its contacts RPB and *f*, thus breaking the circuits between the cam-operated contacts CGS and CGP and the grids of VS and VP. In this way, only the comparison of the order of the hundred thousands is effective, since for the following lower orders the positive voltages emanating from the cathodes of the thyratrons cannot be transmitted to the corresponding tubes. The same is the case if S is greater. RP*c* and RS*c* are inserted respectively in the connections **516** and **515** and establish the anode circuits of the secondary and primary thyratrons. It will be assumed that, owing to the higher order of the primary card P, RP is energised: RP*c* opens, thus breaking the line **516** feeding the anodes of the thyratrons S (Figure 2*b*). This is necessary, since the lower card (of smaller index) must leave first and that only the index of the higher card must be kept for comparison in the following cycle with the index on a new card.

RP*d*, RP*e* and RS*d*, RS*e* (upper part of Figure 2*a*) are alternating contacts which control the feeding of the cards as follows: in the case of equality of the indices PS, none of the relays RP and RS is energised; PR*d* and RS*d* remain in the position shown in the drawing; the current set up by CGH feeds the relay **334**. The latter closes its contacts **334*a*, *b*, *c***, so that CG5 is able to feed simultaneously the electromagnets EAP and EAS through the riders **441**, **444** and the lines "EAP" and "EAS." Thus, the cards P and S are fed forward simultaneously.

On the other hand, **334** also opens its contact **334*f*** (lower part of Figure 2*a*), whereby the anode feed of the primary and secondary thyratrons is cut off since no stored index is to be kept for this cycle.

In the case of primary superiority: RP is energised, RP*d* opens and RP*e* closes. The current supplied by CG**4** then feeds the relay **339** and on closing of its contacts **339*a***, **339*b***, **339*c***, CG5 can feed the electromagnet EAS through the rider **494** and the line "EAS," whereby the secondary cards are fed forward.

In the case of secondary superiority: RS is energised, RS*d* opens and RS*e* closes. The current supplied by CG**4** then feeds the relay **335** and on closing of its contacts **335*a***, **335*b***, **335*c***, CG5 can feed the electromagnet EAP through the rider **451** and the line "EAP," whereby the primary cards are fed forward.

The advantages of the polarisation system employed will clearly be seen on consideration of the operation of the tubes VP and VS with the aid of concrete examples. If a suitable given positive voltage is applied to the grid of VP alone, the reduction of grid polarisation resulting therefrom produces an increase in the anode delivery of VP and therefore an increase in the potential difference across the terminals of **510**. However, owing to a phenomenon identical to that known as total negative feedback in alternating current voltage amplifiers, this increase in potential difference across the terminals of **510** produces a further negative grid polarisation, which tends to reduce the anode delivery of VP, but to a less extent than the increase due to the grid voltage varying positively alone. Similarly, the potential of the cathode VS being higher than in the inoperative position, the anode delivery of VS decreases, which results in further limitation of the potential difference across the terminals of **510**. Finally, a state of equilibrium is set up in which the delivery of VP is increased and the delivery of VS reduced to the point where the latter can even be completely cancelled out. It is found in this case that the difference in anode deliveries obtained is maximum and that, on the other hand, the total current delivered by the two tubes is substantially the same as in the inoperative position, which would not have been the case if the two tubes had been inoperative, and separately polarised in fixed fashion.

If now the said given positive voltage is simultaneously applied to the grids of VP and VS, the effect of total negative feedback takes effect on the two tubes and the increase in the cathode voltage prevents an excessive increase in the feeds.

Finally, for the same reason, when for example a positive voltage of 27 volts is applied to the grid of one of the tubes and one of 24 volts is applied to the grid of the other tube (which corresponds to a comparison of 9+8), the effectiveness of the system is not reduced, but the risks of saturation of the core of the relay are thus avoided.

The operation of the arrangement and of the machine according to the first embodiment can now be examined.

It will be assumed that the machine has been started in the manner hereinbefore indicated and that it is in the second cycle, that is to say, in the cycle in which a primary card P and a secondary card S are passing to the reading position **BP1** and **BS1**. It will be remembered that the reading of the secondary card S is effective, since **BP1** is not in circuit (Figure 2*b*). Assuming that 45 is the index on the secondary card, at the points 5 and 4 of the cycle the thyratrons **T4S** (tens) and **TS5** (units) become conductive, their grids having been brought to the positive potential **80**. During this reading phase, none of the primary thyratrons is set in operation which represents the value zero on the primary side. When the contact D of CGS is closed after the point 13, the positive voltage proportional to **4** across the terminals of RKD.S is transmitted to the grid of VS (Figure 2*a*). Since the potential of the grid of VP does not vary, a higher delivery of the anode of VS and a lower delivery of that of VP are immediately set up, the blade **501** is attracted to the right and the rod **502** closes the contact **500***a* (see dotted line), whereby RS is energised and the holding of RS, the breaking of the grid circuits of VP and VS, the cutting-off of the anode feed of the primary thyratrons (without effect for the moment), and finally the opening of RS*d* and the closing of RS*e* are brought about, and consequently, due to the energisation of the relay **335** the feed of the electromagnet EAP is determined during the closing of CG4 and CG5, that is to say, shortly before the point at which the primary and secondary shafts stop. Thus, the forward feeding of the primary cards is prepared for the following cycle, the thyratrons **T4S**.D and **T5S**.U remaining nevertheless operative.

In the third cycle, the first secondary card remains in position, that is to say, shortly before **BS2**, while the first primary card passes under **BP2** and is therefore effectively read. It will be assumed that the index on the primary card is **72**. During the reading, the thyratrons **T7P** (tens) and **T2P** (units) will be set in operation in the manner already indicated.

When, after the point **13**, CGP.D and CGS.D close, the positive voltage proportional to 7 is transmitted to the grid of VP, while the positive voltage proportional to 4 is transmitted to the grid of VS. The superiority of the primary index results in the attraction of the blade **501** to the left, which produces, through the closing of **500***b*, the energization of RP and then its holding by RP*a*, the breaking of the grid circuits of VP and VS by the opening of RP*b*, and *f*, the cutting off of the anode feed of the secondary thyratrons by the opening of RP*c*, and finally the opening of RP*d* and the closing of RP*e*, which determines a little later, as already explained, the feeding of the electromagnet EAS. It will readily be seen that the closing of CGP.U and of CGS.U (Figure 2*b*) has no effect on the deliveries of VP and VS since the circuits of the connections **513** and **514** are maintained in the broken condition. In the following circuit, therefore, the secondary cards are fed forward, and a second secondary card is read, and compared with the index previously stored of a primary card. Thus, the separate and alternate feed of the primary and secondary cards continue automatically as long as inequality between the indices is detected. It will be obvious that for indices containing a larger number of digits, that is **6** in the embodiment under consideration, the operation would be absolutely equivalent to that just described.

A second embodiment of the storage and comparing arrangement, again applied to the same collating machine, will now be described.

Examination of Figures 3*a* and 3*b* shows that the circuits for reading (lower part of Figure 3*a*), starting the machine and controlling the feed (lower part of Figure 3*b*) are identical to those of the first embodiment. Similarly, the storage and comparing circuits taken individually, are identical to the preceding circuits. The difference in the embodiment as compared with the first embodiment resides mainly in that the process of comparison is different from the first. In the present case, all the unit orders of the primary and secondary indices can be compared simultaneously, in the same way as in the initial machine described in the prior patent specification hereinbefore referred to.

With this process, it is possible to compare indices comprising any number of unit orders provided that the machine is provided with an equivalent number of storage and comparing groups. This number is therefore limited only by the maximum magnitude of the indices to be compared.

As in the case of the first embodiment, only the circuits for comparing the order of the units (Figure 3*a*) and the order of the tens (Figure 3*b*) have been shown, because the understanding of the embodiment would not be further facilitated by the illustration of the circuits for the higher orders.

It will be seen that the storage circuits are again connected to the reading circuits in the same manner by the plug connections **504**, **505**, **506**, **507**, that the anode feed of the primary and secondary thyratrons is effected respectively by the fixed connections **515** and **516**, and finally that the common grid return of the thyratrons again takes place at the terminal *Pol* by the connection **508**. There is now a comparison circuit associated with each primary and secondary storage group for each unit order.

The elements composing the storage and comparing circuits are the same as before except for the following points:

The cam-operated contacts by which the grids of the pentodes are connected to the cathode resistances of the thyratrons form part of separate circuits. There are therefore two cam-operated contacts CGP.U and CGS.U for the order of the units, and two cam-operated contacts CGP.D and CGS.D for the order of the tens, and so on. The circuits between the grids and the cathodes are only broken by the said cam-operated contacts. These contacts, the cams of which are synchronised with the other distributing members, all close at the same time between the points 12 and 13 of the cycle (see Figure 5) and remain closed until a short time after the point 15, which coincides with the closing and opening points of CG5.

The pentodes of the circuit for comparing the units bear the references VUP and VUS (primary and secondary units), while VDP and VDS similarly apply to those for the primary tens and secondary tens, and so on for the other unit orders. The comparison relays bear the references RPU (primary units), RSU (secondary units), RPD (primary tens), RSD (secondary tens) and so on. They are energised on the primary side by the closing of the contacts **500b** and on the secondary side by the closing of **500a**. The holding circuits are no longer required, and the contacts breaking the anode feed circuits of the thyratrons are no longer controlled by the comparison relays, but by the relays **335** and **339** (Figure 3*b*). Thus, Figure 3*b* shows the contact **335f** cutting off the anode feed of the primary thyratrons when the feed of the secondary thyratrons is higher, and the contact **339f** cutting off the anode feed of the secondary thyratrons when the feed of the primary thyratron is higher.

Finally, each pair of comparison relays, such as RPU and RSU or RDP and RSD controls the movement of a pair of alternating contacts such as REU*a*, *b* RSU, *b* etc. (Figure 3*b*), which combine to form a chain having one input and three outputs identical to that described in the aforesaid patent application. This chain of alternating contacts ensures, on the simultaneous comparison of all the primary and secondary unit orders, priority of the highest order where an inequality is detected.

The process of reading and storing does not differ from that previously described. On the other hand, comparison takes place simultaneously over all the unit orders, as already stated.

In fact, on the closing, at the point 12½, of the cam-operated contacts such as CGP.U, CGS.U, etc., the positive voltages which may exist across the terminals of the cathode resistances of the thyratrons are simultaneously applied to the grids of the pentodes respectively associated therewith. Some of the comparison relays RPU, RSU, RPD and RSD are, and remain, energised and those which are energised open their contact *a* and close their contact *b*. If some comparison groups of higher order have not been used, or if, in being so, they have determined an equality of the highest digits, the current set up by CG4 towards the point 13 follows the succession of closed contacts *a* until it finds one which is open and the corresponding closed contact *b*. According to whether it is a contact controlled by a primary or secondary relay which has been moved, it is the relay **339** or the relay **335** which is energised, and it is known that this results in the forward feed of the secondary or primary cards at the end of the cycle. Previously, the anode feed of the appropriate group of thyratrons is cut off either by **335f** or by **339f** in the case of inequality, or the anode feed of the two groups is cut off by **334f** in the case of complete equality of the primary and secondary indices. The further operation is similar to that described with reference to the first embodiment. It will be noted that the present storage and comparing arrangement may be readily and advantageously adapted to a machine dealing with cards on which the indices are represented in each column by one or more holes positioned in accordance with the code. Reference is made inter alia to the known cards comprising only four indicating positions to which the values 1 to 4 respectively are allocated. One or more perforations are then necessary to represent the digits 1 to 9 in accordance with the following code:

Digits	Perforations punched in the positions
0	no perforations.
1	1.
2	2.
3	3.
4	4.
5	4+1=5.
6	4+2=6.
7	4+3=7.
8	4+3+1=8.
9	4+3+2=9.

This application only involves the reduction of the number of thyratrons required for one recording group. There are only four thyratrons for each primary or secondary group, these thyratrons having allocated to them the values 1 to 4, while the elements thereof (cathode and anode resistances) retain the values indicated with reference to the first embodiment. It will be appreciated that since there are one or more perforations to each card column, one or more thyratrons may be set in operation in the course of the analysis of one column.

For example, in the case of the analysis of the digit 7, the thyratrons 4 and 3 are set in operation and deliver respectively currents proportional to 4 and to 3. Since these currents both pass through the common resistance RK, the potential difference set up across the terminals of this resistance is proportional to their sum, that is to say, to 7. It is therefore clear that the processes of comparison previously dscribed may remain unchanged. The advantages of this method reside in a considerable reduction of the number of recording thyratrons and an increase in the output of the machine since the recording phase only necessitates 4 points of the cycle of the machine instead of 10.

Although the embodiments described concern the use of perforated cards, it is obvious that the present storage and comparing arrangement could be employed to deal with cards bearing marks or impressions to be analysed photo-electrically, or by other known means, since it is sufficient for the reading devices to be adapted for supplying time-regulated impulses to the grids of the storing thyratrons.

I claim:

1. In a cyclically operable card controlled machine with means for feeding and reading cards bearing numerical control data, a pair of storage units for storing control data from said cards, each storage unit comprising a distributor device and circuit connections, a series of gaseous discharge tubes adapted separately to be rendered conductive by means of a reading impulse from said reading means and said distributor device and connections, a common cathode resistance for all the tubes of a unit, separate anode load resistances, one for each tube, for determining across said common cathode resistance, when one tube has been rendered conductive, a data representing voltage different in relation to the

differential timing of said reading impulse and to the numerical value of the control data read, data comparing means comprising two vacuum electron tubes, each associated with one of said recording units and adapted to be acted upon by said data representing voltage determined in the associated storage unit, and an electromagnetic controlling device for controlling the subsequent operation of the machine according to the relationship between the respective anode currents of said two vacuum electron tubes.

2. In a cyclically operable card collating machine, with means for feeding and reading cards bearing designation data, two storage units for storing designation data from said cards, each storage unit comprising commutator means operated synchronously with said feeding means, a plurality of gaseous discharge tubes normally extinguished, each tube being assigned to a different index value of the cards and the firing of the tube being initiated when a voltage impulse is applied to its control grid, electric circuit connections between said reading means and the slip ring of said commutator means and between segments of said commutator means and the control grids of said tubes to transmit to said grids the impulses delivered by said reading means, a load resistance for each tube, each resistance being of different value in relation to the index value assigned to each tube, a resistance forming a common output load for all the tubes of a unit, for the generation across said resistance, when anyone of said tubes is fired, a voltage related to the magnitude of the index value read as long as the circuits of the conductive tube are not open, and means common to both storage units to sense the relationship between the voltages generated and to control the subsequent operation of the machine according to said relationship.

3. In a card collating machine with means for feeding and reading cards bearing multidenominational designation data, two groups of storage units for storing a designation datum, each storage unit comprising commutator means operated synchronously with said feeding means, a plurality of gaseous discharge tubes, each tube being adapted to become conductive when a pulse representative of a read digit of corresponding value is applied to its control grid, electric circuit connections between segments of said commutator means and the control grids of said tubes for modifying momentarily the biassing of said grids, a load resistance in the anode circuit of each of said tubes, each resistance being of different value in relation to the digit assigned to each tube, a load resistance common to the cathode circuits of the tubes of a unit for generating across said resistance, when anyone of said tubes has become conductive, a voltage in proportion to the magnitude of the digit read as soon as the biassing of the grid of the corresponding tube is modified, and means common to both storage units for sensing the relationship between the voltages generated and for controlling the subsequent operation of the machine according to said relationship.

4. In a cyclically operable card collating machine with card feeding and reading means for feeding and reading two cards bearing designation data to be compared, two storage units, each comprising a commutator device operated synchronously with said feeding means, a plurality of gaseous discharge tubes normally nonconductive whose control grids are separately connected to corresponding segments of the associated commutator device for receiving reading pulses, anode circuits for the tubes including resistances of different value, cathode circuits with a common resistance for the tubes of a unit for generating a voltage related to the magnitude of a datum just read and with the tube becoming conductive in the same unit, data comparing means rendered operative after the reading phase of a cycle by cyclically controlled contacts, said comparing means comprising two vacuum tubes with identical operating characteristics, electric circuit connections including said cyclically controlled contacts for applying, in the comparison phase of a cycle, the voltages available at the terminals of said two common resistances to the control grid of each of said vacuum tubes, a differential electromagnetic relay having two opposed coils respectively energized by the anode current flows of said vacuum tubes and jointly acting upon its armature, said armature occupying a middle position prior to a comparison or when the data compared are equal and occupying one of two positions, removed from said middle position, when the data compared are unequal, and machine control means operating according to the position occupied by said armature.

5. In a cyclically operable card collating machine, with card feeding and reading means for feeding and reading two cards each bearing a multidenominational designation datum; two groups of storage units arranged in pairs, each group being adapted to store one designation datum, and each pair corresponding to a denominational order to be compared, each storage unit comprising commutator means operated synchronously with said feeding means, a plurality of gaseous discharge tubes, each tube being assigned to become conductive when a pulse representative of a digit of corresponding value is being applied to its control grid, electric circuit connections between segments of said commutator means and the control grids of said tubes for applying said reading pulses to said grids, a load resistance in the anode circuit of each of said tubes, each resistance being of different value in relation to the digit assigned to each of said tubes, a load resistance common to the cathode circuits of the tubes of a unit, at the terminals of which resistance appears a constant voltage in relation with the magnitude of the digit read as soon as a tube of said unit has received a reading pulse, data comparing means rendered operative after the reading phase of a cycle by cyclically controlled contacts, said comparing means comprising two vacuum tubes with identical operating characteristics, electric circuit connections including said cyclically controlled contacts for applying successively, in the comparison phase of a cycle, the voltages available at the terminals of the pairs of said common cathode resistances to the control grid of each of said vacuum tubes, beginning with the cathode voltages appearing at the pair of the highest denominational order, a differential electromagnetic relay with two opposed coils respectively energized by the current delivery of said vacuum tubes, a relay armature under control of said coils, said armature assuming one of two shifted positions when said current deliveries are unequal thus manifesting a condition of unequality of the data being compared, two comparing relays, one of which is energized according to the shifted position assumed by said armature, each

comparing relay opening, when energized, a contact for switching open the anode circuits of the tubes in a group of storage units when inequality of the compared data has been detected.

6. In a cyclically operable card handling machine with card feeding and reading means for feeding and reading two files of cards bearing multidenominational classifying numbers, groups of storage units and associated comparing devices, one group for each denominational order to be compared, one storage unit comprising a pair of storage elements, each storage element comprising a commutator device for conveying timed reading impulses, and a plurality of normally non-conducting thyratrons with circuits adapted to build up a steady voltage different according to the timing of the reading impulse which renders conductive the corresponding one of said thyratrons, each comparing device comprising two vacuum tubes with identical operating characteristics, electric circuit connections including cyclically actuated contacts for applying the steady voltages built upon the circuits of a pair of storage elements separately to the control grids of the two associated vacuum tubes; a differential electromagnetic relay with two opposed coils respectively energized by the anode current deliveries of said vacuum tubes; a relay armature under control of said coils and arranged to assume one of two shifted positions when said anode current deliveries are unequal thus manifesting a condition of inequality of the compared digits of a denominational order, a pair of comparing relays, one of which is energized according to the shifted position assumed by said armature, and chain circuits of pairs of change-over contacts controlled by associated pairs of related comparing relays for energizing one of three controlling relays according to one condition of equality and two conditions of inequality manifested in the highest denominational orders of the numbers compared.

7. The invention as set forth in claim 5, in which, in the case of a condition of inequality, one of two of said last mentioned controlling relays controls one contact for cutting off the anode circuits of the thyratrons of the storage elements assigned to store classifying numbers read from a predetermined file of cards.

KNUT ANDREAS KNUTSEN.

No references cited.