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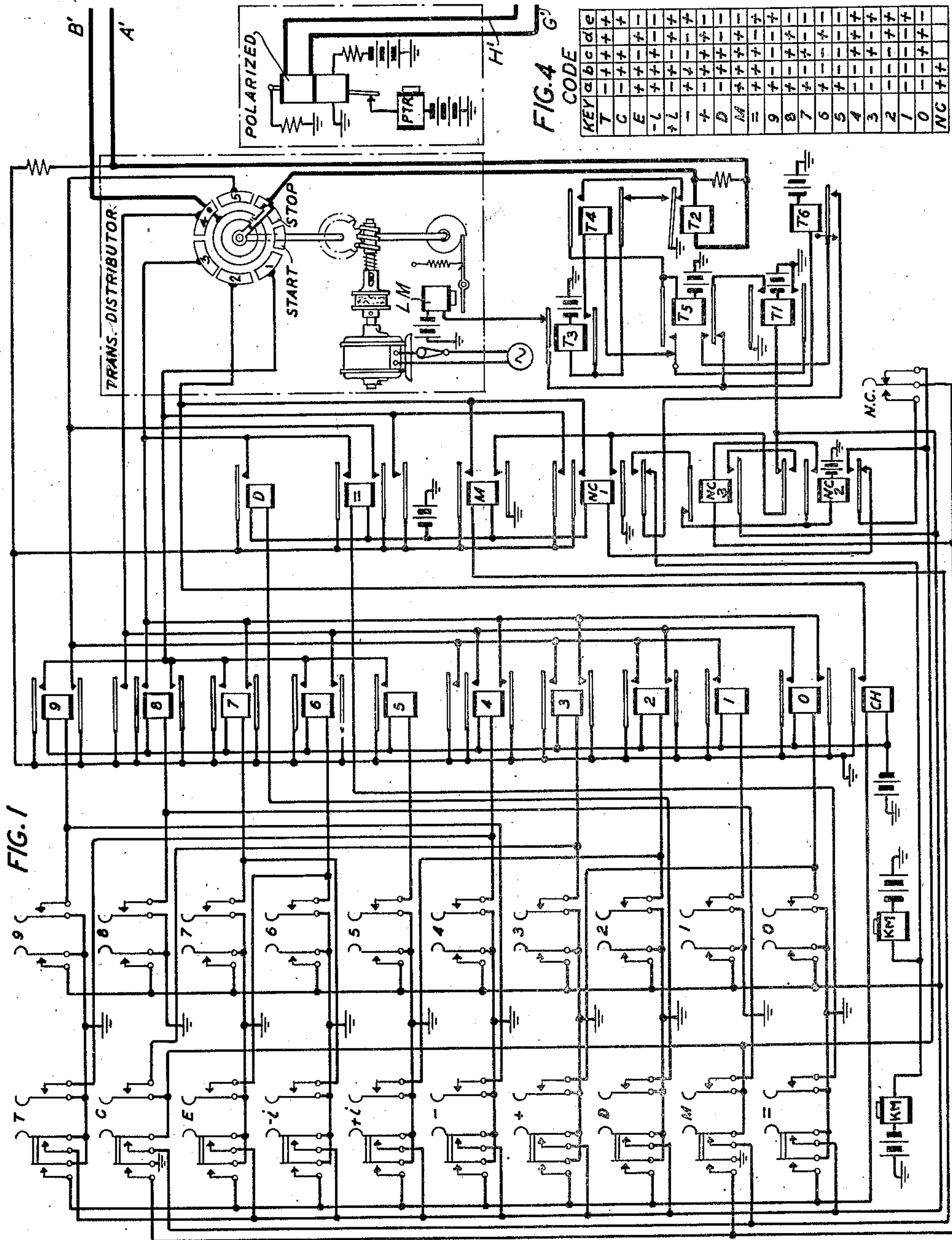
S. B. WILLIAMS

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REMOTELY CONTROLLED ELECTRICAL CALCULATOR

Filed Feb. 13, 1943

3 Sheets-Sheet 1



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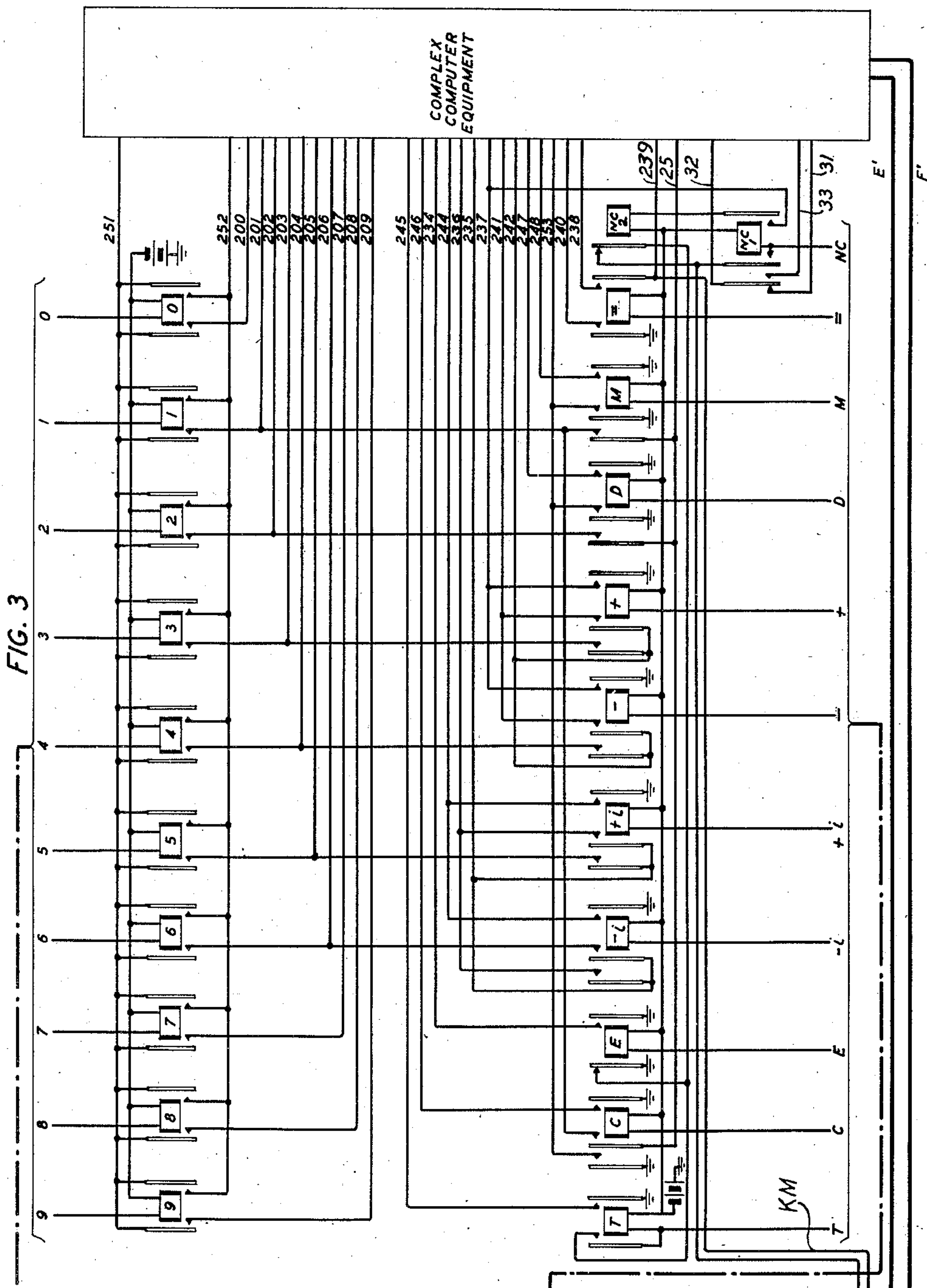
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UNITED STATES PATENT OFFICE

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REMOTELY CONTROLLED ELECTRICAL
CALCULATOR

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Application February 13, 1943, Serial No. 475,723

2 Claims. (Cl. 235—61)

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This application relates to signal transmission systems and its principal object is to provide for the long distance control of a keyboard operated electrical device over a simple transmission channel.

A specific object of the invention is to provide means for remotely operating an electric calculator such as that disclosed in application, Serial No. 564,853, filed November 23, 1944, in the name of George R. Stibitz. The said Stibitz application discloses an electrical calculator in which mathematical information in equation form is entered by means of a keyboard having generally a key for each of the ten digits of the decimal system and for each of the various mathematical signs and symbols and for certain controlling functions. In addition and in proximity to the keyboard there is provided a printing device which is operated from the calculator and which will record the problem as it is registered by the said keys and then the solution as that is obtained by the calculator.

This Stibitz calculator, like other calculating devices is arranged to be remotely controlled in that the operator's station is located at any one convenient place while the calculating device is located at another place, the two being connected by a cable containing essentially one conductor for each of the said keys and certain other controls. Where the calculator and one or even several operators' stations are located in the same building this cabling arrangement is perfectly feasible and economical and such arrangements have been in commercial use for many years.

The present invention, however, aims at long distance operation of a calculating device. The term "long distance" is used in the meaning commonly accepted in the telephone and telegraph arts and denotes distances up to hundreds of miles where, although cabling between the calculator and the operator's station is not impossible, it is nevertheless wholly impracticable.

A feature of the invention, therefore, is the combination of a calculating device, an operator's keyboard therefor and a simple transmission channel therebetween. In accordance with this feature the signals from the keyboard are translated into code and then transmitted over a channel in the manner of printing telegraph signals and at the distant end are again translated into signals like those from the keyboard to be fed into the calculator exactly as though the printing telegraph channel were not interposed between the keyboard and the associated calculator.

Another feature of the invention is the use of time delay means at each end of a long distance line. The time delay at the entry key end will prevent too early transmission of more signals after the signals representing the depres-

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sion of any one of the entry keys have been sent, this being for the purpose of insuring that the proper entry will be made in the calculator at the other end. Practically this delay is used to control the release of the keys, these being of the type which are locked in operated position until electrically released by what may be termed a satisfaction signal. At the calculator end of the long distance line the conventional satisfaction signal will be used to place the receiving apparatus in immediate readiness to receive further signals, such apparatus being arranged to automatically block further reception in the absence of such a signal. However, if such a satisfaction signal is not received within a predetermined time, then time delay means thereat will automatically unblock the receiving apparatus so that any mistake that has been made and which results in the failure to receive the satisfaction signal will at once become apparent on the printed record and can be rectified.

Referring to the figures of the drawing:

Fig. 1 represents the transmitting circuit in accordance with the invention;

Fig. 2 represents a distant end receiving circuit;

Fig. 3 represents a translating circuit at the receiver end; and

Fig. 4 represents the five-unit code for decimal digits and operational symbols utilized in connection with the transmitting and receiving circuits.

The complex computer referred to herein and described fully in said Stibitz application may be briefly characterized as an electrical relay calculator designed to perform the multiplication and division of complex numbers ($F+iG$, and $D+iE$), the numbers being expressed electrically in a symmetrical binary number system representation, the basic arithmetical operations being performed on a binary basis.

Since the exact details of structure and operation of the Stibitz complex computer are not deemed essential to the understanding of this invention, the schematic showing thereof in Fig. 3 is deemed sufficient for the purposes of this specification.

I. TRANSMITTER CIRCUIT

Referring to Fig. 1, the distant operator's station consists of two strips of keys for decimal digits (0-9) and symbols (T, C, E, $-i$, $+i$, etc.), and relays 0-9, CH, =, D, M, NC₁, NC₂, NC₃ for providing a concurrent distribution of + and - states in accordance with the signaling code (Fig. 4) on the telegraph transmitter distributor.

Each digit key operates a corresponding digit relay to place a concurrent distribution of grounds on five wires leading to five segments of

the transmitter distributor to provide a code (Fig. 4) representation of the corresponding digit.

Thus, digit key 8 operates digit relay 8, to connect ground to the wires leading to segments 1, 3, 4; segments 2 and 5 being unaffected, all in accordance with the code for digit 8, namely, $+-++-$ (Fig. 4).

The symbol keys, which have the same general purpose as the corresponding symbol keys of the complex computer, are operated to place a concurrent distribution of grounds on the five segments of the transmitter distributor.

Considering the symbol keys of the group T, C, E, $-i$, $+i$, $-$, $+$, each operates through the corresponding digit relay (see five-unit codes for digits and symbols) and the symbol characterizing $(+)$ relay CH, to provide a distribution of grounds as per the symbol code, Fig. 4.

Thus, the $(+i)$ symbol key operates through the paired (#2) digit relay to connect ground to segments 4 and 5, through the relay CH to put ground on segment 2, segments 1 and 3 being unaffected, all in accordance with the code for the symbol $(+i)$, namely, $-++--$ (Fig. 4).

As another example, the (E) symbol key operates through the paired (#6) digit relay to connect ground to segments 1, 4 and through the general symbol characterizing relay CH to put ground on segment 2, thereby providing the code representation (Fig. 4) $++-+-$ for (E).

The symbol keys D and $(=)$ operate through the CH relay and their respective D and $(=)$ relays to provide a distribution of grounds on segments 1-5 of the transmitter distributor in accordance with the code, Fig. 4, to wit:

D ----- $-++--$
 $(=)$ ----- $++-+-$

The symbol key M operates through the (#8) digit relay and through a contact on the M relay to provide the code therefor, namely:

M ----- $++++-$

The symbol key NC operates through relay NC₁ to provide the code therefor, namely:

NC ----- $++---$

In transmitting a typical problem such as the multiplication of complex numbers

$$(F+iG) \times (D+iE)$$

or the division of complex numbers

$$(D+iE) \div (F+iG)$$

to the calculator, the keys of the transmitter are operated in the sequence:

- (1) Either the M or D key
- (2) Either the $+$ or $-$ key
- (3) Digit keys for factor F
- (4) Either $+i$ or $-i$ key
- (5) Digit keys for factor G
- (6) Either $+$ key or $-$ key
- (7) Digit keys for factor D
- (8) Either $+i$ key or $-i$ key
- (9) Digit keys for factor E
- (10) $(=)$ key

Accordingly, in a practical example, the problem is entered on the transmitting keys thus:

$$(a) \quad \begin{matrix} M, & +75645342 & -i86756453, & -65432122 & +i34567898 & = \\ & F & G & D & E \end{matrix}$$

$$(b) \quad D, +75645342 -i86756453, -19506470 +i82915593 =$$

Thus, upon the operation of the keys in the operator's set, a concurrent distribution of grounds is produced on the segments 1 to 5, in-

clusive, of the transmitter distributor, corresponding respectively to the signaling code representations of the digits and symbols. The operation of any one of the keys serves to operate relay T₁ to unlatch the distributor for sending teletypewriter signals of digits and symbols (Fig. 4) over the outgoing telegraph loop A'B' and telegraph repeater in a time-sequence order.

The operation of relay T₁ also operates relay T₆.

Transmitter distributor

The transmitter distributor shown in Fig. 1 is well known in the telegraph art, viz., United States Patent 1,311,915, patented August 5, 1919, by P. M. Rainey, United States Patent 2,154,592, patented April 18, 1939, by E. F. Watson, or United States Patent 2,055,567, patented September 29, 1936, by E. F. Watson.

The details of structure and mode of operation thereof are adequately described in said patents and in the Bell Laboratories Record, volume 17, No. 2, pages 53-59, October 1938.

In somewhat more detail the operation of the controlling relays at the transmitting distributor is as follows. The latch magnet LM normally holds the transmitting distributor brush on the stop segment so that relay T₂ is normally energized. When one of the keys, such for instance as that marked D, is operated then a circuit may be traced from ground, the inner left contacts of key D, winding of relay T₁ to battery, whereby relay T₁ is energized. It may be noted that key D is now mechanically locked in its depressed condition (in a manner similar to that indicated in Patent 2,176,932, issued to C. Smith, October 24, 1939) under control of magnet KM. Upon the operation of relay T₁, a circuit may be traced from the upper armature and front contact of relay T₁, the lower armature and back contact of relay T₅ whence the circuit divides going in one direction through the upper armature and back contact of relay T₃ through the winding of latch magnet LM to battery to operate this magnet, and in another direction through the winding of slow release relay T₆ to battery to also operate this relay. Relay T₆ opens a circuit extending from its back contact through the outer lower armature and back contact of relay NC₁ to the magnets KM so that these magnets cannot become operated and release any one of the mechanically locked keys, such as D, until after the release of relay T₆.

The operation of the latch magnet LM now allows the distributor brush to begin its (clockwise) rotation. As it leaves the stop segment the circuit of relay T₂ is broken and this relay releases. A circuit is now established from ground, the armature and back contact of relay T₂, back contact and lower armature of relay T₄, winding of relay T₃ to battery whereby relay T₃ is operated to release the latch magnet LM so as to stop the distributor arm when it next reaches the stop segment.

During the rotation of the brush the code for D, as shown in the table of Fig. 4, is transmitted over the conductor B' (responsive to the operation of relays CH and D) in a conventional manner.

During the rotation of the brush, the ground for the operation of T₃ is extended over the lower armature and front contact of relay T₃, through the winding of T₄, the normal contacts of the upper armature of T₅, the lower armature and front contact of T₁ to ground. Since this circuit is from ground to ground it is ineffective to op-

operate relay T4 and hence this relay remains unoperated until the next operation of T2. Now, when the distributor arm reaches the stop segment and stops thereon the circuit for relay T2 is closed.

The circuit arrangement as shown does not provide two-way transmission over the telegraph channel A'B' so that no means are here provided to exercise a conventional control over the relay T2 from the distant end. Therefore, in accordance with the present arrangement, relay T2 becomes operated again as soon as the transmitting distributor arm reaches the stop segment and closes the circuit thereof. Now the circuit for relay T3 is opened (at the back contact of relay T2) but relay T3 does not release since the circuit through the winding of relay T4 is now effectively closed in series with the winding of relay T3 whereby T3 remains operated and relay T4 becomes operated. Therefore, a circuit is now established from ground armature and front contact of relay T2, front contact and upper armature of relay T4, winding of relay T5 to battery. Relay T5 locks to the ground supplied from the front contact and lower armature of relay T1 and, in so locking, opens the circuit of relay T4, allowing T4 to release. Relay T5 also opens the circuit of relay T6 so that after a slight delay in accordance with the characteristics of this relay, T6 releases. Now a circuit is completed from ground, the upper armature and front contact of relay T1, lower armature and front contact of relay T5, armature of relay T6 and thence over the circuit previously traced to the key magnets KM whereby the key (such as D) is released to return to normal if no longer under finger pressure, or as soon as the finger pressure is relieved. Upon the release of the key, relay T1 is released, whereupon relay T5 is unlocked and the circuit of relay T1 to T6 is returned to normal.

II. RECEIVER CIRCUIT

The time-sequence signals of digits and symbols, transmitted over the telegraph loop A'B', C'D', are received at the distant receiving end, where they operate a conventional telegraph relay TR, which in turn controls and operates a conventional teletypewriter receiver distributor.

The decoding relays A, B, C1, D1, E1 for digits and A, B, C2, D2, E2 for symbols, operate as a group in accordance with the signaling code (Fig. 4), as set up by grounds on the appropriate conductors through the operation of the rotating cams 1, 2, 3, 4, 5 under the control of the received signals.

Thus the received signals for digit 8, namely, +, -, +, -, +, - operate relays A, C1, D1 through the intermediate action of cams 1, 3 and 5, resulting in the extending of a ground at LK to lead No. 8.

Likewise, the received signals for the symbol (+i), namely, -, +, -, +, -, +, operate relays B, D2, E2 through cams 2, 4, 5 to extend a ground at LK to the lead marked +i.

The relay LK operates from the No. 7 cam and contacts of the distributor to prevent more than one revolution of the distributor per code received.

Thus, the decoding relays A, B, C1 or C2, D1 or D2, E1 or E2 set up a ground state on one of the ten leads marked 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 to provide electrically a decimal digit representation, or on one of the corresponding conductors, marked

NC, -i, M, E, =, -, T, C, +, D, +i to provide electrically a representation of the symbols.

These two groups of conductors lead to the receiving recording circuit, Fig. 3, which operates directly the complex computer equipment.

In the complex computer, the entry keys are operated in a manner similar to that shown in Patent 2,176,932, issued to C. Smith, October 24, 1939, whereby a depressed key is mechanically locked until a key magnet is energized to release it, or until another key is depressed to mechanically unlock the first key upon the operation of the second. When the functions directed by the depression of the key have been completed, then a circuit is completed which will connect ground to conductor KM (within the complex computer) to release the depressed key. Thus in the complex computer if a wrong key is depressed, as for instance the digit 2 key when the + or - key should have been depressed, the functions directed by the digit 2 key cannot be completed and hence the key will not be released. The fact that the digit 2 key in this assumed case remains depressed and does not release in regular order will give the operator notice that a key has been operated in the wrong order whereupon the mistake may be rectified by depressing the proper key to mechanically unlock the wrongly depressed key.

In the present arrangement the conductor KM might be arranged to control the operation of relay T2 at the transmitting end and thus perform exactly the same function as in the complex computer as disclosed in the said Stibitz application. However, a slightly different arrangement is used herein. Instead of using the signal on conductor KM to release the key which has been depressed as heretofore, it is now used to control the effectiveness of the receiving distributor shown in Fig. 2. Thus when ground appears on conductor KM the receiving distributor is immediately rendered active and responsive to new incoming signals. If the signal over conductor KM does not come in then the receiving distributor is (momentarily) locked out of service and during this interval renders such distributor unresponsive to incoming signals so that the depression of another key after a wrongly depressed key will not cause a registration. Lest it may appear this operation is a defect it should be noted that the printer at the operator's station will record whatever is registered in the complex computer and, hence, if the depression of some key in error causes a mutilation of the problem as recorded it is an easy matter to depress the error key E to return the complex computer to normal to start the registration of the problem over from the beginning. Experience has proved that the provision of facilities whereby the signal on conductor KM may be transmitted back to control the relay T2 in conventional manner is not economically justified since the above described method of correcting an error is adequate.

When in the operation of the system a start signal is received the relay TR moves its armature to the position as shown (known as "space") whereupon the clutch magnet is operated over a circuit including the contacts operated by number 6 cam and the back contact and outer upper armature of relay LK. The clutch magnet allows the cams of the receiving distributor to make a complete (counter-clockwise) revolution thus subjecting the relays A, B, C1, D1, E1, C2, D2 and E2 to the mark signals of the incoming code.

As the receiving distributor starts its action the number 7 cam grounds the conductor leading to

relay LK and this in turn extends ground to the other relays for controlling and locking purposes. Relay LK opens the normally closed circuit of the slow release relay AL which acts to operate the relay RL after a given time interval if the normally expected ground does not appear on conductor KM in the meantime. After the receiving distributor has completed its revolution the original ground for operating relay LK is removed by the operation of number 7 cam to the position shown but relay LK remains locked in position through the back contact and upper armature of relay RL until this relay is operated either by the ground signal appearing on conductor KM by the timed release of relay AL, or by the coded operation of NC3. When in any manner relay RL is operated, relay LK is released ready for another operation of the receiving distributor. Thus the ground signal on conductor KM acts in the present case to clear the way for another registering operation in the complex computer.

III. RECEIVING CIRCUIT

The receiving circuit shown in Fig. 3 consists of digit relays 0 to 9, each operated by the ground condition existing on each of the incoming leads 0 to 9 and symbol relays T, C, E, -i, +i, etc. operated from the corresponding incoming leads. The operation of these relays, Fig. 3, effects the registration of whatever character has been transmitted from the far end, Fig. 1, in the same manner as though a key of the complex computer had been operated.

By comparison with Fig. 2 of the Stibitz application aforementioned, it will be apparent that the contacts of the relays shown in Fig. 3 of this application are wired exactly like the keys thereof. The nomenclature for the leads 200 to 209, inclusive, 251, 252, 238, 240, 253, 248, 247, etc. (Fig. 3) leading into the complex computer has been adopted from Fig. 2 of the Stibitz application for ease of identification.

The problem having been thus presented to the complex computer equipment represented in block diagrammatic form, Fig. 3, is solved and results are transmitted over the telegraph line E', F', G', H' to the printer PTR shown in Fig. 1, and located at the operator's station. The printer itself is a conventional form of teletypewriter, well known in the telegraph art, and therefor, requiring no further detailed description. Reference is made to the United States patent of A. H. Reiber, 2,247,408, patented July 1, 1941, or to the aforementioned citation in the Bell Laboratories Record as illustrating a form of printer used in the described system.

In the arrangement illustrated the connection between the operator's station and the calculator is shown to consist of a telegraph line A'B' for entering information in the calculator and a separate telegraph line G'H' for operating the printer. It will be understood that these separate channels may be combined in conventional manner into a single channel (as described on page V of the October, 1940, volume XIX, number 2, of the Bell Laboratories Record), the two channels being here shown for the sake of clarity.

What is claimed is:

1. In combination, entry keys, a calculator, a long distance line therebetween, a translator connected between said entry keys and said long distance line to translate the signals created by

the operation of said keys into signals suitable for transmission thereover, a translator at the other end of said line for translating signals transmitted over said line into signals like the said signals created by the operation of said keys for operating said calculator, time delay means at said calculator end of said long distance line for blocking the reception of further signals for a predetermined period of time after the reception thereof of signals transmitted thereto from the distant end responsive to the operation of one of said keys and means in said calculator responsive to its operation by signals transmitted thereto over said line for controlling said delay means, whereby the delay normally introduced by said delay means may be shortened.

2. In combination, entry keys, a calculator, a long distance line therebetween, a translator connected between said entry keys and said long distance line to translate the signals created by the operation of said keys into signals suitable for transmission thereover, a translator at the other end of said line for translating signals transmitted over said line into signals like the said signals created by the operation of said keys for operating said calculator, time delay means at said calculator end of said long distance line for blocking the reception of further signals for a predetermined period of time after the reception thereof of signals transmitted thereto from the distant end responsive to the operation of one of said keys comprising a locking relay responsive to the reception of a signal for passing said signal to said translator and for blocking the reception of following signals, a release relay for releasing said locking relay, a slow release relay responsive to the operation of said locking relay for operating said release relay after a predetermined period and means in said calculator responsive to its operation by signals passed to said translator for operating said release relay prior to its operation by said slow release relay.

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