

Jan. 19, 1954

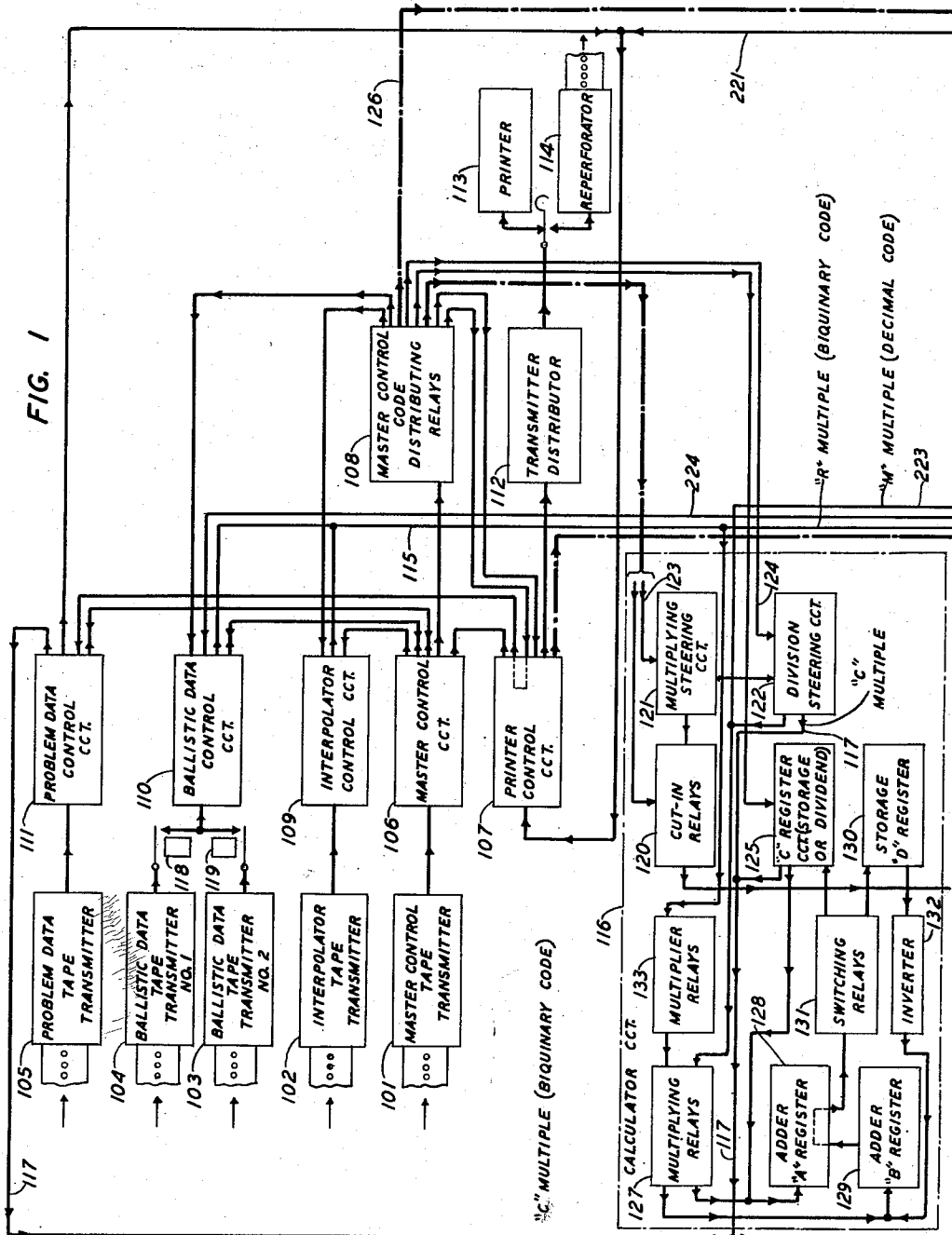
J. P. JULEY

2,666,578

SWITCHING CONTROL SYSTEM

Filed Dec. 17, 1946

3 Sheets-Sheet 1



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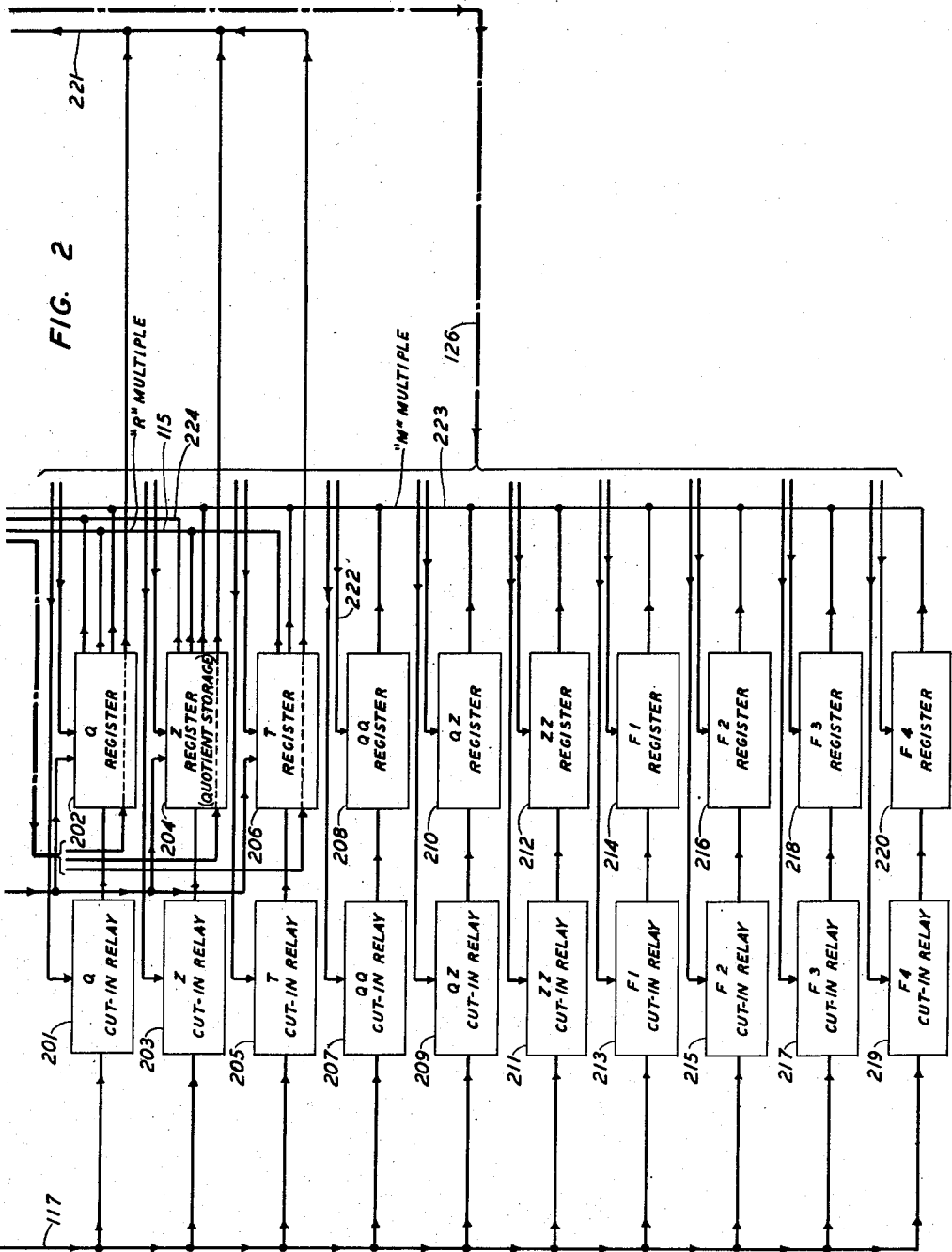
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SWITCHING CONTROL SYSTEM

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3 Sheets-Sheet 2



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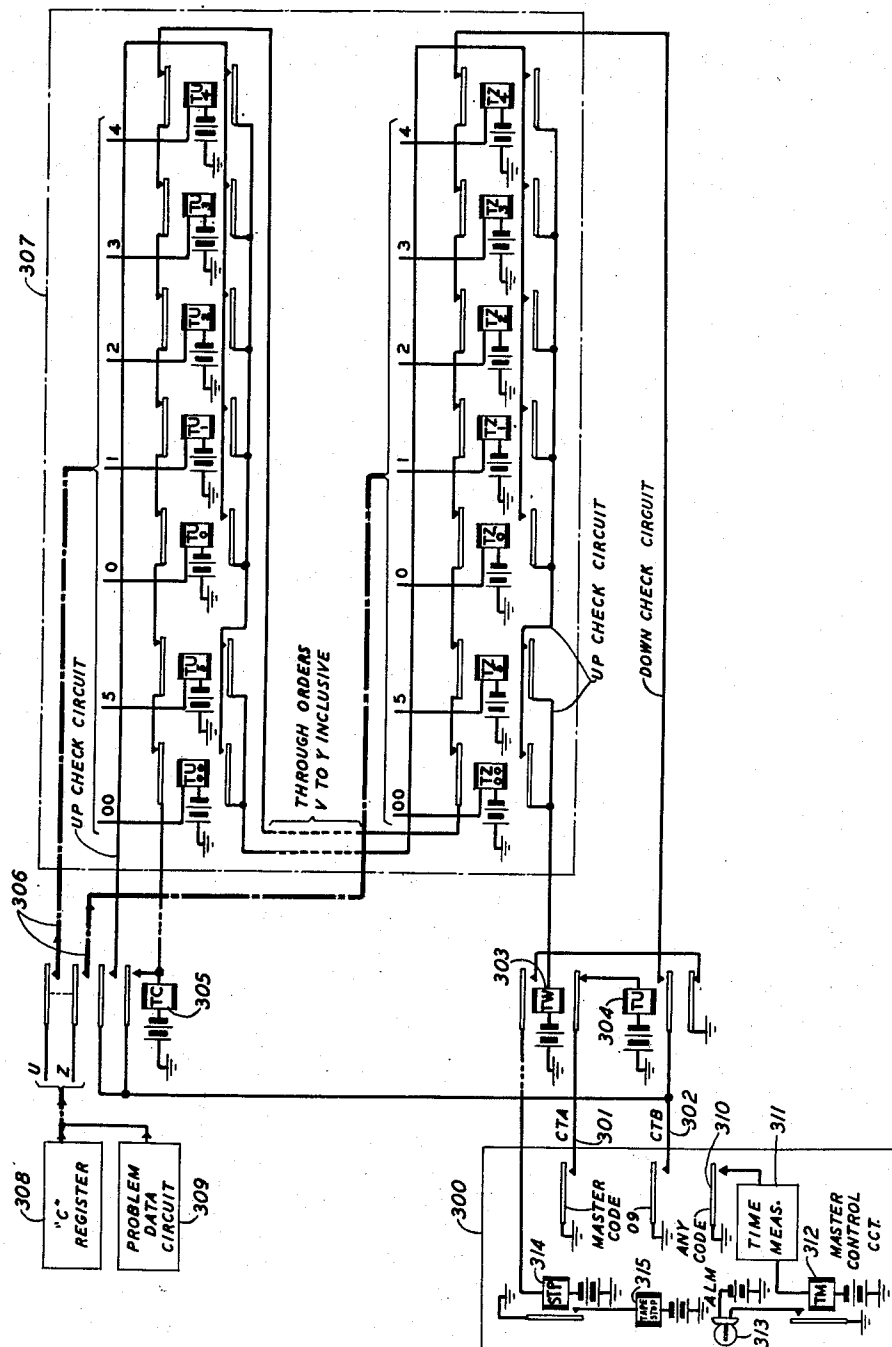
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3 Sheets-Sheet 3

FIG. 3



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SWITCHING CONTROL SYSTEM

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4 Claims. (Cl. 235—61)

1

This invention relates to calculators and particularly to electrical devices by which mathematical calculations may be carried out by the movement of simple electromagnetic means without the use of gear trains, number wheels, cams and other mechanical elements.

An object of the invention is to provide calculating means which will perform long and complicated operations in a minimum of time and with a minimum of apparatus. The prime object of the invention is accuracy since there can be no compromise in this respect in a calculator.

The usefulness of a calculator depends directly on the confidence which the user has in the accuracy of the result. This is reflected in the operation which has become habitual with many users of calculating machines, namely, that of duplicating the calculations and comparing the results for deviations. The idea that cogs and gears cannot slip is not fully justified and experience has proved that these mechanical calculators are in fact subject to errors. By contrast the electrical circuit calculators are definite and positive in action. There are no cams to slip nor gears to get out of mesh and experience has proved that the results produced are reliable and accurate. Such devices are, like all electrical circuit devices, subject to troubles due to defective circuits but herein lies the difference, that any circuit defect in the electrical calculator immediately brings in an alarm and the trouble is reported, whereas in a mechanical calculator a gear which has slipped out of mesh reports no trouble but simply produces a dishonest result.

A particular object of the present invention is to provide a means where a plurality of like circuits are to be operated whereby no single trouble or electrical fault can produce an error in calculation.

As a specific example of this improvement, the calculator includes a plurality of registers all set from a common trunk. There is a connecting device for associating each register with this common trunk known as a cut-in relay. It will be realized that if two cut-in relays were to be simultaneously operated the two corresponding registers would be connected to the trunk in parallel and both would be set where it might have been intended that only one was to have been set. Thus, a single trouble such as a cross between the

2

two wires leading to the two cut-in relays would result in the setting of one of the registers in error. To avoid such an erroneous operation the association of a register with the trunk through the cut-in relays is divided into two parts, each under independent stimulus but one depending on the other.

In the device of the present invention the operation of associating a register with the common trunk to receive a registration is a function of a master control circuit which responds to coded signals in a master or routine index. Usually an operation ordered by the master control circuit is in response to a single code. In accordance with the present invention a double code is used providing two separate and distinct stimuli to cause the operation, one of which does not become effective unless and until the other has produced a proper reaction. Thus two registers cannot be operated in parallel unless the two corresponding code wires of each are concurrently crossed. While the possibility that any two wires may become crossed is remote, the probability that four particular wires will become crossed in a particular pattern is so extremely remote that it need not practically be considered a possibility. Add to this the fact that any single trouble if it causes an unauthorized and uncompleted operation will stop the train of operations and bring in an alarm and it will be seen that a calculator based on dependent operations rather than mere sequential operations such as the cam-driven machines is accurate and reliable.

The drawings consist of three sheets having three figures, as follows:

Fig. 1 and Fig. 2 taken together with Fig. 1 placed above Fig. 2 constitute a flow chart to indicate the movement of signals comprising both operational orders and mathematical information between various units of the device, Fig. 1 containing the various tape transmitters, control circuits and the calculator and Fig. 2 containing the registers and their cut-in relays, and,

Fig. 3 is a schematic circuit diagram used to explain those details of the device in which the present invention is embodied.

This application is one of a group of seven applications all based on the same arrangement. The Andrews-Vibbard application is a full and complete disclosure and includes a disclosure of

the present invention, the other applications including the present application being abbreviated disclosures of certain features of the complete device, as follows:

Applicant	Serial Number	Filing Date	Subject
Andrews-Vibbard.....	716, 680	December 17, 1946...	Automatic Calculator.
Vibbard.....	716, 827	do.....	Control Circuit.
Strickler.....	716, 783	do.....	Testing System.
Cesareo.....	716, 753	do.....	Automatic Code Trans-
			lating System.
Andrews.....	716, 782	do.....	Calculator Sign Control
			Circuit.
Cesareo-Strickler.....	716, 754	do.....	Automatic Calculator.

The device in which the present invention is incorporated is a calculator operated by electrical circuit change, in which each new circuit operation is dependent upon the successful completion of a previous operation. It consists essentially of a calculating arrangement, a plurality of tape transmitters of the kind commonly used in printing telegraph operation for entering both operational orders and mathematical information, a plurality of registers in which mathematical information from the tapes or calculated by the calculator may be stored temporarily and a printing device also of the type commonly used in the printing telegraph art for recording various items of information including the arguments of the problems, partial results and the final results.

In Fig. 1 there is shown a master control tape transmitter 101 which is used to transmit operational orders from a so-called routine tape into the master control circuit 106 which has general control over all the operations of the device. Other similar transmitters are the interpolator tape transmitter 102, the ballistic data tape transmitters 103 and 104 and the problem data tape transmitter 105, each with its control circuit. All of these transmit mathematical information from appropriate tapes and all of this information is generically problem data. That provided by the problem data tape constitutes the arguments of the problem, that from the interpolator tape constitutes correlated or empirical data and that from the ballistic tapes constitutes table information or precalculated data such as is usually found in the so-called tables of functions such as trigonometric, logarithmic ballistic and other such data. In the operation of this device the routine tape is operated cyclically, that is, it runs through its transmitter over one complete set of routine orders necessary for the calculation of a function from one given argument or set of arguments. The problem data tape usually contains a series of arguments and is moved forwardly step-by-step under control of the master control circuit, the master tape operating through one cycle for each argument. The remaining tapes contain necessary information and may be moved from point-to-point either forwardly or backwardly to transmit information called for by the master control from time to time during the calculation.

The calculator here generally shown as included in the broken line rectangle 116, consists primarily of four relay registers, the A register 120 constituting an augend element, the B register 129 constituting an addend element and the C register 125 and D register 130 being used alternatively as sum elements. All problems presented to the calculator are in the form of problems in multiplication and the calculation is actually performed by summing the values

registered at various times in the A and B registers. For this purpose a set of multiplying relays 127 and a set of multiplier relays 133 are provided, by means of which a multiplicand operat-

ing the multiplying relays 127 may be multiplied by one digit at a time of the multiplier which operates the multiplier relays 133. There is provided a set of switching relays 131 for determining into which register, the C register 125 or the D register 130 the values in the A and B registers shall be summed. Values stored in the D register 130 may be transferred only to the B register 129, by way of an inverter 132. The inverter is a means by which the value being transferred from the D register to the B register may be transferred as it is or in its complemental form. Values stored in the C register 125 may be transferred either to the A register or transmitted out over the C multiple 117 for transfer to any one of the various registers shown in Fig. 2.

The calculator 116 is under general control of a steering circuit 121 which controls the various steps in a multiplying calculation cycle. When a problem in division is presented an additional circuit, the division steering circuit 122 is brought into action to make the necessary changes and alterations in the calculating cycle. The cut-in relays 120, ordered into operation by the master control circuit 106 through the code distributing relays 108, operate to activate one decimal denominational order at a time of certain registers which then transmit over the R multiple 115 to operate the multiplier relays under control of the steering circuit 121. The division steering circuit, ordered into operation over the path 124, besides modifying the calculation cycle, provides a supply of multiplier digits over the R multiple 115 to the multiplier relays 133 as trial quotient digits and transmits the correctly calculated quotient digits over the C multiple 117.

There are in this device several trunk lines or paths over which information may be passed, as indicated by the arrow heads on the lines representing these paths, such as the C multiple 117, the R multiple 115 and the M multiple 223. The C multiple generally is for transferring information from the C register to any one of the various storing registers shown in Fig. 2. The M multiple generally is for transferring multiplicands from any of the registers of Fig. 2 to the multiplying relays 127 and the R multiple is for transferring multipliers a digit at a time from certain of the registers of Fig. 2 to the multiplier relays 133.

Fig. 2 shows a plurality of registers such as 202 each with its cut-in relay such as 201. The registers and the cut-in relays are controlled from the master control code distributing relays 108 over connections represented by the bundle 126. Details of this control shown in Fig. 3 include the novel features of the present invention and will be described shortly. The master control circuit 106 is shown as having control over

5

the other control circuits, such as the printer control 107, the interpolator control 109, the ballistic control 110 and the problem data control 111. The master control circuit 106 transmits operational orders from the master tape to the master control code distributing relays 108 which translates the routine orders into signals to control the various operations of the device.

The printer control circuit transmits information into the transmitter distributor 112 in translated form suitable for telegraphic transmission either to a printer 113 where it is immediately recorded or to a reperforator 114 where it is recorded in code suitable for later operating a printer or for reentry into the device for other calculating purposes.

Now certain of the operational orders issued by the routine tape call for the operation of the cut-in relay, say 205, to connect the T register 206 to the C multiple 117 so that some number registered in the C register 125 may be transferred to the T register. This is shown in more detail in Fig. 3. By way of example the master code 09 (operations 35, 83, 111 or 133 in the typical example set forth in detail in the Andrews-Vibbard application) is cited. This activates the leads CTA and CTB, whereupon the T register is made available to receive a registration of a number calculated by the calculator and now registered in the C register. The master control circuit 300 will ground the CTA lead 301 and the CTB lead 302. Ground on lead 301 will be extended through a back contact of TW relay 303 to cause the operation of the TU relay 304. Now if the register is properly and fully released the down-check circuit consisting of a series connection involving an armature and back contact of every biquinary code relay of the register will be closed. Therefore the CTB lead 302 will be closed through to the TC relay 305. Relay 305 will then operate and lock to the CTB lead so that upon the first movement of any one of the register relays it cannot be released. The TC relay 305 also closes the C multiple 306 (representing seven conductors for each decimal denominational order) to the various orders of the T register 307. While the C multiple is arranged to transmit either from the C register 308 or the problem data circuit 309 it will, under master code 09, transmit from the C register. Thus, under operation 35 of the typical example, a certain figure has been calculated and the calculated result, now in the C register is to be transferred to the T register. As soon as each denominational order of the T register is properly set there will be one binary relay and one quinary relay in each such order operated and hence the series up-check circuit will be closed. This will result in extending the ground from the CTB lead 302 through an armature and front contact of the TC relay 305, the up-check circuit to the winding of the TW relay 303. Relay 303 therefore opens the operating circuit of the TU relay 304 and this in turn opens the original operating circuit for the TC relay 305. The continued operation of the TC relay depends on the ground from the master control circuit over the CTB lead. However, the completion of the up-check circuit and the operation of the TW relay 303 will constitute a signal that the ordered circuit operation has been completed and therefore the master control advances. Since this removes the ground from the CTB lead, the TC relay will release and thus disconnect the T register from the C multiple.

6

Thus it will be seen that two leads, CTA and CTB, must be grounded to complete this operation. Ground on CTA alone will bring up the TU relay but unless CTB is also grounded the TC relay cannot be operated. CTB alone will have no effect and hence it is that two independent stimuli are needed, neither one of which alone is effective but which cooperate in such a manner that the second only becomes effective when and if the first has produced a proper response.

There is a similar arrangement for each of the registers as may be seen from an examination of the list of master codes. If any two leads such as the A leads for two different registers become crossed it will be seen that only that register whose B lead is also affected will be cooperatively associated with the C multiple. A simple examination of the various possibilities will lead to the conclusion that no single trouble can lead to an error in calculation and the laws of probability will show that the possibility of two troubles occurring simultaneously is so remote that it need be given no practical consideration.

The alarm circuit is shown schematically in Fig. 3. Every operational order on the master or routine tape is in the form of a code and any code will close a circuit to the timing means. This is represented herein by the contact closer 310 which will close a circuit through a time measuring device 311 to the TM relay 312. If the contact 310 is held closed over a given interval the relay 312 will operate and display an alarm 313. However, the time measuring device 311 is set to give ample time for all normal operations, and hence after the register 307 has been properly set and the up-check circuit has been closed the TW relay 303 will operate as described. This releases the TU relay 304 whereby a circuit is closed from ground through a back contact of relay 304, a front contact of relay 303 to operate the step relay 314. This may be termed a satisfaction signal since it constitutes a signal that the last order issued by the master tape has been satisfactorily carried out. The step relay 314 therefore operates the tape stop magnet 315 which opens the connections to the CTA lead, the CTB lead and the time measuring circuit and advances to the next coded orders.

Therefore, if through some error, an order such as the master code 09 is given when the register 307 is occupied the ground on the CTA lead 301 will cause the operation of the TU relay 304 but since the down-check circuit is open at numerous points the CTB lead 302 is ineffective to operate the TC relay 305. Hence the operation is blocked and in due time the time measuring device 311 will bring in an alarm 313, since no circuit for the STP relay 314 can be completed.

What is claimed is:

1. In a calculator constructed and arranged so that no single trouble can result in an error in calculation, a plurality of registers, an enabling means for each of said registers, each of said enabling means comprising a first part and a second part, pairs of signal conductors for controlling each of said enabling means, each of said pairs of signal conductors having a first conductor and a second conductor, a signal applying means for applying independent signals to the conductors of said pairs of signal conductors, said first part of each of said enabling means comprising apparatus responsive to an independent signal over the first conductor of one pair of said pairs of signal conductors for

7

connecting the second conductor of said one pair to the second part of the same enabling means, said second part of each of said enabling means comprising apparatus responsive to an independent signal over the second conductor of one pair of said pairs of signal conductors when said second conductor of said one pair has been connected to the second part of said enabling means by the operation of the first part of the same enabling means for completing the enabling of one of said registers, and an alarm means controlled by said signal applying means for operating an alarm when either part of any of said enabling means fails to operate in response to a signal applied to the one of said signal conductors to which said part is connected.

2. In a calculator, means for preventing any single trouble from resulting in an error in calculation, including a plurality of registers, a common transmission path into said registers, a pair of signal conductors for each of said registers, connecting means responsive to an independent signal over each of said signal conductors of said pair for cooperatively connecting the associated one of said registers with said common transmission path, said connecting means comprising a first means and a second means, control means for applying independent signals to each of said signal conductors of said pair, said first means being responsive to a signal over one of said conductors of said pair for connecting the other of said conductors of said pair to said second means, said second means being controlled by said first means and responsive to a signal over the other of said conductors of said pair for completing the connection of said associated register with said common transmission path, a timing means controlled by said control means for timing a predetermined interval and an alarm means controlled by said timing means for operating an alarm when either said first means or said second means or both fail to operate during said predetermined interval in response to signals applied to the conductors of said pair to which said first means and said second means are connected.

3. A register for receiving, storing and supplying coded information having a plurality of incoming terminals, a source of information, a trunk line comprising a plurality of conductors leading from said source of information, a connector for connecting the conductors of said trunk line to said incoming terminals and means for operating said connector comprising a first and a second operating conductor, a first relay, a down-check circuit and a second relay, means for concurrently electrically energizing said operating conductors, said first relay being controlled by the electrical energization of said first operating conductor to connect said second operating conductor to said down-check circuit,

8

said down-check circuit being enabled only by the complete release of said register, said second relay being controlled by the operation of said first relay and the enabling of said down-check circuit and responsive to the electrical energization of said second operating conductor to operate said connector to connect the conductors of said trunk line to said incoming terminals, an up-check circuit, said second relay in operating also closing a circuit to extend the electrical energization on said second operating conductor to said up-check circuit, said up-check circuit being enabled by the proper setting of said register in storing information from said source to extend the said electrical energization received from said second relay to a third relay, said third relay operating in response to said electrical energization received from said second relay through said up-check circuit when enabled to deenergize said first relay and to furnish a signal indicating satisfactory completion of the registering operation.

4. In a calculator, a relay register having a plurality of incoming terminals, a plurality of conductors, a connector for connecting said conductors to said terminals, means for controlling said connector for minimizing operating errors comprising a first and a second operating conductor, a cut-in relay for operating said connector, a down-check circuit completed by the relays of said register when and only when said register is certainly released, means for concurrently electrically energizing said two operating conductors, a first conductor relay responsive to the electrical energization of said first conductor, a circuit closed by said first conductor relay for extending said electrical energization of said second conductor through said down-check circuit to operate said cut-in relay and said connector, an up-check circuit completed by the relays of said register when and only when said register has been properly set, a second circuit closed by said cut-in relay for extending the electrical energization of said second conductor through said up-check circuit to operate a second circuit relay for opening the connection between said first conductor and said first conductor relay and satisfaction means controlled by said first conductor relay in its released position and said second circuit relay in its operated position for reporting the successful completion of a registration in said relay register.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,651,401	Mercer	Dec. 6, 1927
1,687,669	Hinrichsen	Oct. 16, 1928