

March 30, 1948.

G. DEAKIN

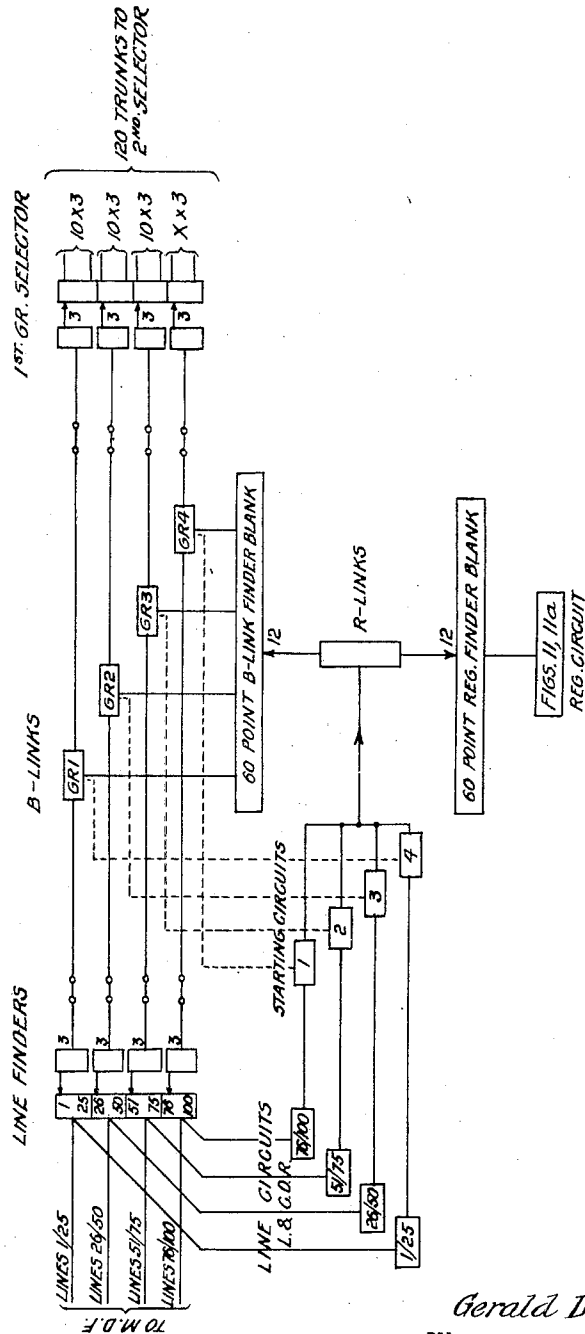
2,438,496

TELEPHONE SYSTEM EMPLOYING KEY TYPE CALL TRANSMITTER

Filed June 19, 1944

8 Sheets-Sheet 1

Fig. 1.



INVENTOR.
Gerald Deakin
BY
R. J. Perry
AGENT

March 30, 1948.

G. DEAKIN

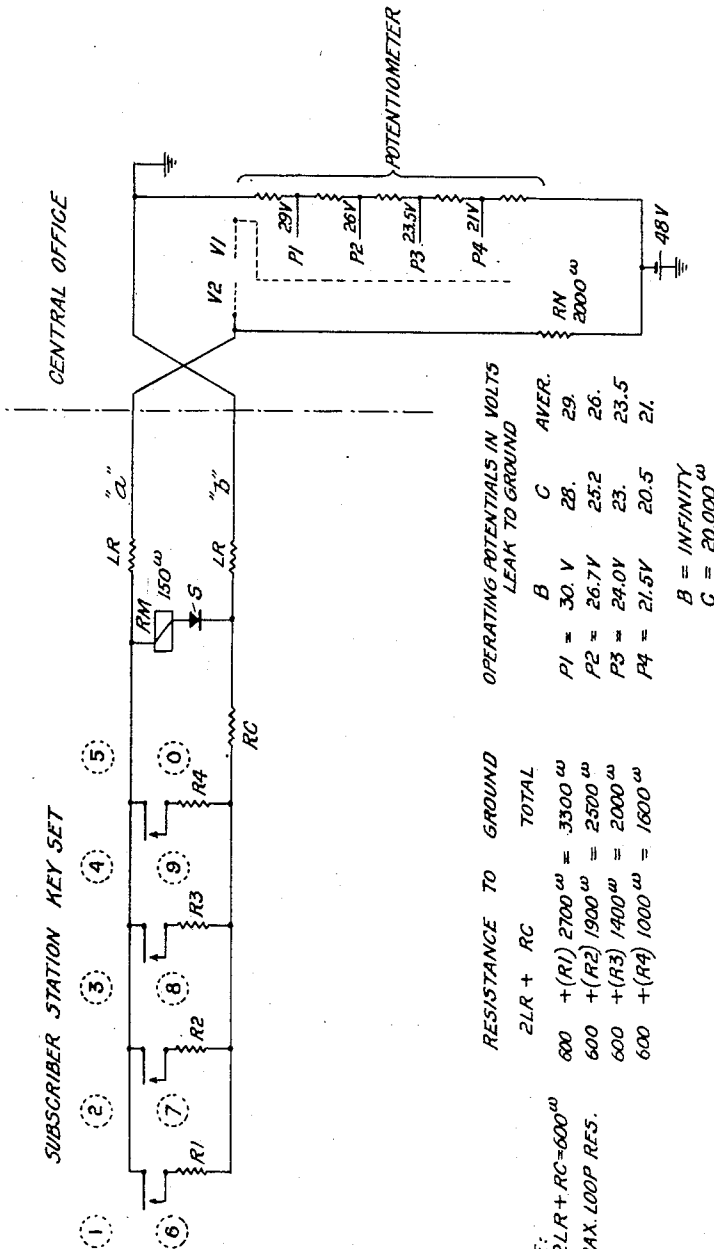
2,438,496

TELEPHONE SYSTEM EMPLOYING KEY TYPE CALL TRANSMITTER

Filed June 19, 1944

8 Sheets-Sheet 2

Fig. 2.



OPERATING POTENTIALS IN VOLTS
LEAK TO GROUND

	B	C	AVER.
P1	30. V	28.	29.
P2	26.7 V	25.2	26.
P3	24.0 V	23.	23.5
P4	21.5 V	20.5	21.
	B = INFINITY	C = 20,000 ω	

RESISTANCE TO GROUND

2LR + RC	TOTAL
600 + (R1) 2700 ω	= 3300 ω
600 + (R2) 1900 ω	= 2500 ω
600 + (R3) 1400 ω	= 2000 ω
600 + (R4) 1000 ω	= 1600 ω

NOTE:
2LR + RC = 600 ω
= MAX LOOP RES.

BY

INVENTOR.
Gerald Deakin

R. J. Henry
AGENT

March 30, 1948.

G. DEAKIN

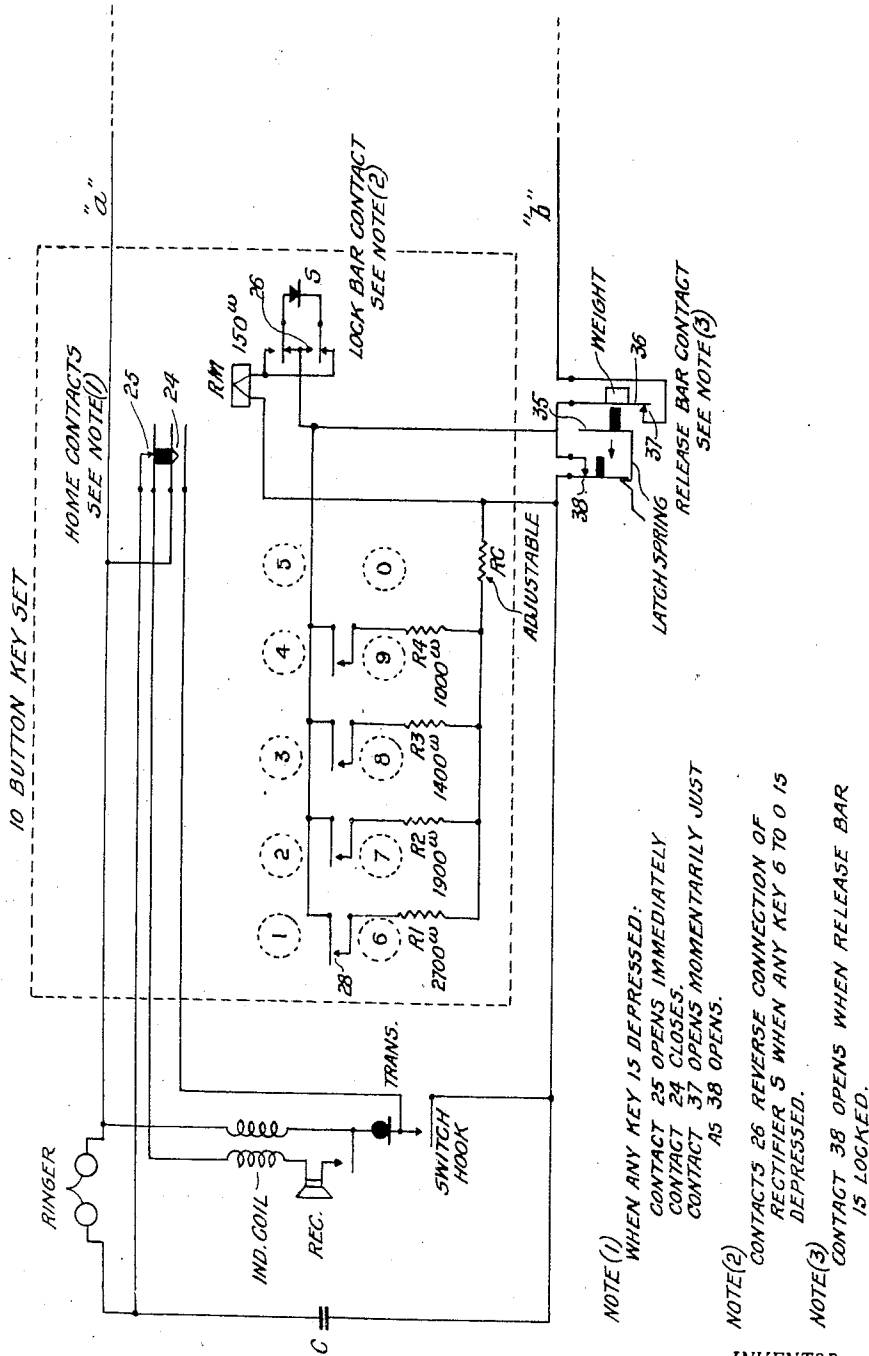
2,438,496

TELEPHONE SYSTEM EMPLOYING KEY TYPE CALL TRANSMITTER

Filed June 19, 1944

8 Sheets-Sheet 3

Fig. 3.



BY

INVENTOR.
Gerald Deakin

R. J. Perry
AGENT

March 30, 1948.

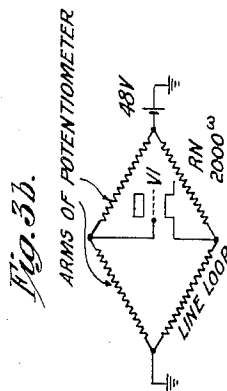
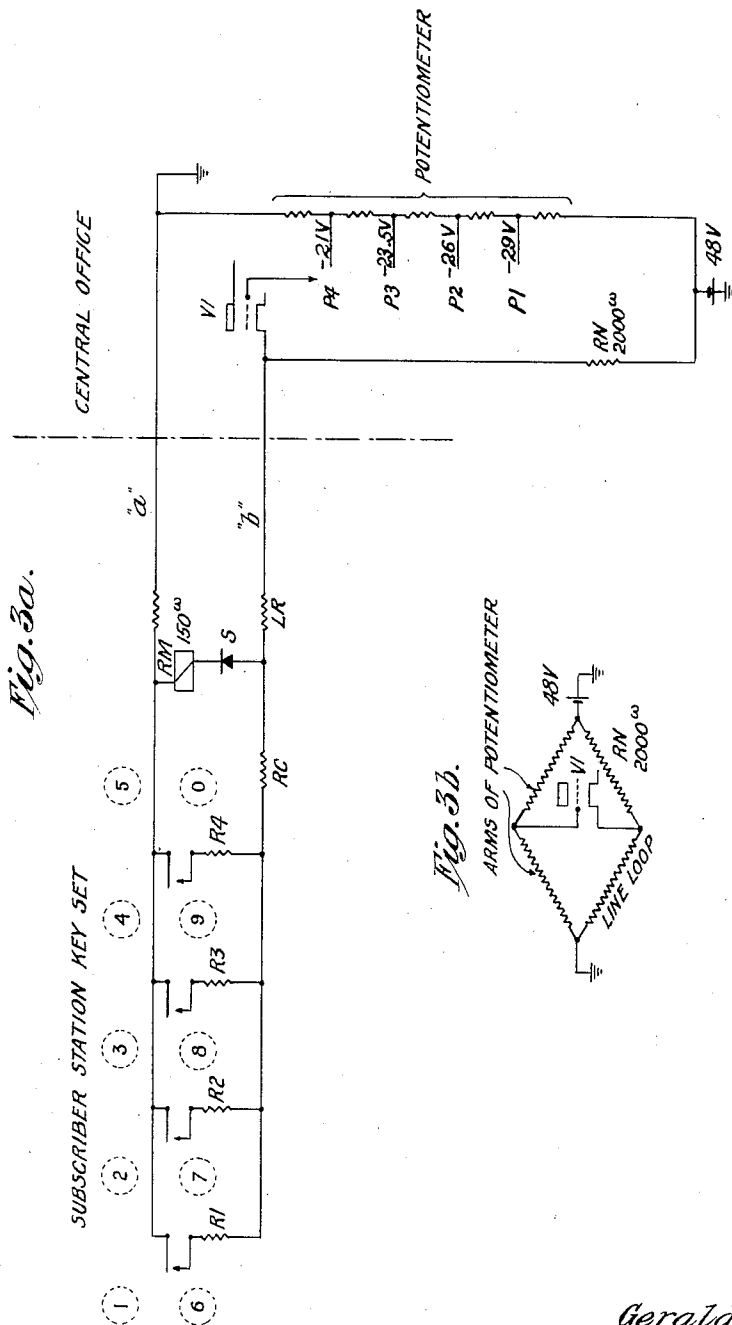
G. DEAKIN

2,438,496

TELEPHONE SYSTEM EMPLOYING KEY TYPE CALL TRANSMITTER

Filed June 19, 1944

8 Sheets-Sheet 4



INVENTOR.
Gerald Deakin
BY
[Signature]
AGENT

March 30, 1948.

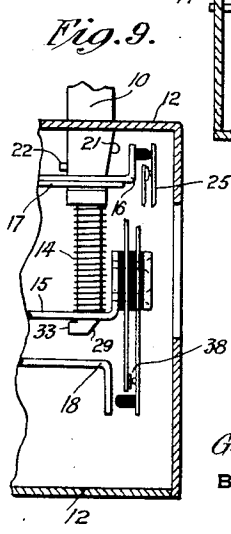
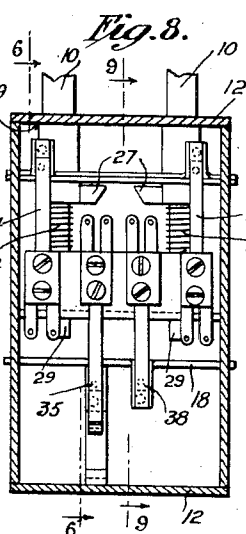
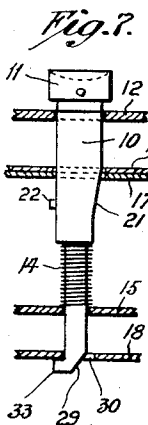
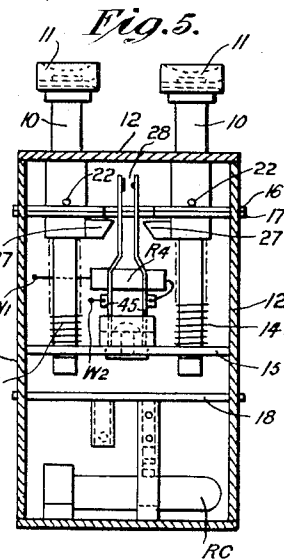
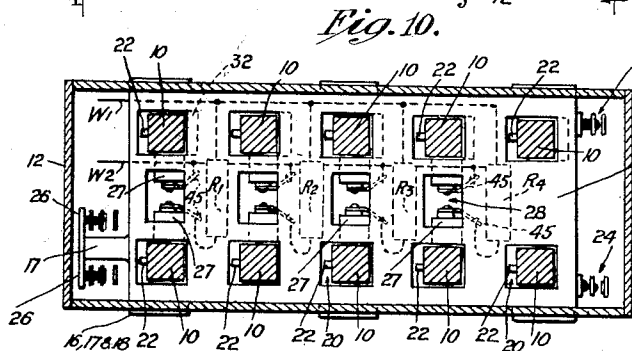
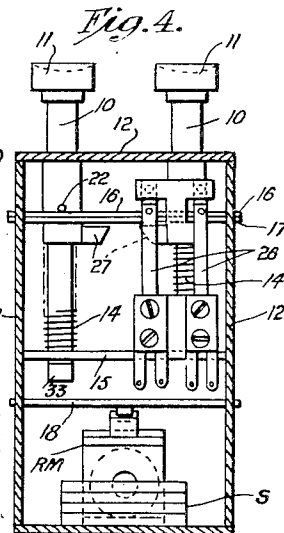
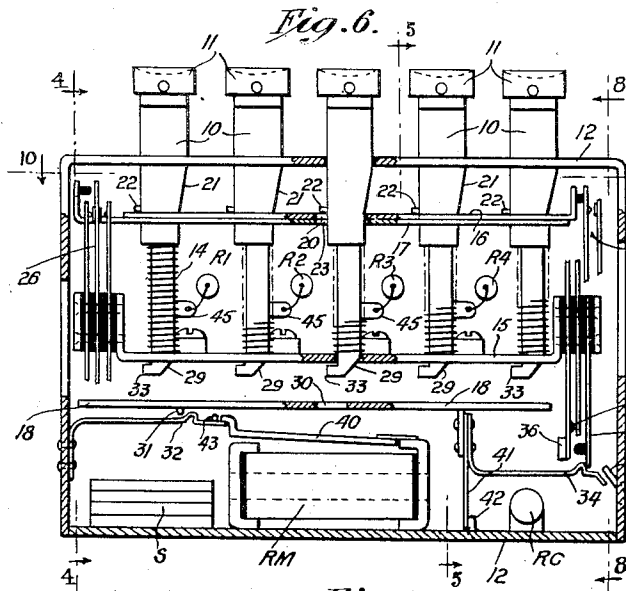
G. DEAKIN

2,438,496

TELEPHONE SYSTEM EMPLOYING KEY TYPE CALL TRANSMITTER

Filed June 19, 1944

8 Sheets-Sheet 5



INVENTOR
Gerald Deakin
BY
R. J. Perry
AGENT

March 30, 1948.

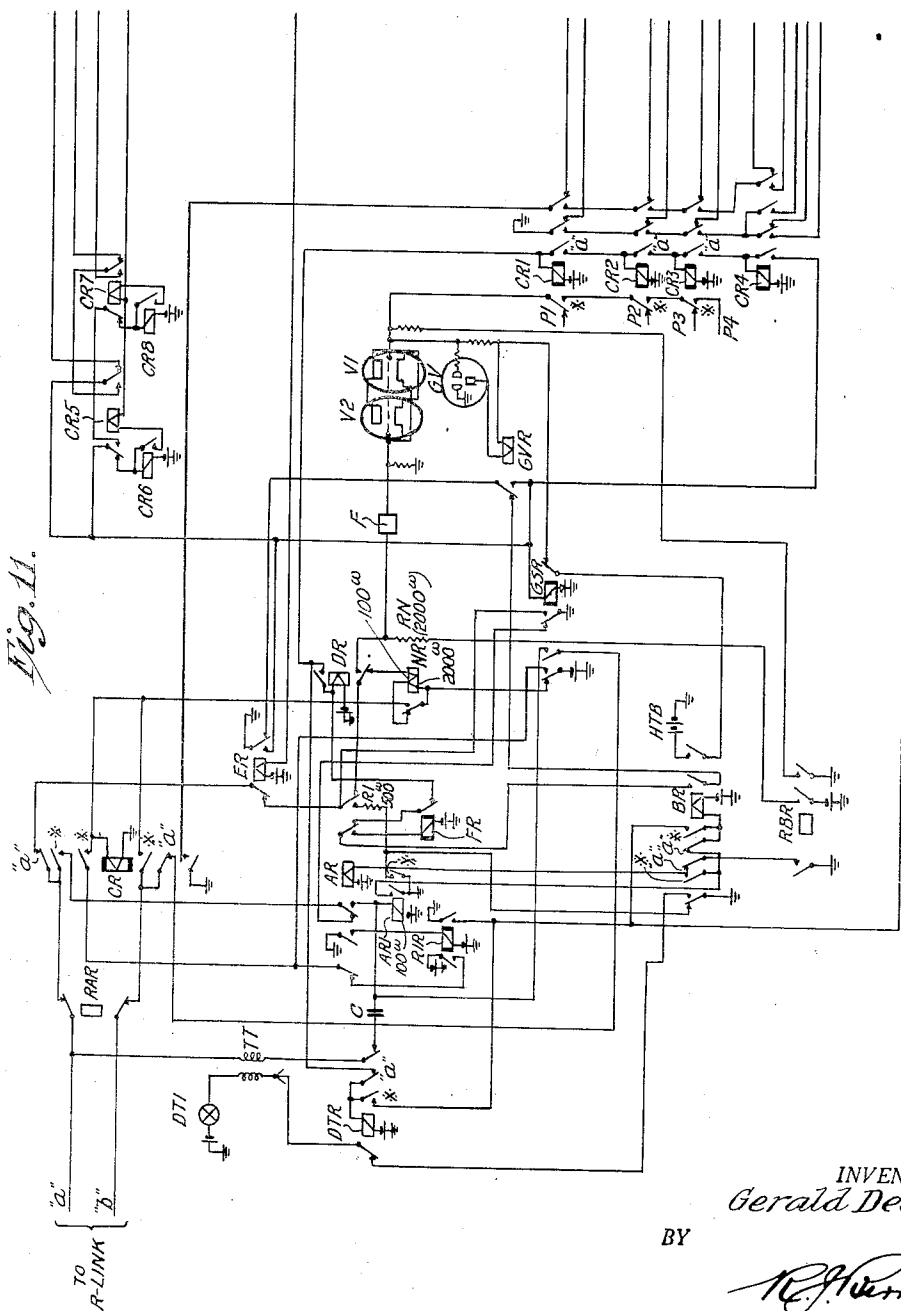
G. DEAKIN

2,438,496

TELEPHONE SYSTEM EMPLOYING KEY TYPE CALL TRANSMITTER

Filed June 19, 1944

8 Sheets-Sheet 6



INVENTOR.
Gerald Deakin

BY
R. J. Perry
AGENT

March 30, 1948.

G. DEAKIN

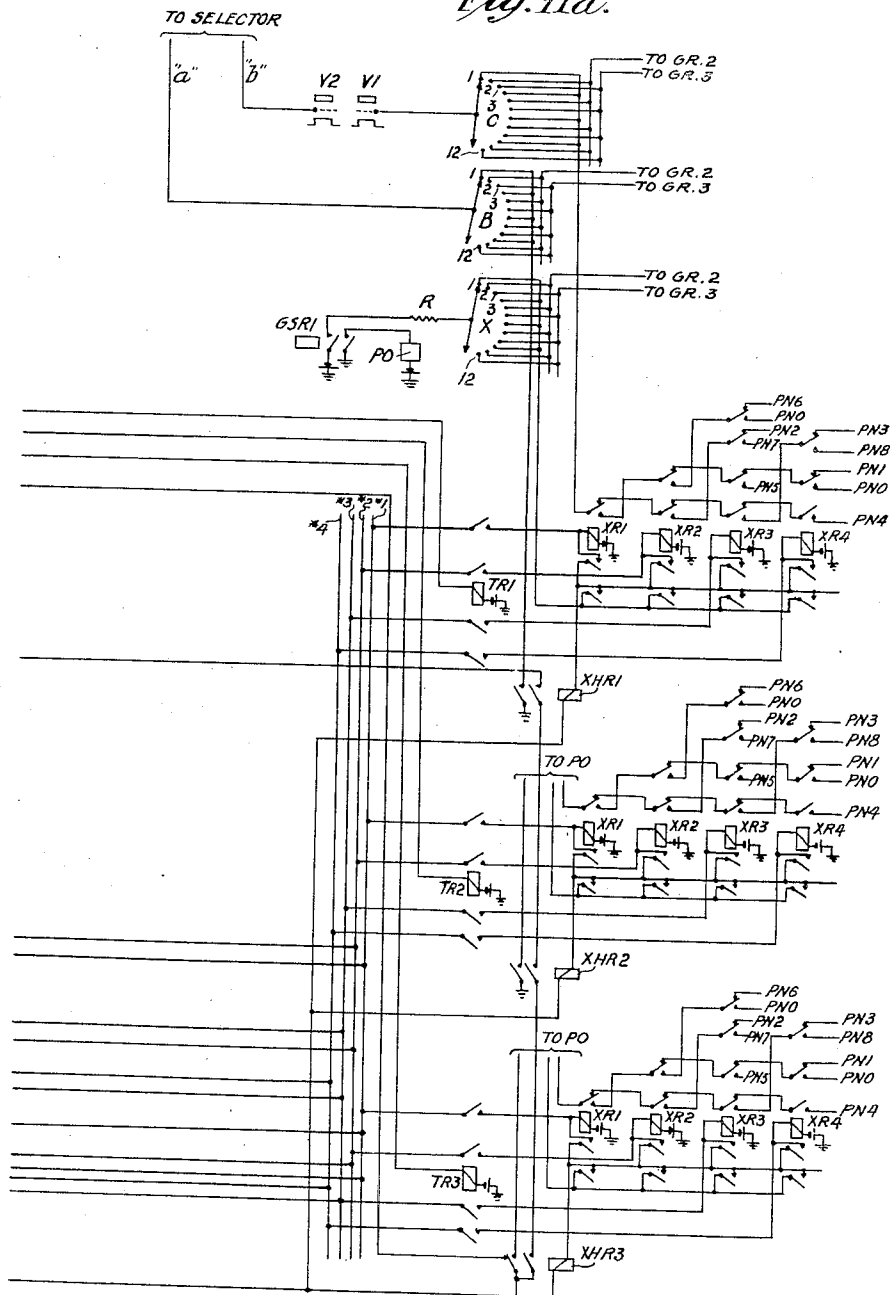
2,438,496

TELEPHONE SYSTEM EMPLOYING KEY TYPE CALL TRANSMITTER

Filed June 19, 1944

8 Sheets-Sheet 7

Fig. 11a.



INVENTOR.
Gerald Deakin

BY

R. J. Perry
AGENT

March 30, 1948.

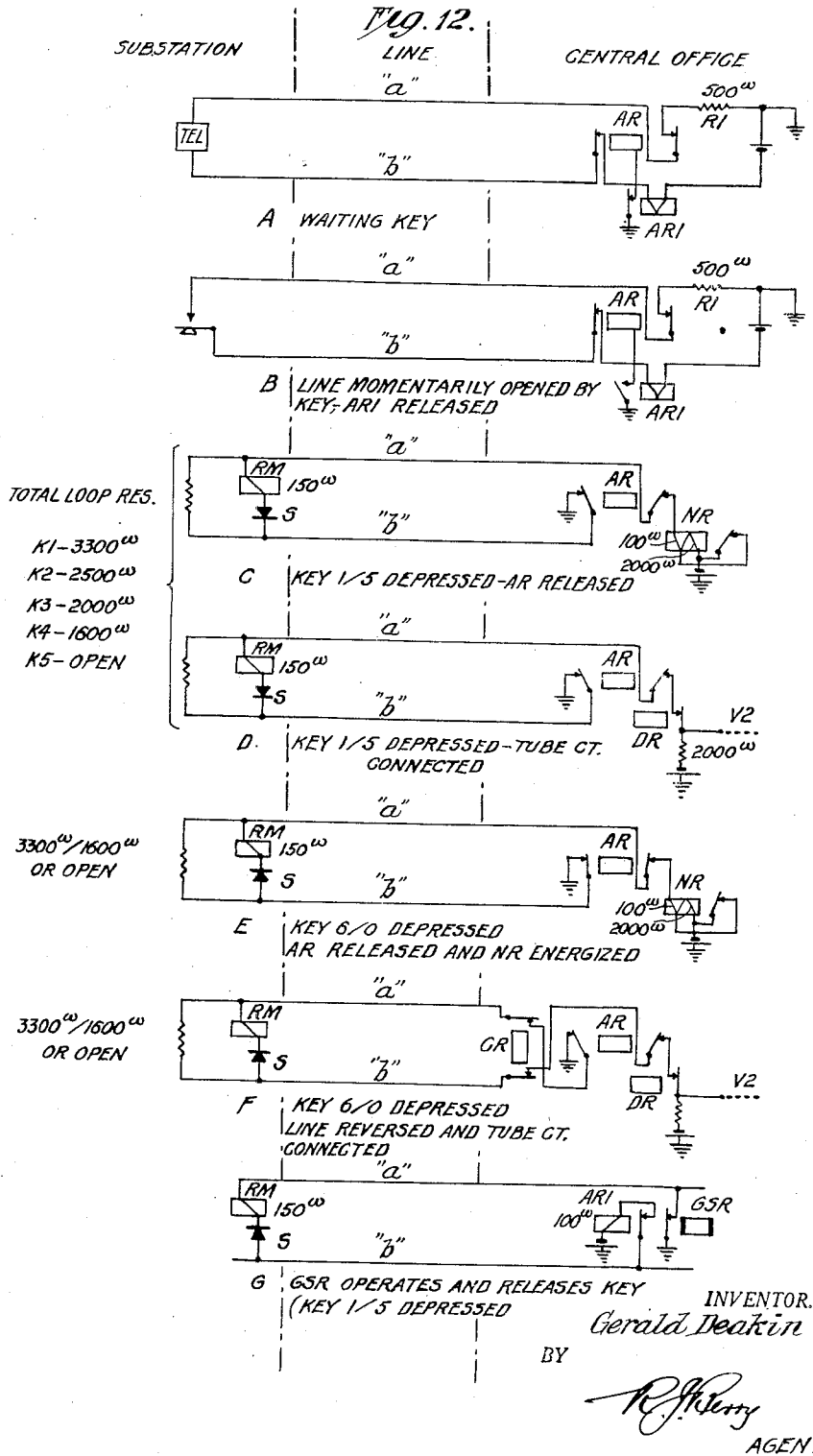
G. DEAKIN

2,438,496

TELEPHONE SYSTEM EMPLOYING KEY TYPE CALL TRANSMITTER

Filed June 19, 1944

8 Sheets-Sheet 8



UNITED STATES PATENT OFFICE

2,438,496

TELEPHONE SYSTEM EMPLOYING KEY
TYPE CALL TRANSMITTER

Gerald Deakin, New York, N. Y., assignor to International Standard Electric Corporation, New York, N. Y., a corporation of Delaware

Application June 19, 1944, Serial No. 540,946

57 Claims. (Cl. 179-90)

1

This invention relates to new and useful improvements in switching systems of the type useful for controlling telecommunication.

The present is a continuation of my application Serial No. 533,466, filed May 1, 1944, now abandoned.

The object of the invention is to provide a key-controlled switching system which is so rapid that a single set of ten keys may be used for controlling a plurality of successive numerical switching operations, e. g. in automatic telephone systems, and yet simple enough to permit installation at subscribers' stations.

In a telephone system embodying the various features of the present invention high speed keying (up to 6 per second) into a P. A. B. X or fast central office equipment is made possible, and slower keying (1 or 2 per second) into switchboards incapable of receiving at high speeds. Each ten button key set is equipped with means, such as sliding and locking bars which hold a key depressed and prevent any other key from being depressed until a switching device such as a register is ready to receive another digit, at which time the depressed key is automatically released. In one form, the register is equipped with three sets of digit storing means, e. g. relays, whereby the first three digits may be keyed at the maximum speed, making it particularly suitable for high speed three-digit P. A. B. X operation. The number of groups of digit storing relays is not fixed. There may be only one group without storage facilities. There may be two groups in which one digit may be stored, pending the selection of the previous digit. Such a register would be useful in high speed two-digit P. A. B. X operation. There may be four or more groups but it is thought that in most cases the additional expense would not be warranted. However, when it is necessary to dispose of the calls with extreme rapidity, one group of digit-storing relays should be provided for each digit. The registers could be provided for the operators at manual or automatic P. B. X switchboards.

When sending from a P. A. B. X to a slow speed central office or from a high speed central office to a slow speed central office, the speed with which keys are released will depend upon the time taken to complete selection in the central office. For example, when a three-digit storing register circuit is used for out-trunking from a P. A. B. X to a slow speed central office (10 or 12 pulses per second), then the first three digits may be keyed in rapid succession and stored, respectively, in the three sets of storing relays. As soon as a free out-trunk is selected by the P. A. B. X which ordinarily will be done very rapidly, the first set of storing relays is freed to receive the fourth digit. From then on the keys will be released as rapidly as the selections

2

are completed. Since the register is always capable of storing three digits, the last key button may be depressed before the last three central office selections take place.

When keying into a central office equipped with registers adapted to receive at a rate of 20 steps per second, the speed of keying may be correspondingly increased.

The system here disclosed is suitable for use with two-wire lines free from appreciable earth potentials having a maximum loop resistance, including the subscriber's set, of 600 ohms and a minimum leakage to ground of 20,000 ohms. These figures are not limits and are merely given to show that the system is capable of working in a modern cable plant maintained with reasonable care such as is necessary regardless of the system used.

While the provision of a key-controlled switching system is the important object of the invention, some of the features, particularly those relating to the register, may be found useful in other types of control system. This will be clear from the following description and the appended claims.

In the drawings:

Fig. 1 is a block diagram of a telephone system embodying the invention;

Fig. 2 is a simplified diagram illustrating the functioning of the invention;

Fig. 3 is a substation circuit;

Figs. 4-10 illustrate the key set, Fig. 4 being a section along lines 4-4 of Fig. 6, Fig. 5 a section along lines 5-5 of Fig. 6, Fig. 6 a section along lines 6-6 of Fig. 8, Fig. 7 an enlarged view of a detail of Fig. 6, Fig. 8 a section along lines 8-8 of Fig. 6, Fig. 9 a section along 9-9 of Fig. 8, and Fig. 10 a section along lines 10-10 of Fig. 6;

Figs. 11 and 11a are diagrams of the register; and

Fig. 12 illustrates the circuits at various stages of their operation.

SUBSCRIBER'S SET CIRCUIT (FIGS. 2 AND 3)

The subscriber's set consists of an ordinary telephone set and a ten-button key diagrammatically shown in Fig. 3, all mounted in a table or other set, for example, as shown in my copending design application Serial No. D. 113,244, filed April 13, 1944, now Design Patent No. 140,904, patented April 17, 1945. The key set consists of ten buttons, an upper and a lower locking plate, a rectifier reversing plate, a release magnet, and home contacts, the mechanical construction of which will be described later. First the functioning of the circuit will be described.

When any key is depressed, home contact 25 opens the receiver circuit and home contact 24 short-circuits the telephone circuit. The purpose of the former is to prevent an objectionable

3

click in the receiver when the line is short-circuited. As soon as any key is depressed, the upper locking bar prevents the depression of a second key until the first key is fully restored.

When the key plunger reaches the locking plate at the bottom, contact 38 opens and removes a short-circuit from keys. At about the same time a latch spring is released which causes a weighted spring momentarily to open contact 37. This is done so that the line circuit may not be opened long enough to cause a release at the central office which could take place if the length of opening depended on the speed of depression or the continuity of depression. When the key is fully depressed, it is locked in position by the lower locking plate and remains so depressed until released by the release magnet RM which, when operated, releases the lower locking bar and thus the plunger returns to normal whereupon another key may be operated.

Buttons 1 and 6 when depressed cut in resistance R1, buttons 2 and 7 cut in R2, 3 and 8 R3, and 4 and 9 R4. Buttons 5 and 0 do not cut in a resistance. The keys make contact and cut resistances into the line at the moment when contact 38 removes the short-circuit.

RC is an adjustable resistance which is used to adjust the line loop to a constant resistance of, say, 600 ohms.

When any one of the lower keys 6 to 0 of the five pairs of keys is depressed, the second locking top plate reverses the connection of the rectifier at 26. This plate is not restored to its normal position until the key plunger is released.

The tip spring of the lower locking bar is associated with the switch-hook in such a way that no key can be locked depressed unless the handset has been removed. Should a subscriber hang up with a key depressed, the key will be released when the handset is replaced and trips the locking plate.

TEN BUTTON KEY SET (FIGS. 4-10)

Obviously, the above-described operations can be performed in many ways and the mechanical structure here disclosed is given merely for the sake of exemplifying a controlling device embodying the features of the present invention.

The key set has ten keys. Each key has a molded plunger 10 with a removable key top 11. Plunger 10 is guided by a square hole in the top of frame 12 and at the bottom by a hole in plate 15 which is attached to key frame 12. The keys are kept in their normal position by springs 14. A shoulder on the plunger at 19 limits the upper movement.

There are three sliding plates 16, 17 and 18, each free to slide endwise to the right (Fig. 6). These sliding plates are held in position by lugs projecting through slots in the side of the housing 12 as indicated in Figs. 5 and 10.

The key plunger 10 normally pierces the sliding plates 16 and 17 as shown in Fig. 10. The hole 20 in plate 16 is such that whenever any key is depressed the slanting surface 21 of the plunger forces plate 16 to the right. Pin 22 molded in the depressed plunger 10, however, passes through hole 20 in the plate before the hole is moved sufficiently to prevent the depression of the key. A second key may not be depressed when one key is already depressed.

Locking bar 17 is similarly arranged, except that the holes 23 for keys 1 to 5 are longer. The slanting surface 21 of the plunger does not engage

4

this plate when any button 1 to 5 is depressed. However, when any key 6 to 0 is depressed, sliding plate 17 is moved to the right along with sliding plate 16.

When any button is depressed, sliding bar 16 moves to the right, opens contact 25 (Fig. 9) and closes contact 24 (Fig. 6). These are the contacts identified in the circuit of Fig. 3. When any button 6 to 0 is depressed, sliding bar 17 moves to the right and operates contacts 26 (see Figs. 4, 6 and 10).

The upper part of the plunger is provided with a lug 27. When any key except keys 5 and 0 is depressed, the depressed lug forces two adjacent springs together to close contact 28. Such contact is not provided for keys 5 and 0. It will be seen from Fig. 10 that the same contact is closed when any other pair of keys, such as 1 and 6 are depressed.

Just as the depressed key nears the end of its stroke, sliding surface 29 at the bottom of the key plunger engages the edge of hole 30 in sliding plate 18 and forces the plate to the right. When the plunger is fully depressed, pin 31 attached to plate 18 engages a catch on spring 32, whereby when pressure is released from the key, plate 18 does not return to its normal position and the tip 33 of the plunger catches under the edge of hole 30 in plate 18 and the key remains depressed (see Fig. 7).

When the plunger forces plate 18 to the right, spring 34 attached to plate 18 forces spring 35 also to the right. Just before plate 18 reaches the end of its movement, lug 36 attached to frame 12 engages the slanting tip of spring 34 forcing it downward to release spring 35 which now returns under considerable tension of its own to engage weighted spring 36, forcing this spring away from the center spring 37, thereby opening contact 36-37 long enough to allow the requisite opening of the line circuit. This snap opening of the line circuit is provided so that the line circuit may not be opened too long when a key is depressed slowly. Plate 18 also opens contact 38 (Figs. 8 and 9).

To release a depressed key, electro-magnet RM is energized. Armature 40 is attracted and depresses spring 32, thereby freeing pin 31, after which plate 18 returns to its normal position under the tension of spring 41, the free end of which rests against lug 42 of frame 12. The inclined back of the catch on spring 34 permits this spring to assume the position shown in Fig. 6.

When the key is restored, plates 16 and 17 return to their normal positions, the former under the tension of springs 24 and 25 and the latter under the tension of spring 26.

Part 43 is connected to the switch-hook of the subscriber's set in such a way that it forces 32 out of reach of pin 31 when the switch-hook is in its normal position, whereby a key will not be locked down when the handset is on the switch-hook. Parts 43 and 32 are shown with handset removed.

Radio type resistances R1 to R4 are connected to and supported at one end by lugs 45 of the one spring making contact 28. The other end is strapped to wire "w1."

The plug-in adjustable resistance RC is conveniently located at the bottom of the set. The socket for RC, not shown, is attached to the base of 12.

Rectifier 46 is also attached to the base of 75 frame 12.

FUNDAMENTAL SIGNALING CIRCUIT (FIG. 2)

The fundamental signaling circuit is substantially a Wheatstone bridge circuit and when the potentials of the opposite corners of the square bear a predetermined relationship to one-another, e. g. are the same, the responsive device in the registering circuit operates. The potentials involved and how they are obtained are shown on Fig. 2. Any source of direct current may be used, e. g. the normal exchange battery of 48 volts. The potential of this battery may vary from 40 to 60 volts without disturbing operation; thus no voltage regulation of the battery is necessary.

At the central office four potentials P1 to P4 are obtained by means of a potentiometer placed across the exchange battery. These potentials are applied in rotation to the grid of triode V1 of the register by counting or other step-by-step operated means such as counting relays CR1—3. The corresponding potentials applied to the grid of V2 are obtained from the same battery by inserting at the keys into the metallic line loop the proper resistances R1—4 as indicated in the table on Fig. 2. It will be seen that a pair of keys, such as 1 and 6, 2 and 7, etc., introduce the same resistance. Keys 5 and 0 are not equipped with contacts since these two digits are recorded without the use of potentials. The manner in which odd and even key buttons of each pair are detected will be explained in connection with the register circuit. It will suffice to say here that the signal circuit is always as shown in Fig. 2 when an operating potential is applied to the grid of V2. At this time the connection of the rectifier S in series with the release magnet RM is always such as to prevent the flow of current from the "b" wire to the "a" wire and thus RM does not interfere with signaling.

The value of the resistors R1 to R4 is given in the table. Resistor RC is always adjusted so that the loop resistance of the metallic line from the office to the key, but excluding the key resistor, is 600 ohms. RC may be a small plug-in radio type resistor.

When key 1 or key 6 is depressed, the total loop resistance is 3300 ohms. When the line has an infinite insulation resistance to ground, the resulting potential on the grid of V2 is 30 volts. When the "b" wire has a leak to ground of 20,000 ohms, the potential is reduced to 28 volts. The average is 29 volts and the potentiometer at the central office is adjusted to give P1 this average potential of 29 volts.

The resistances R2, R3 and R4 are selected to give a graduated series of potentials approximately 3 volts apart. The value of these resistances and the corresponding potentials under the different conditions are given in the table.

In the signaling system as here disclosed the lines have a loop resistance not exceeding 600 ohms and an insulation resistance, "b" wire to ground, of not less than 20,000 ohms. While these figures are not limits, they are met by the vast bulk of lines in any modern cable plant.

OPERATION OF REGISTER CIRCUIT
(FIGS 1, 11, AND 11a)*Subscriber removes handset*

When the subscriber removes the handset and closes the line circuit, the line relay operates, after which an R-link seizes a B-link and then a register. After this the register causes the line finder of the B-link to seize the calling line, whereupon relays RAR and RBR of the register

circuit (Fig. 11) fall away and pull up respectively, all as described in application Serial No. 521,160, filed February 5, 1944. It is at this stage that the parts of the register circuit shown in Fig. 11 come into effect. When RAR makes its back contacts, it connects in said application a stepping relay to the calling line. This stepping relay receives the digit pulses and passes them on to digit switches through an in-control distributing switch. The digit switches store the digit record. In the present case, when RAR makes its back contacts, it connects to the calling line a tube circuit, including four counting relays CR1 to CR4. These counting relays transfer the record of the digit keyed to digit storing relays XR1, XR2, etc., the counterpart of the digit switches above referred to and the distribution of these digit storing relays is made by counting relays CR5 to CR8 and transfer relays TR1 to TR3, the counterpart of the in-control switch. In both cases the result is the same. PN potentials according to the digit keyed are placed on the terminals of the C bank of the out-control switch PO and ground on the B terminals, either directly or through translator switches. The operation of the selectors in completing the connection in the P. A. B. X or central office, as the case may be, and the generation of dial pulses for out-trunking remain as described in said application. To control the release of the key, an extra bank is added to the PO switch and an extra contact to the GSR1 relay so that whenever GSR1 operates, it places battery on a terminal in bank x at the same instant it energizes PO.

When RBR (Fig. 11) makes its front contact, it energizes AR over a back contact of BR. AR connects AR1 to the "b" wire and a circuit is established from battery, winding AR1, front AR, back CR, back RAR, "b" wire through telephone set, "a" wire, back RAR, back CR, back ER, front AR, resistor R1, back BR to ground. AR1 operates and energizes BR, ground, front AR1, back BR and winding BR to battery. BR disconnects itself from AR1 and locks up over front R1R. At the same time BR disconnects the winding of AR from a front contact of RBR and in place thereof connects it to a front contact of AR1 without opening the circuit of AR. AR1 now locks up AR. BR removes ground from the "a" wire but the line circuit remains closed to ground over a front contact of AR1. BR closes the primary circuit of the dialing tone transformer TT. The secondary winding of this transformer is bridged across the calling line through condenser C. The subscriber hears the dialing tone. FR is energized, circuit from ground, back ER, back GVR, front BR, front AR, winding FR, to battery. The circuit remains in this condition until a key is depressed.

Key group selection

When any key is depressed, the line circuit is momentarily opened by the key set (B, Fig. 12). This momentary opening of the line circuit releases AR1 (Fig. 11). AR1 breaks its front contacts and opens its own holding circuit and at the same time releases AR. AR falls away and makes its back contacts, among other things connecting NR from battery to the "a" wire via back contacts of DR, AR, ER and CR. The "b" wire is grounded over a back contact of AR and a back contact of CR.

Should a key 1 to 5 have been depressed, the connection of the rectifier S in the subscriber's set circuit will be as shown at C in Fig. 12. Cur-

rent will not flow through release magnet RM and the current which flows through the low resistance winding of NR (Fig. 11) and the key resistor R1 to R4 (Fig. 2), as the case may be, will not be sufficient to energize NR. However, should a key 6 to 0 have been depressed, the connection of the rectifier is reversed (E, Fig. 12). Sufficient current now flows through the low resistance winding of NR, the rectifier, and the release magnet to operate NR which breaks its back contact quickly and introduces an additional resistance RN of some 2,000 ohms under which condition RM does not operate. NR has two windings, a low resistance winding and a high resistance winding. Normally the latter is short-circuited. The former winding enables the relay to be adjusted to operate over the maximum loop of 800 ohms (the maximum permissible line resistance of 600 ohms plus the resistance of the rectifier and release magnet) but not to operate over the minimum keyed resistance R4 which, as will be seen from Fig. 2, is 1600 ohms. When NR closes its front contact, it energizes CR (Fig. 11) which reverses the line connections so that current ceases to flow through RM. By means of this reversal of the rectifier connections, it is possible to reduce the number of different subsequent key selecting pulses from 10 to 5 and thus cut in half the number of potentials necessary for the operation of the tube circuit. Keys 1 to 5 develop the same potentials as keys 6 to 0 respectively (see Fig. 2).

When AR breaks its front contact, it opens the circuit of slow releasing relay FR, the purpose of which is to allow time for NR to operate CR, if CR is to be operated at all. After the elapse of a short interval of time, FR closes its back contact and energizes DR, circuit from ground, back GVR, front BR, back AR, back FR, winding DR to battery.

Key 1 depressed

When key 1 is depressed, AR1 falls away and releases AR. AR connects relay NR to the "a" wire, ground to the "b" wire and releases FR. When FR makes its back contact, DR becomes energized and disconnects NR, and in place thereof connects the grid of V2 in multiple with resistor RN to the "a" wire. Resistor RN is connected to battery over a front contact of RBR. The keying circuit is diagrammatically shown at D in Fig. 12. DR operates DTR which operates and locks up and disconnects the dialing tone transformer. The resistance R1, which key 1 introduces into the line circuit, is such as to produce a potential P1 on the grid of V2, the average value of which potential is arbitrarily assumed to be 29 volts. Since the grid of V1 is normally connected to the same potential over the back contact of CR1, gas valve GV fires instantly and energizes GVR which opens its back contact and consequently the circuit of CR1 before the latter has had time to operate and energize CR2. Similarly, if digit 3 were keyed, GV would fire when CR2 is operated and connects P3 to the grid of V1 over the back contact of CR3.

Digit 1 stored

When GVR makes its front contact, it energizes TR1 and CR6 over back contacts of CR5. As soon as TR1 makes its front contacts, XR1 operates over a circuit from ground, back CR1 and front TR1. XR1, according to the following table, places the required potential PN1 on terminal 1 of bank C via the back contacts of XR2, XR3, and XR4.

TABLE

Digit keyed	Relays energized	
	XR	CR1/4
1	1	None
2	2	1
3	3	2
4	4	3
5	1+3	4
6	1+2	None
7	2+3	1
8	3+4	2
9	4+1	3
0	1+2+3	4

15 F is a filter to prevent improper operation of the triodes by the dialing tone or the like.

Key released

GVR energizes GSR. A low resistance circuit is established from ground, front GSR, back ER, back CR, back RAR, "a" wire, release magnet of subscriber's set (G, Fig. 12), rectifier S, "b" wire, back RAR, back CR, front GSR, winding AR1 to battery. The current through this low resistance circuit is now in such a direction and of such a strength as to energize release magnet RM of the subscriber's set. RM releases the depressed key. AR1 remains energized and locks up AR. GSR removes battery from NR so that NR is not energized when GSR grounds the "a" wire. GSR removes ground from the "b" wire. This is done so that AR1 will not buzz on a premature release. When GSR releases, it removes the shunt from resistor R1 and this resistance is introduced into a holding circuit of AR1. The line circuit is now restored to the waiting position (A, Fig. 12) and it remains in this condition until another key is depressed.

Register prepares for storing second digit

40 GSR opens the circuit of the high tension battery. GV is de-ionized and releases GVR. When GVR breaks its front contact, CR6 locks up over its front contact in series with CR5. CR5 transfers the front contact of GVR to the back of CR1 which is connected to the winding of TR2.

In parallel with the foregoing, TR1 releases when GVR breaks its front contact. XR1, however, remains energized and locked up over its front contact and the winding of XHR1. XHR1 places ground on terminal 1, bank B of the out-control switch PO.

First selection takes place

55 When XHR1 places ground on bank B, the AR relay of the selector under control operates and the selector searches for a trunk having potential PN1 on the "t" wire. When a free trunk is found, GSR1 (Fig. 11a) is energized and energizes PO, at the same time placing battery through R on the brush x, terminal 1, thereby shunting out XR1 which releases. When XR1 breaks its front contacts, XHR1 releases and frees the first group of XR relays for another digit, but as previously indicated, the next digit when it does arrive will come in on the second group since TR2 is now connected to the front contact of GVR.

Digit 5 keyed

70 We will assume that digit 5 is keyed after digit 1 and, as will be seen from the potential diagram (Fig. 2), this key inserts no operating potential resistance in the line circuit. Thus 75 counting relay CR1 will operate, circuit from

ground, back ER and GVR, front BR, back AR, back FR, front DR, winding CR1 to battery. CR1 connects CR2 to this grounded circuit and CR2 operates. CR2 connects CR3 and CR3 connects CR4. The tube circuit does not operate, but when CR4 closes its front contact, the ground is extended over front CR5 and back CR7 to energize TR2. XR1 and XR3 (see table above) operate and lock up. CR4 also operates GSR, re-energizing AR1 which locks up to the line and releases the key. When AR operates, FR is energized and DR and the counting relays are released, whereupon TR2 releases. Another relay energized by CR4 is CR8 which locks up over its front contact in series with CR7. CR7 transfers the front contact of GVR from TR2 to TR3. When TR2 is released, XHR2 operates and places a ground on terminal 2 in bank B of PO and the second selection may now be made in the usual way for digit 5.

Digit 6 keyed

When key 6 is depressed, the same potential is placed on the grid of V2 as when key 1 was depressed, but because of the reversal of the rectifier, as previously explained, NR operates momentarily and locks up CR, thus reversing the line connection at the central office as shown at F in Fig. 12. When TR3 operates, relays XR1 and XR2 are energized in accordance with the above table.

When XHR3 operates, counting relays CR5 to CR8 are released and ground is placed on terminal 3 of bank B of PO.

Digit 0 keyed

We will assume that the fourth digit keyed is the digit 0. In this case NR locks up CR but no potential is placed on the line, the same as when the opposite digit 5 was keyed. Therefore, counting relay CR4 operates with the result that relays XR1, XR2, and XR3 of the first group are again energized as per the table, assuming, of course, that the first selection has been completed.

Key set blocked

Assume now that the second selection is still incomplete, in which event XHR1, XHR2, and XHR3 will be energized and close over their front contacts a series circuit for relay ER to R/R front. ER opens the line circuit, energizes GSR and removes ground from the armature of GVR, thus releasing DR. The circuit remains in this condition until the second selection is complete, after which the above traced holding circuit is opened at a front contact of XHR2, whereupon ER falls away and GSR closes the line circuit. AR1 locks up to the line, since GSR is slow releasing, and releases the key set.

The fifth digit may now be keyed. The call will come in on the second group of XR relays, after which the holding circuit will be again closed unless the third selection has been completed. In this manner a key is held depressed until there is a free group of XR relays to receive and store pulses.

The bank of the cut-control switch PO has in this particular case 12 terminals which are multiplied in four sets of three to accommodate the three groups of XR digit storing relays. In other words, PO may accommodate 12 digits, using each group of XR relays four times.

It will be readily seen that the number of groups of digit storing XR relays may be decreased or

increased. If there were only one group of relays, the out-control switch PO would not be necessary since the three wires running to banks X, B, and C could be permanently attached to their respective brush circuits. If there were six groups of XR relays, the multiplying of the PO switch banks would be changed to two groups of six instead of four groups of three. If one group of storing relays were provided for each of a seven-digit number, there would be no multiplying in the banks of the PO switch. The ease with which arrangements may be made for storing various numbers of digits adds important flexibility to the circuit.

Out-trunk calls from a P. A. B. X

Local calls within a P. A. B. X equipped for key sending may be completed rapidly but when a call is out-trunked, the PN potentials selected by the digit storing relays are placed on a bank of an out-trunk pulse controlling switch, such as PT in the register circuit described in said copending application. The speed and character of the out-trunk pulses may be adjusted to the character and speed of the pulse receiving equipment in the central office. As soon as the out-trunk pulse control switch PT has completed a selection, GSR1 operates as described in said application, releases the digit storing relays and consequently determines the speed with which the keys are released.

Release, regular and premature

The method of release when a call is completed is the same as described in said copending application. However, should the subscriber hang up before the completion of selection, the partially completed selection is released when AR1 falls away upon the opening of the line circuit. AR1 releases AR. The release of AR energizes DR in the usual way and the counting relays CR1-4 are energized. When CR4 operates, GSR is energized but as the line circuit is opened, AR1 is not re-energized and therefore does not re-energize AR. In due course R/R, the circuit of which is now opened by AR, breaks its front contacts and releases the connection.

SPEED OF KEYING

In a P. A. B. X of the Universal System type

The maximum speed with which keying may be done in a three-digit P. A. B. X equipped with three sets of storing relays is calculated as follows:

	Time in Milli-Seconds, Digits Keyed	
	1 or 6	5 or 0
Depression of key.....	50	50
AR1 breaks front contact.....	2	2
AR makes back contact.....	6	6
FR makes back contact.....	20	20
DR operates.....	6	6
CR1-4 operates.....	32	32
GVR opens back contact.....	2	2
TR operates.....	10	10
XR operates.....	10	10
Release of key.....	50	50
	156	188
Keys per second.....	6.5	5.3
Average maximum.....	Approx. 6	

Remark: The above assumes 50 milli-seconds for depressing a key $\frac{1}{2}$ ".

Theoretically at least, the three keys may be successively depressed in a total of one-half a sec-

ond which is faster than the selectors can complete the call. During hours of normal traffic it should be possible to complete a call to number 555 in a keying P. A. B. X in an average of 1.5 seconds after the depression of the first key, provided that all three keys are depressed rapidly one after the other. In actual practice it is not likely that an average familiar number will be depressed at a rate faster than three keys per second so that the delay of the ringing tone after depressing the last key will not be noticeable in a P. A. B. X local operation.

*Subscriber-to-subscribe trunk calls from
a P. A. B. X*

Under normal traffic conditions a subscriber will pick up a free trunk almost instantly after the trunk key is depressed and if the P. A. B. X is equipped with three sets of digit storing relays, the next three digits may be rapidly depressed. In large areas, such as New York, these digits would be the office prefix digits. The speed with which the keys will be released to permit the completion of the keying of the four-digit office number will depend upon the speed with which the central office is able to absorb the digit pulses.

When keying into a straight Strowger exchange without digit storing facilities, time must always be left for the vertical stepping of the switch and for the horizontal hunting for a free trunk and, since a straight Strowger system has no means of signaling to the sending equipment whether the haul is long or short, time must always be allowed for the long haul. Thus keying into such a Strowger exchange cannot be done more rapidly than about 1 digit per 1.25 seconds. This means that since three digits may be stored, the last key may be depressed 4 or 5 seconds before the ringing or busy tone is heard. This delay may be noticeable but it may not be objectionable. In actual practice, subscribers will probably learn to key at a slower rate so as more or less to anticipate the slower speed of the switch.

When keying into a system provided with a register in which provision may be made for more rapid reception, keying may be done at approximately .75 second per digit, thus reducing the average time of the ringing or busy tone after the last key is depressed to approximately three seconds, this also upon the assumption that the next digit is keyed as soon as the key for the previous digit is freed.

Key set applied to central office operation

When keying is applied to central office operation, it will probably not be necessary to provide for more than three sets of digit storing relays since in the Universal System, by virtue of the disposition of trunks which multi-potential selection makes possible, all selections may be very rapidly made, with the exception of the "tens" selection which must of necessity be spread out over the entire bank. The average for all selections, except the "tens" selection, during hours of normal traffic should be less than .5 second and that of the average "tens" selection 1 second, thus making the total selection time of a seven-digit number for the Universal System 4 seconds, exclusive of translation. Where three-digit office translation is required, as will be the case in all large cities, an average of 1.5 seconds must be added to the total selection time, increasing it to 5.5. If three groups of storage relays are provided, the first three but-

tons may be depressed very rapidly. This will take care of the office prefix. With translation the third key would be freed in about 1.5 seconds after its depression, the time taken to translate the office prefix. The keys would then become free at an average rate of .5 second and the waiting time after the depression of the last key would be about two seconds. This wait is not objectionable and if the time of keying is spread out, the delay will not be noticeable.

The fact that digits may be stored tends in itself to increase the speed of selection. In the customary dial system, for instance, the pulses for the next digit may not even be prepared for sending in until after the dial comes to rest. The subscriber must locate the finger hole and this in itself is often a source of delay, next he must pull it to the finger stop, and only after he has removed his finger from the finger hole does the sending of pulses to the central office commence. With a key set and storing relays, the subscriber can easily select the proper keys one after the other since the designations of the keys are not concealed during keying. The designations visible through the holes of a stationary dial are concealed during dialing.

When it is desired to provide P. B. X attendants and toll or other operators with means to key rapidly the entire number, additional groups of storing relays may be added to the registers used by these operators. In this way the numbers may be disposed of as fast as they can be keyed, but the delay after the keying of the last digit may be 5 or 6 seconds. Such delay, however, is generally of little importance to a P. B. X attendant or toll operator who usually has something else to do while awaiting answer by the called party.

Figs. 3a and 3b illustrate a modification of the control circuit in which the triode V2 is eliminated. The line loop is connected with the cathode of the single triode V1 to whose grid the various potentials may be applied as previously explained. The a and b wires are crossed as compared to Fig. 3. Otherwise, the two embodiments are identical.

What is claimed is:

1. In a telecommunication system, a plurality of lines, each having a multi-digit number, means including a plurality of stages of numerical selector switches for establishing a connection between a calling and a called line, a central exchange register for variably operating the selectors in accordance with the different digits of the called number, a plurality of keys associated with each line, an electric discharge tube in the register, means for connecting the keys of the calling line with said tube, means responsive to the operation of the connected keys for applying various potentials to said tube, and means controlled by the tube for variably operating the register.

2. In a telecommunication system, a plurality of lines, each having a multi-digit number, means including a plurality of stages of numerical switches for establishing a connection between a calling and a called line, a register comprising a plurality of digit switches, less than the digits in line numbers, means for successively connecting operated digit switches with the selectors to control their setting, a plurality of keys, each adapted variably to operate any digit switch in accordance with the different digits of the called number, means responsive to each actuation of a key for connecting it with an idle digit switch in

13

a predetermined order; and means for preventing the actuation of the keys if all the digit switches are busy.

3. The system according to claim 1, and means for preventing the operation of the keys until the control of a selector by the register is completed.

4. In a telecommunication system, a signal-controlling device, a signal responsive device, a circuit interconnecting said devices, a source of electrical potential, means including a plurality of resistances for establishing a plurality of potential changes in said circuit in accordance with the operation of the controlling device, and means in the responsive device for detecting said potential changes.

5. The system according to claim 4, and means in the responsive device for recording said potential changes.

6. The system according to claim 4, and means for switching one resistance or another into the circuit depending on the operation of the controlling device.

7. In a telecommunication system, a signal-controlling device, a signal responsive device, a circuit including a two-wire line interconnecting said devices, a source of electric potential, means including a plurality of resistances at the controlling device for establishing a plurality of predetermined potential changes at the responsive device by changing the resistance of said circuit in a predetermined manner, and means in the responsive device for detecting and recording the potential change.

8. In a telecommunication system, a signal-controlling device, a signal responsive device, a circuit including a two-wire line interconnecting said devices, a source of electric potential, means including a plurality of keys and a lesser number of resistances at the controlling device for establishing a plurality of predetermined potential changes at the responsive device by changing the resistance of said circuit in a predetermined manner, and means in the responsive device for detecting and recording the key which has been actuated.

9. In a telecommunication system, a signal-controlling device comprising ten keys and four different resistances, a signal responsive device, a circuit including a two-wire line interconnecting said devices, a source of electric potential, means including said keys and resistances at the controlling device for establishing predetermined potential changes at the responsive device, and means in the responsive device for detecting and recording which key has been operated.

10. In a telecommunication system, a controller comprising a plurality of resistances and a rectifier, a responsive device, a connection between the controller and the device, a source of potential, means responsive to the operation of the controller for connecting to the device said source over one of said resistances and the rectifier poled in a predetermined manner, switching means in the responsive device operable in accordance with the potential applied thereto, and switching means in the responsive device operable in accordance with the poling of the rectifier.

11. In a telecommunication system, a controller comprising a plurality of keys, a lesser number of different resistances and a rectifier, a responsive device, a connection between said device and controller, a source of potential, means responsive to the actuation of certain keys for switching certain resistances in said connection, means re-

14

sponsive to the actuation of any one of a group of said keys for switching the rectifier in one direction in the connection and for switching the rectifier in the opposite direction when one of the other keys is actuated, switching means in the responsive device operable in accordance with the potential applied thereto, and switching means in the responsive device operable in accordance with the poling of the rectifier.

12. In a telecommunication system, a controller comprising five pairs of keys, four different resistances and a rectifier, a responsive device, a connection between said device and controller, a source of potential, means responsive to the actuation of any key of four pairs for selectively switching said resistances in said connection, means responsive to the actuation of one key of any pair for switching the rectifier in one direction in the connection and for switching the rectifier in the opposite direction when the other key of any pair is actuated, switching means in the responsive device operable in accordance with the potential applied thereto, and switching means in the responsive device operable in accordance with the poling of the rectifier.

13. In a telecommunication system, a signal-controlling device comprising a plurality of keys, a lesser number of different resistances and a rectifier, a signal responsive device, a circuit including a two-wire line interconnecting said devices, a source of electric potential, means at the controlling device for connecting a resistance across the wires when either one of a pair of keys is actuated and for inserting the rectifier in the circuit in one direction or the other depending on which key of the pair is actuated, and means in the responsive device for detecting and recording the potential change and the direction of current in the circuit.

14. In a telecommunication system, a signal-controlling device comprising five pairs of keys, four different resistances, one for each of four of said pairs of keys, and a rectifier, a signal responsive device, a circuit including a two-wire line interconnecting said devices, a source of electrical potential for said circuit, contacts for selectively bridging said resistances across the wires when a key of said four pairs is actuated, contacts for connecting said rectifier in the circuit in one direction when one and the opposite direction when the other key of said five pairs is actuated, means in the responsive device responsive to the potential changes, and means responsive to the current direction changes in the circuit, and a switching device having ten positions corresponding to the ten keys variably operated by said means in the responsive device.

15. In a switching system, a controller comprising a plurality of keys operable in accordance with successive digits, means for locking the controller in the actuated position whenever a key is operated to prevent the operation of any other key, means including a magnet for unlocking the controller, a responsive device, a source of potential, means for establishing a connection between the controller and the device for repeatedly operating the latter in accordance with successive digits, and means for actuating the magnet upon each operation of the device.

16. The switching system according to claim 15, and in which different resistances are switched into the connection depending on the key actuated, and means in the device variably operable under the control of said resistances.

17. In a switching system, a controller operable

in accordance with successive digits, means for locking the controller in the actuated position, means including a magnet for unlocking the controller, a rectifier forming part of the controller, a source of potential, a responsive device, means for establishing a connection between the controller and the device for repeatedly operating the latter in accordance with successive digits, means for connecting the rectifier in the connection, in one direction upon certain and in opposite direction upon certain other operations of the controller, means in the responsive device variably operable depending upon the connection of the rectifier, and means for actuating the magnet controlled by said device.

18. The switching system according to claim 15, and in which means are provided for connecting the rectifier and controller in series in the connection, in one direction upon certain and the opposite direction upon certain other operations of the controller, and means in the responsive device for reversing the direction of current flow in said connection.

19. In a switching system, a controller operable in accordance with successive digits, means for locking the controller in the actuated position, means including a magnet for unlocking the controller, a responsive device, a source of potential, means for establishing the connection between controller and the device for repeatedly operating the latter in accordance with successive digits, means in the controller for switching said magnet into said connection, means at the responsive device for establishing a circuit from said source over said connection and magnet, and means at the device for varying the resistance of said circuit to control the operation of said magnet.

20. The switching system according to claim 19, and in which means are provided at the device for varying the direction of current flow in the circuit to control the operation of the magnet.

21. In a switching system, a controller operable in accordance with successive digits, means for locking the controller in the actuated position, means including a magnet for unlocking the controller, a plurality of digit responsive devices, means for successively associating said controller with idle responsive devices, and means for actuating the magnet upon the completion of the actuation of a responsive device but only if the next device is idle.

22. In a switching system, a controller operable in accordance with successive digits, means for locking the controller in the actuated position, means including a magnet for unlocking the controller, a plurality of digit-storing devices, means variably responsive to the actuation of the controller, means for associating the variably responsive means with successive idle storing devices to actuate them, means for performing a plurality of successive stages of switching operations under the control of the storing devices, means for successively associating actuated storing devices with successive stages to control the switching operations, and means for actuating the magnet upon the completion of the actuation of a storing device but only if the next device is idle.

23. In a switching system, a controller having ten keys operable in accordance with successive digits, means for locking an actuated key and preventing the actuation of the other keys, means including a magnet for unlocking the keys, a plurality of digit-storing devices, means variably responsive to the actuation of the keys, means for associating the variably responsive means with

successive idle storing devices to actuate them, means for performing a plurality of successive stages of switching operations under the control of the storing devices, means for successively associating actuated storing devices with successive stages to control the switching operations, and means for actuating the magnet upon the completion of the actuation of a storing device but only if the next device is idle.

24. In a switching system, a controller having ten keys operable in accordance with successive digits, means for locking an actuated key and preventing the actuation of the other keys, means including a magnet for unlocking the keys, a plurality of groups of digit-storing relays, means variably responsive to the actuation of the keys, means for associating the variably responsive means with successive groups of idle storing relays to actuate them, means for performing a plurality of successive stages of switching operations under the control of the storing relays, means for successively associating actuated group of storing relays with successive stages to control the switching operations, and means for actuating the magnet upon the completion of the actuation of a group of relays but only if the next group is idle.

25. In a telecommunication system, a plurality of signal-controlling devices, a signal responsive device, a plurality of circuits, means for connecting a controlling device over one of the circuits with said responsive device, a source of potential common to all the circuits, means including a plurality of normally inactive keys at each controlling device for establishing a plurality of predetermined potential changes in the connected circuit, electromagnetic means for locking the keys in their actuated position, means at the responsive device responsive to the potential of the connected circuit, and means controlled by the last-mentioned means for operating the electromagnetic means of the controlling device over the connected circuit.

26. In a telecommunication system, a plurality of signal-controlling devices, a signal responsive device, a plurality of two-wire circuits, means for connecting a controlling device over one of the circuits with said responsive device, a source of D. C. potential common to all the circuits, means including a plurality of normally inactive keys at each controlling device for establishing a plurality of predetermined potential changes in the connected circuit, electromagnetic means for locking the keys in their actuated position, means at the responsive device responsive to the potential of the connected circuit, and means controlled by the last-mentioned means for operating the electromagnetic means of the controlling device over the connected circuit.

27. In a telecommunication system, a plurality of signal-controlling devices, a signal responsive device, a plurality of two-wire circuits, means for connecting a controlling device over one of the circuits with said responsive device, a source of D. C. potential common to all the circuits, means including a plurality of normally inactive keys at each controlling device for establishing a plurality of predetermined potential changes in the connected circuit, a rectifier, contacts controlled by certain keys for connecting the rectifier in the circuit in one direction, contacts controlled by the other keys for connecting the rectifier in the circuit in the opposite direction, an electromagnet at each controlling device, means for locking the keys in their actuated position controlled by the associated magnet, means at the respon-

sive device responsive to the potential and the direction of the current in the connected circuit, an energizing circuit closed for the magnet of the controlling device over the connected circuit under the control of the last-mentioned means.

28. In a telecommunication system, a plurality of signal-controlling devices, a plurality of signal responsive devices, a plurality of circuits, means for connecting a controlling device over one of the circuits with an idle responsive device, a source of potential for said circuits, means including a plurality of normally inactive keys at each controlling device for establishing a plurality of predetermined potential changes in the connected circuit, electromagnetic means for locking the keys in their actuated position, means at the responsive device responsive to the potential of the connected circuit, and means for operating the electromagnetic means of the controlling device over the connected circuit while the responsive device is operated.

29. In a switching system, a normally inactive controller variably operable in accordance with a plurality of successive digits, a source of current, means for establishing a circuit including said controller with the source bridged across the circuit, a multi-electrode tube having cathode, grid and plate electrodes, means responsive to every actuation of the controller first momentarily to open said bridge and then to connect the grid of the tube with the circuit, means for applying potentials to said grid depending on the operation of the controller, a relay, means for operating said relay controlled by the tube, and a switching device variably operable under the control of said relay.

30. The system according to claim 29, and in which said controller comprises resistances and keys arranged selectively to switch the resistances in the circuit, and means to connect the grid with the circuit irrespective of the speed at which a key is operated.

31. In a switching system, a normally inactive controller variably operable in accordance with a plurality of successive digits, a D. C. source, means for establishing a circuit including said controller with the source bridged across the circuit, a pair of multi-electrode tubes having cathode, grid and plate electrodes, means responsive to every actuation of the controller first momentarily to open said bridge and then to connect the grid of one tube with the circuit, means for applying various potentials to said grid depending on the operation of the controller, a relay, a circuit for operating said relay when the same potentials are applied to the grids of the two tubes, step-by-step means controlled by said relay for applying said various potentials to the grid of the second tube, means actuated by the controller for starting the operation of the step-by-step means, and switching devices variably operable under the control of said relay and step-by-step means.

32. The system according to claim 31, and in which the controller comprises a plurality of different resistances and keys arranged selectively to switch the resistances in the circuit, and means to connect the grid of the first tube with the circuit irrespective of the speed at which the key is operated.

33. The switching system according to claim 29, and means for re-establishing said bridge upon the operation of the switching device.

34. The switching system according to claim 29, a plurality of switching devices, means for associating the relay with one switching device after

the other for variably controlling its operation, and means for re-establishing the bridge upon the operation of a switching device.

35. The switching system according to claim 29, means for associating the relay with one switching device after the other for variably controlling its operation, and means for re-establishing the bridge upon the operation of each switching device.

36. The switching system according to claim 29, means for locking the controller in its actuated position, and means for unlocking the controller and re-establishing the bridge upon the operation of the switching device.

37. The switching system according to claim 29, means for locking the controller in its actuated position, and means for first unlocking the controller and then re-establishing the bridge upon the operation of the switching device.

38. The switching system according to claim 29, and in which said controller comprises keys, means for locking the actuated key and preventing the operation of the other keys, a magnet for controlling the locking means, and means operative upon the operation of the switching device for first operating the magnet and then re-establishing said bridge.

39. The switching system according to claim 29, and in which said controller comprises keys, means for locking the actuated key and preventing the operation of the other keys, a magnet for controlling the locking means, a plurality of switching devices, means for associating the relay with one switching device after the other for variably controlling its operation, and means operative upon the operation of each switching device for first operating the magnet and then re-establishing the bridge.

40. In a switching system, a controller variably operable in accordance with a plurality of successive digits, a source of potentials, a multi-electrode discharge device, means for establishing a connection between said controller and said device, a relay, means for operating said relay when potentials applied to two electrodes of said device bear a predetermined relationship to one-another, means including said connection for applying various potentials to one electrode in accordance with the operation of the controller, means actuated by the controller for applying various potentials to the second electrode, and switching means variably operable under the control of said relay and the last-mentioned means.

41. The system according to claim 40, and means for operating the relay when the same potentials are applied to the two electrodes.

42. In a switching system, a controller operable in accordance with a plurality of successive digits, a source of potentials, a responsive device, means for applying various potentials to the responsive device in accordance with the operation of the controller, step-by-step means for applying various potentials to the responsive device, means for operating the step-by-step means when the controller is actuated, a relay operated when the potentials applied to the responsive device bear a predetermined relation to one-another, and switching devices variably operable under the control of said relay and step-by-step means.

43. The switching system according to claim 42, and means for operating the relay when the two potentials applied to the responsive device are the same.

44. The switching system according to claim 42, and in which the step-by-step means comprises a set of counting relays having contacts for applying said potentials.

45. The switching system according to claim 42 and in which the controller is arranged to apply four different potentials, and the step-by-step means comprises a set of three counting relays, having contacts for applying said four different potentials.

46. In a switching system, a controller variably operable in accordance with a plurality of successive digits, a potential source, a pair of triodes, means for establishing a connection between said controller and said triodes, a relay, means for operating said relay when the potentials applied to the grids of the two triodes bear a predetermined relationship to one-another, means for applying various potentials to the grid of the first triode in accordance with the operation of the controller, step-by-step means controlled by said relay for applying various potentials to the grid of the second triode, means actuated by the controller for starting the operation of the step-by-step means, and a plurality of digit storage devices variably operable under the control of said relay and step-by-step means.

47. In a switching system, a controller comprising a set of keys operable in accordance with a plurality of successive digits, a potential source, a pair of triodes, means for establishing a connection between said controller and said triodes, different resistances selectively switched into the connection depending on the key operated, a relay, means for operating said relay when the same potentials are applied to the grids of the two triodes, means including said resistances for applying various potentials to the grid of the first triode in accordance with the operation of the keys, step-by-step means controlled by said relay for applying said various potentials to the grid of the second triode, means actuated by the controller for starting the operation of the step-by-step means, and a plurality of digit storage devices variably operable under the control of said relay and step-by-step means.

48. In a switching system, a normally inactive controller variably operable in accordance with a plurality of successive digits, a D. C. potential source, a pair of triodes, a relay, means for operating said relay when the same potentials are applied to the grids of the two triodes, means for applying various potentials to the grid of the first triode in accordance with the operation of the controller, means including a set of counting relays controlled by said relay for applying said various potentials to the grid of the second triode, means actuated by the controller for starting the operation of the counting relays, and a plurality of digit storage devices variably operable under the control of said relay and counting relays.

49. In a switching system, a normally inactive controller comprising a set of ten keys operable in accordance with a plurality of successive digits, a D. C. potential source, a pair of triodes, a two-wire circuit connecting the controller with the triodes, a relay, a gas valve for operating said relay when the same potentials are applied to the grids of the two triodes, a plurality of different resistances selectively switched into the circuit by the keys for applying various potentials to the grid of the first triode in accordance with the operation of the keys, means including a set of counting relays controlled by said relay for applying said various potentials to the grid of the

second triode, means actuated by the actuated key for starting the operation of the counting relays, and a plurality of digit storage devices variably operable under the control of said relay and counting relays.

50. The switching system according to claim 49, and in which four resistances may be selectively switched in circuit by the keys, and four counting relays having contacts for applying five different potentials.

51. In a telecommunication system, a plurality of signal-controlling devices, a signal responsive device, a plurality of two-wire circuits, means for connecting a controlling device over one of said circuits with said responsive device, a source of potential common to all the circuits, means including resistances at each controlling device for establishing a plurality of predetermined potential changes in the associated circuit, and means in the responsive device for detecting the potential change.

52. In a telecommunication system, a plurality of signal-controlling devices, a signal responsive device, a plurality of two-wire circuits, means for connecting a controlling device over one of said circuits with said responsive device, a source of D. C. potential common to all the circuits, means including a plurality of resistances at each controlling device for establishing a plurality of predetermined potential changes at the responsive device by changing the resistance of the connected circuit to a predetermined extent, and means in the responsive device for detecting and recording the potential change in the connected circuit.

53. In a telecommunication system, a plurality of signal-controlling devices, a signal responsive device, a plurality of two-wire circuits, means for connecting a controlling device over one of said circuits with said responsive device, a source of D. C. potential common to all the circuits, means including a plurality of keys and a lesser number of resistances at each controlling device for establishing predetermined potential changes in the connected circuit, means in the controlling device for altering the direction of current flow in the connected circuit, and means in the responsive device for detecting the potential and direction of the current in the connected circuit.

54. In a telecommunication system, a plurality of signal controlling devices, a signal responsive device, a plurality of two-wire circuits, means for connecting a controlling device over one of the circuits with said responsive device, a source of D. C. potential common to all the circuits, a plurality of different resistances at each controlling device, variably operable contacts in the controlling devices for varying in a predetermined manner the potentials in the connected circuit, and means in the responsive device responsive to said potentials and to a predetermined range of variations thereof for indicating which contact was actuated.

55. In a telecommunication system, a plurality of signal-controlling devices, a signal responsive device, a plurality of two-wire circuits, means for connecting a controlling device over one of the circuits with said responsive device, a source of D. C. potential common to all the circuits, a compensating resistance for each circuit, four different control resistances at each controlling device, five pairs of keys for establishing five predetermined potentials in the connected circuit, and means at the responsive device responsive to the five potentials in the circuit and to a predetermined range of variations thereof.

56. In a telecommunication system, a plurality of signal-controlling devices, a signal responsive device, a plurality of two-wire circuits, means for connecting a controlling device over one of the circuits with said responsive device, a source of D. C. potential common to all the circuits, a compensating resistance for each circuit, four different control resistances at each controlling device, five pairs of keys for establishing five predetermined potentials in the connected circuit, means at the responsive device responsive to the five potentials in the circuit and to a predetermined range of variations thereof, means in the control device for causing current to flow in the connected circuit in one direction when one key of a pair is operated, and in the opposite direction when the other key of the pair is operated, and means in the responsive device for detecting the direction of current flow in the connected circuit.

57. In a telecommunication system, a controlling device comprising five pairs of keys, a different resistance for each of four pairs, each key having a normal and an actuated position, means for locking a key in the actuated position and preventing the actuation of the other keys, a magnet for unlocking the keys, a rectifier in said controlling device, a responsive device, a two-wire line circuit interconnecting said devices, a telephone transmitter and receiver associated with the controlling device, a normally closed first contact connecting the receiver with the circuit opened upon the actuation of any key, a normally open second contact closed upon the actuation of any key for short-circuiting the transmitter, a third contact normally short-circuiting said resistances, rectifier and magnet, said third contact being opened upon the actuation of any key to a point near its locking position, a weighted fourth contact operated thereupon for momentarily opening the line circuit, normally open fifth contacts, one for each pair of keys, the fifth contacts being in parallel and normally short-circuited by said third contact and connecting the associated resistance in the circuit when either key of the pair is actuated and opens the third

contact, an adjustable resistance connected between the third and fifth contacts, a sixth contact normally connecting one pole of the rectifier to the fourth contact and the other pole to the winding of the magnet, means operated upon the actuation of one key of any pair for actuating the sixth contact to reverse the connection of the rectifier, means in the responsive device for connecting said source in the circuit including the transmitter, the receiver, and the third and fourth contacts, means in the responsive device operated by current flowing over a relatively low resistance path including the magnet, but the latter energizing only when the sixth contact is actuated by a key and reverses the connection of the rectifier, means in the responsive device for reversing the direction of current flow in the circuit, said responsive device comprising an electric discharge device having a plurality of electrodes, a source of direct current, means in the responsive device for applying to one electrode a potential determined by said resistances, counting means in the responsive device for applying to another electrode various potentials in succession, a relay operated when the potentials applied to the two electrodes bear a predetermined relationship to one-another, a low resistance path for the line circuit closed by said relay to allow energization of the magnet, and a variably operable storing device controlled by said relay and counting means.

GERALD DEAKIN.

REFERENCES CITED

35 The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
40 944,537	Bullard	Dec. 28, 1909
1,708,949	Matthies	Apr. 16, 1929
1,761,115	Gardner	June 3, 1930
2,060,184	Dimond	Nov. 10, 1936
2,041,083	Myers	May 19, 1936
45 1,982,290	Gardner	Nov. 27, 1934