

June 5, 1962

O. A. CLARK ETAL

3,038,031

PERMUTATION CODE SELECTING CIRCUIT

Filed Dec. 31, 1957

4 Sheets-Sheet 1

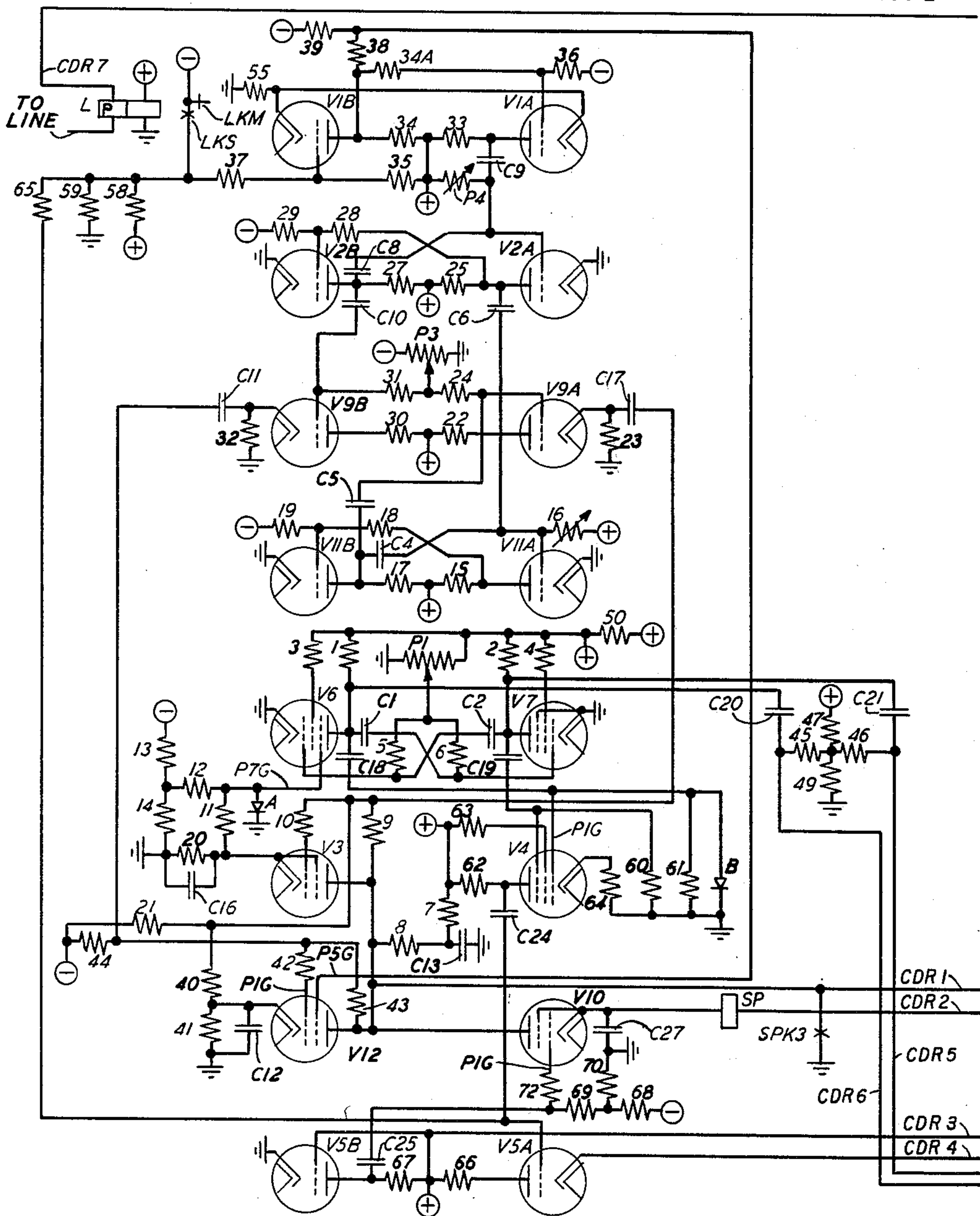


FIG. 1

FIG. 5

FIG. 1	FIG. 2	FIG. 3	FIG. 4
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INVENTORS: O. A. CLARK
J. L. MAXWELL
H. K. THOMPSON

BY *John E. Cassidy*
ATTORNEY

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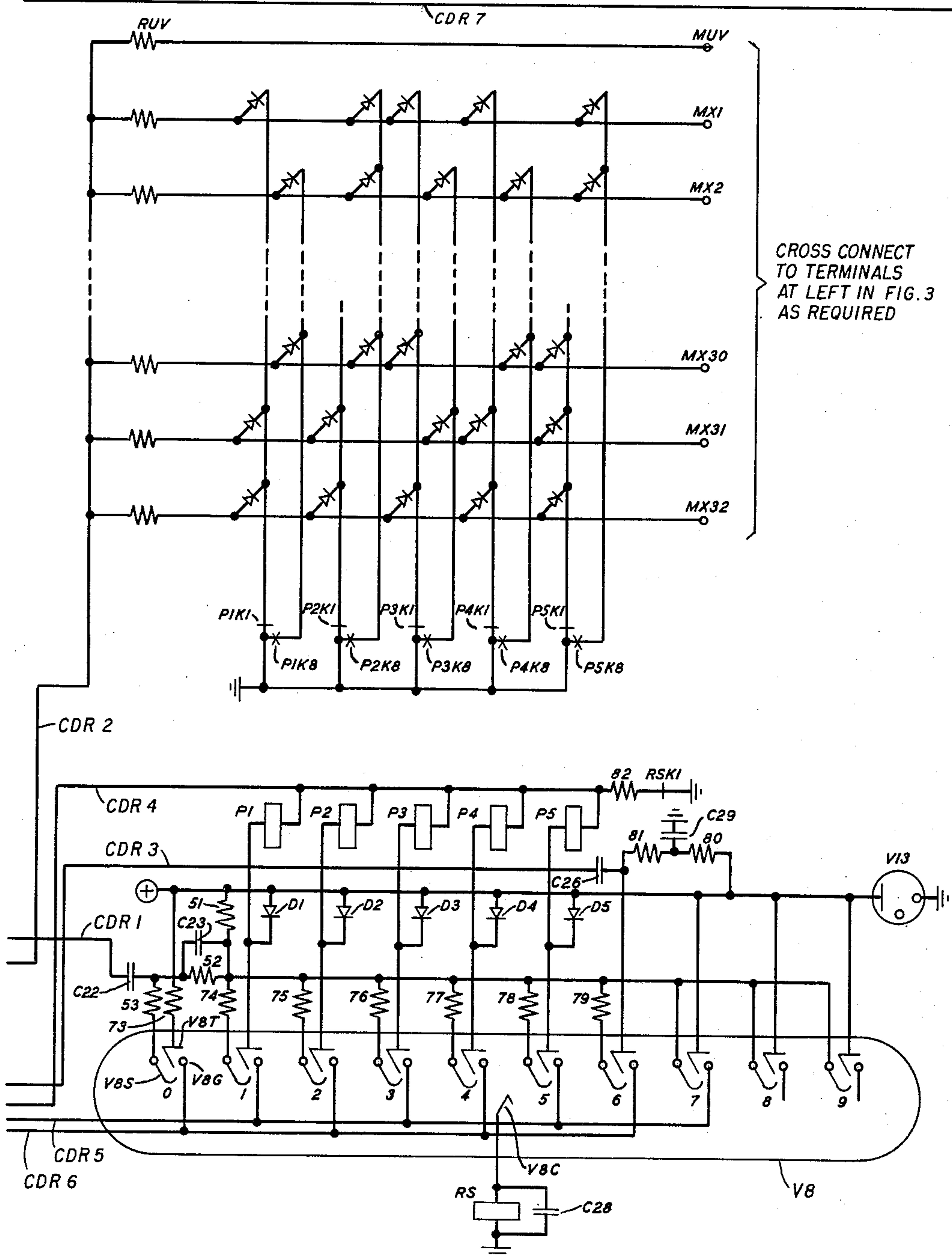
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4 Sheets-Sheet 2



O. A. CLARK
 INVENTORS: J. L. MAXWELL
 H. K. THOMPSON
 BY *John E. Canidy*
 ATTORNEY

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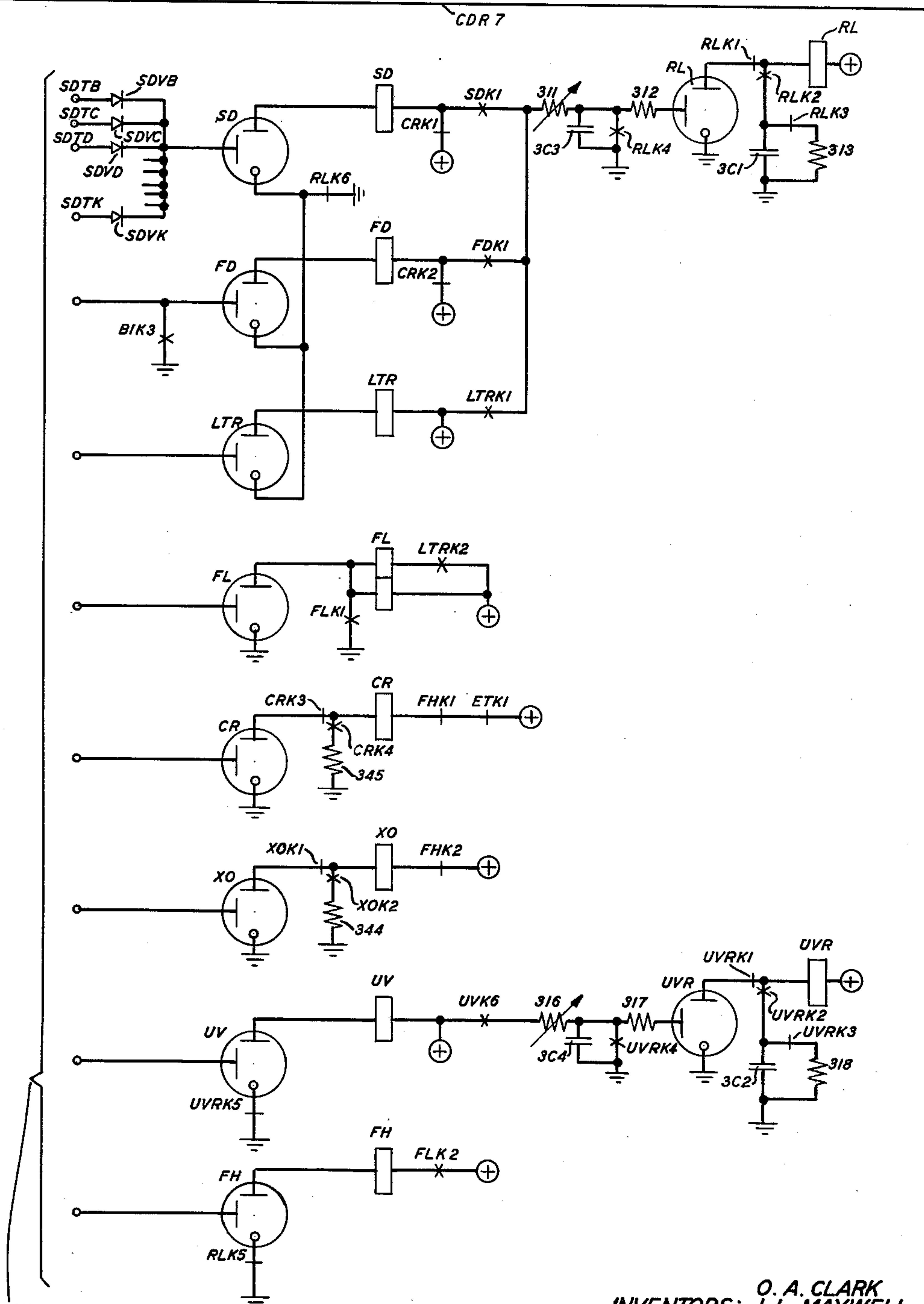
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CROSS CONNECT
TO TERMINALS
AT RIGHT IN FIG. 2
AS REQUIRED

FIG. 3

O. A. CLARK
INVENTORS: J. L. MAXWELL
H. K. THOMPSON

BY *John E. Cassidy*
ATTORNEY

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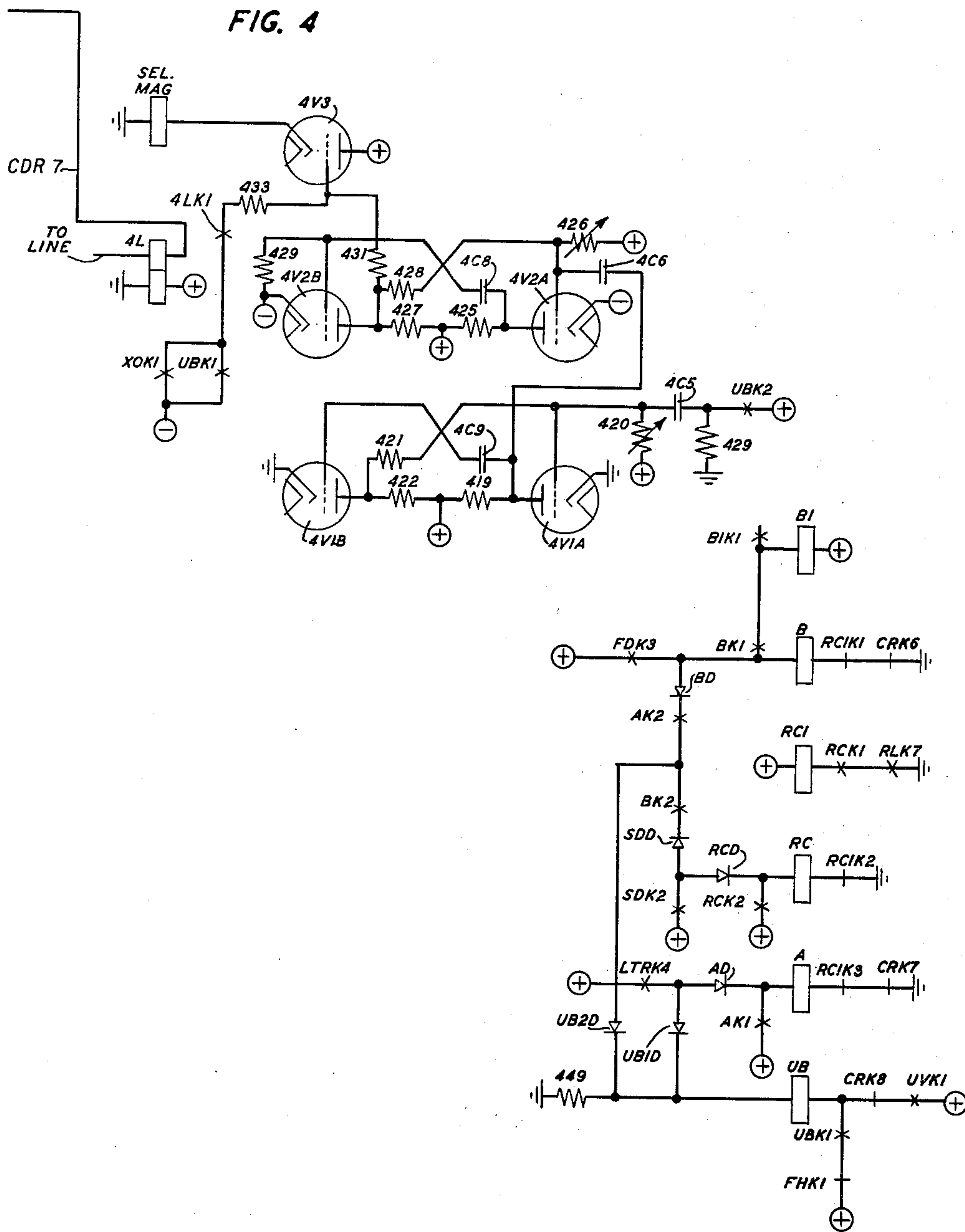
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4 Sheets-Sheet 4



O. A. CLARK
 INVENTORS: J. L. MAXWELL
 H. K. THOMPSON
 BY *John E. Cassidy*
 ATTORNEY

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3,038,031

PERMUTATION CODE SELECTING CIRCUIT

Orville A. Clark, San Francisco, John L. Maxwell, Redwood City, and Harold K. Thompson, Inverness, Calif., assignors to American Telephone and Telegraph Company, a corporation of New York

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6 Claims. (Cl. 178—53.1)

This invention is an improved selector circuit for effecting selections in response to multielement, two-condition, permutation code signal combinations and particularly to multielement, two-condition, start-stop, permutation code signal combinations.

An object of the invention is the improvement of selector circuits which are controlled by permutation code signal combinations.

One improvement consists in a reduction of the expense required to maintain the selector circuit by reducing the number of magnetic relays required in the basic selector portion of the circuit. Coadjunctive with this is an improvement in the reliability of the circuit through minimizing the number of relay contacts required in the basic selector, which relay contacts are perhaps the most frequent cause of circuit failure.

A feature of the invention is an improved selecting arrangement comprising a matrix of varistors through which individual paths are establishable in response to control by permutation code signals.

Another feature of the invention is an arrangement for establishing an ultimate selection incident to prior selections in response to a succession of permutation code signals.

Another feature of the invention is an arrangement for intercepting erroneously directed messages.

The present selector circuit may be employed in telemetering systems, in communication systems, such as in telephone or telegraph switching systems, particularly in teletypewriter switching systems and in other systems.

The invention may be understood from a consideration of the following description when read with reference to the associated drawings which taken together disclose a preferred embodiment in which the invention is incorporated. It is to be understood, however, that the invention may be incorporated in other embodiments which will be suggested to those skilled in the art by the present disclosure.

In the drawings:

FIGS. 1, 2, 3 and 4 taken together and arranged as in FIG. 5 show the selector circuit of the present invention.

In the following description the values of constants cited are by way of example as an aid in understanding the invention and are not to be considered as limitations.

In the present embodiment the circuit is arranged to be controlled by multielement, two-condition, start-stop, permutation code signal combinations. In such combinations the first or start signal is always a spacing signal. It is followed by five intelligence-determining signals, each of which may be either marking or spacing and then by the stop signal which is always a marking signal. All signals are of the same duration except the stop signal which is 40 percent longer than the others.

Relay contacts on the drawings are shown in accordance with the detached contact convention. The relay contacts are separated from the relay winding. The relay winding is identified by a symbol or symbols, A, for instance. Contacts on relay A are identified by the symbol for the winding, followed by the letter "K," for contact, and then a numeral or a letter. Thus, a contact on relay A may be identified as the AK1 contact. A contact which is normally closed is designated by a short line, about $\frac{3}{16}$ inch long, at right angles to the circuit path. A normally open con-

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tact is designated by two crossed lines forming an X in the circuit path.

Refer now to FIGS. 1, 2, 3 and 4 arranged as in FIG. 5. Conductors CDR1, CDR2, CDR3, CDR4, CDR5 and CDR6 which extend between FIG. 1 and FIG. 2 are correspondingly designated in each figure. The incoming line L extends through the left-hand winding of relay L in FIG. 1 and then continues through conductor CDR7 in FIGS. 2, 3 and 4 and the top winding of relay 4L in FIG. 4.

The present selector circuit employs a beam switching tube as an electronic distributor. The 6700 Burroughs magnetron beam switching tube is suitable for this purpose. This tube which is identified as tube V8 in the lower portion of FIG. 2 on the drawings consists of ten identical arrays of spades, targets and grids symmetrically located around the central cathode. These ten sets are designated 0 through 9 in tube V8. Each of the sets comprises a spade such as V8S, a target such as V8T and a grid such as V8G. The single common cathode is designated V8C. An axial magnetic field is applied by a cylindrical permanent magnet not shown, cemented to the outside of the glass envelope. The tube is sometimes referred to as a trochotron. The spades form and sustain the electron beam, the targets produce a pentode-like output current and the grids switch the beam from array to array. Cathode current does not flow immediately when power is turned on. As soon as the potential of a spade is reduced to about that of the cathode, a beam forms from the cathode to the spade and the corresponding target. The current to the target can be used to perform various functions. By suitable choice of spade load resistors, bistable operation can be obtained. If a spade load resistor is smaller than a critical value a beam to that spade will extinguish after a short time (of the order of tens of microseconds). Use is made of this property at spade 6. The beam is switched to this spade at each stop pulse. The load resistor 79 on spade 6 is too low to sustain the beam. This clears the tube at the end of each signal combination.

The line relay L, shown in the upper portion of FIG. 1, is a receiving relay for the selector circuit. It has a line winding and a biasing winding. The line winding is connected in series with the line which extends to a central station. The circuit through the line winding is closed during the idle condition, during the reception of a marking signal element among the intelligence-determining elements and during the stop signal element. It is open during the reception of the start signal element of each combination, which is always a spacing signal element, and during the reception of spacing signal elements among the intelligence-determining elements. Current flows continuously through the biasing winding of relay L and is in such direction that its effect tends to close spacing contact LKS. The effect of the current in the line winding when current flows therein is dominant over the effect of current in the biasing winding and contact LKM is closed at such times and contact LKS open. When no current flows in the line winding the effect of the biasing current closes contact LKS.

It will be assumed that the line to the distant station is closed and idle. For this condition, relays SP in FIG. 1 and RS in FIG. 2 will be released, contact RSK1 will be closed, and polar relays P1, P2, P3, P4 and P5 in FIG. 2 will be operated to close their respective contacts P1K1, P2K1, P3K1, P4K1 and P5K1, shown above these relays in FIG. 2. Tubes V1B, V2A and V11A will be conducting. Tubes V1A, V2B, V11B, V9A and V9B will be non-conducting. Tubes V6 and V7 comprise an astable multivibrator. The multivibrator provides a driving source for switching the beam in tube V8. It also supplies gating pulses through tubes V4 and V5A and V5B to the

targets of tube V8 for energizing relays P1 through P5. Normally tube V6 is cut off due to negative potential supplied over a path extending from the negative source through resistors 13 and 12 to the pin 7 grid P7G of tube V6. Tubes V3, V10 and V12 are miniature thyra-

trons and share common anode resistors 7 and 8. The function of these resistors will be explained hereinafter. Upon receipt of a start pulse from the line, relay L will close its spacing contact LKS. This connects a negative potential source through contact LKS and resistor 37 to the grid of tube V1B. This negative potential abruptly cuts off tube V1B. As a result:

- (a) The anode of tube V1B goes more positive.
- (b) Tube V1A conducts and its anode voltage goes more negative.
- (c) The pin 5 grid P5G of tube V12 goes more positive.

However, tube V12 does not conduct at this time but it is primed so that it will fire when a positive pulse is applied to its pin 1 grid P1G. The sudden sharp drop of the positive potential of the anode of tube V1A results in a narrow negative pulse on the grid of tube V2A due to the differentiating action of grid variable resistor P4 and the coupling capacitor C9. Tubes V2A and V2B are connected as a monostable multivibrator whose relaxation period is adjustable by means of variable resistor P4. The leading edge of the differentiated pulse reduces the grid potential of tube V2A sufficiently to cause this tube to cut off. Tube V2B then conducts. Tube V2B continues to conduct for a period depending upon the setting of variable resistor P4. At the end of this period tube V2B cuts off and tube V2A conducts. Variable resistor P4 is set so that the time from the instant of triggering, that is, from the time of the closing of the spacing contact LKS of relay L, is equal to one-half of the duration of a normal start pulse. When the circuit is arranged for operation at a speed of 75 words per minute, each of the signal elements except the stop pulse is 17.6 milliseconds in duration. Thus, tube V2B cuts off 8.8 milliseconds after the start of the start signal interval. When tube V2A and tube V2B return to normal, that is, with tube V2A conducting and tube V2B cut off, the potential at the anode of tube V2B suddenly rises sharply in a positive direction. Capacitor C10 and resistor 31 differentiate the resulting positive square pulse. The resulting sharp positive pulse appears at the cathode of tube V9B. This pulse is applied to the pin 1 grid P1G of tube V12 through capacitor C11 and resistor 42. The pin 1 grid P1G of tube V12 is normally biased negatively. The positive pulse from the cathode of tube V9B is sufficient to raise the potential of pin 1 grid P1G of tube V12 to about 0 volts. If the pin 5 grid P5G of tube V12 is still at 0 volts, which will be its condition in the event of the reception of a legitimate start pulse, as a result of which spacing contact LKS of relay L would remain closed, tube V12 will fire. When tube V12 fires the following occurs:

- (a) A small drop in potential appears across tube V12.
- (b) A relatively large current flows from the positive potential source through resistors 7 and 8, tube V12 and capacitor C12 to ground.
- (c) The potential of the anode of tube V12 drops very sharply. This drop may be from 225 volts to 10 volts, for instance.
- (d) Capacitor C12 charges. This potential may rise to 60 volts in about 300 microseconds, for instance. This voltage appears on the cathode of tube V12. As a result of this, the potential of the anode of tube V12 will rise to 70 volts, for instance.
- (e) The potential of the anode of tube V12 remains at 70 volts, for instance, as long as tube V12 conducts. When the potential of the anode of tube V12 suddenly drops to 10 volts, for instance, the resulting negative pulse is coupled through capacitor C22 in FIG. 2 to the junction of resistors 52 and 53 and capacitor C23. This large negative pulse through resistor 53 causes the po-

tential of spade V8S of the 0 array in tube V8 to drop to about zero. This pulse through resistor 52 and capacitor C23 also causes the potential of spades of arrays 1 through 9 in tube V8 to fall to zero. The action of capacitor C23 is to delay the recovery of the potential of spade V8S of the 0 array toward the positive potential supply, which is supplied through resistor 51, compared to the potential of the other spades. This insures that the electron beam will be directed to spade 0 and to no other spade.

The electron beam having been formed and locked to spade 0, now supplies a current which may be about 1 milliamperes, for instance, from spade to cathode, plus a current, which may be about 6 milliamperes, for instance, from target V8T of the 0 array to the cathode in tube V8. These two currents flow from the common cathode V8C of tube V8 through the winding of relay RS to ground operating relay RS, thus closing contact RSK1.

It was stated in the foregoing that at the end of the timing interval of the monostable multivibrator, comprising tubes V2A and V2B, conduction would start in tube V2A. The lowered potential of the anode of tube V2A due to the drop in resistor 25 results in a negative square wave which is differentiated by capacitor C6 and variable resistor 16 producing a negative pulse at the grid of tube V11A.

Tubes V11A and V11B form a second monostable multivibrator. The negative pulse on the grid of tube V11A triggers this vibrator. Its period is dependent upon the setting of variable resistor 16. Variable resistor 16 is set to make the complete cycle of the multivibrator equal to the duration of each signal element of the start-stop combination except that of the longer stop element. Assuming operation at the rate of 75 words per minute, this interval is 17.6 milliseconds. The total elapsed time from the triggering of the multivibrator comprising tubes V2A and V2B to the end of the cycle of the multivibrator tubes V11A and V11B will be equal to one and one-half normal signal elements of a combination. By adjustment of variable resistor 16, the end of the cycle of the multivibrator tubes V11A and V11B can be centered in the No. 1 intelligence-determining pulse of the combination being received.

In a manner similar to that described in the foregoing for the combination of tubes V2A, V2B, V9B and V12, the positive pulse developed at the cathode of tube V9A applied through capacitor C17 raises the normally negative potential of the control grid of tube V3 above the critical potential and fires tube V3.

When tube V3 fires, the following occur:

- (a) A heavy initial current flows from the positive potential supply through resistors R7 and R8, tube V3 and capacitor C16 to ground.
- (b) Due to the current still being drawn through resistors R7 and R8 by tube V12, the initial potential applied to the anode of tube V3 will be 70 volts, for instance.
- (c) Because of the 10-volt drop assumed across the tube V3 and because for a moment the cathode of tube V3 appears as though directly grounded through capacitor C16, the potential of the anode of tubes V3 and V12 falls suddenly to 10 volts, for instance.
- (d) As the potential of the anode of tube V12 approaches and goes below the 60-volt potential assumed at the cathode of tube V12, tube V12 cuts off.

Tube V3 continues to conduct and as capacitor C16 charges, the voltage at the cathode of tube V3 rises. In a short time the voltage of the cathode stabilizes at 65 volts and that of the anode at 75 volts. When the potential of the cathode of tube V3 rises sufficiently to swing the potential of the pin 7 suppressor grid P7G of tube V6 from its normal negative potential to near ground, tube V6 suddenly conducts and tube V7 cuts off. Pin P7G of tube V6 is clamped to ground by varistor A to prevent its going positive.

As previously stated, tubes V6 and V7 comprise an astable symmetrical multivibrator which will run free whenever the suppressor grid of tube V6 is near ground potential. Accordingly, this multivibrator produces a square wave output voltage at the anode of each of tubes V6 and V7, the frequency of which may be varied by adjusting potentiometer P1. The square wave output voltage appearing at the anodes of tubes V6 and V7 is coupled through differentiating networks comprising capacitor C18 and resistor 61 and capacitor C19 and resistor 60 to separate control grids of buffer tube V4. Differentiation of the negative-going edge of this square wave creates a negative pulse which is used to reduce the potential of the grids of tube V4 to below cutoff. Tube V4 normally conducts but when the potential of either grid is reduced below cutoff the tube cuts off and its anode potential rises creating a positive square pulse at the anode of tube V4. This pulse is of about 1 millisecond duration. This positive pulse is used to gate tube V5A.

Besides furnishing negative pulses to buffer tube V4 the multivibrator comprising tubes V6 and V7 also supplies negative driving pulses to the grids of beam tube V8. These pulses are directed through capacitors C20 and C21 to the even grids and the odd grids, respectively. Therefore, a driving pulse is received alternately first by the even grids and then by the odd grids as long as this multivibrator runs.

After the beginning of a start signal, at the end of the total periods of the monostable multivibrator tubes V2A and V2B and monostable multivibrator tubes V11A and V11B, the multivibrator comprising tubes V6 and V7 will apply simultaneous negative pulses to the pin 1 control grid P1G of tube V4 and to the even grids of tube V8. This action will cause the electron beam in tube V8 switch from array 0 to array 1 in tube V8 at the center of the first intelligence-determining signal following the start pulse. Subsequently, the beam will switch to arrays 2, 3, 4 and 5 at the center of each of the succeeding character-determining signal elements of the combination. The transfer from array 5 to array 6 will occur after the lapse of a normal signal element. This will be somewhat in advance of the center of the stop pulse which is 1.42 times the duration of the other pulses of the combination. Due to the gating action of tube V4 a 1-millisecond positive pulse will appear at the grid of gate tube V5A at the same time that the beam forms to each successive array in tube V8.

Relays P1, P2, P3, P4 and P5 are polar relays. The armatures of each is actuated between two opposed contacts engaging one or the other depending upon the direction of current through its winding. When the actuating current ceases flowing the armature of the relay remains in engagement with the contact to which it has been actuated. At the end of reception of the stop signal element, relay RS, connected to the common anode V8C of tube V8, releases as a result of the extinguishing of the electron beam in tube V8. This resets relays P1, P2, P3, P4 and P5 to their normal condition in which contacts P1K1, P2K1, P3K1, P4K1 and P5K1 are closed. The path for this may be traced from ground through contact RSK1, resistor 82, windings of relays P1, P2, P3, P4 and P5 and diodes D1, D2, D3, D4 and D5, respectively, in parallel, to a source of positive potential.

Tube V5A is an AND gate. It will allow current to flow from a positive source through resistor 66, tube 5A and from its cathode through any one of relays P1 through P5 and its respective target connection if the electron beam is directed to the corresponding array connected to the relay and if relay L is in the marking condition. If relay L is in the spacing condition no current will flow through tube V5A nor through any of relays P1 through P5 even though a positive pulse exists at the grid of tube V5A. This is because of the large negative voltage supplied by relay L through its spacing contact LKS and

resistor 65 to the grid of tube V5A. If relay L is in the spacing condition, current will flow from a positive source of potential through diodes D1 through D5 associated with the target to which the beam is formed. This permits enough current through the winding of relay RS to hold it operated even though no current flows through the gate tube V5A.

Attention is called to the fact that relay RS operated at the time the beam was directed to the 0 array. This opened contact RSK1 and the path from ground through contact RSK1, resistor 82 and the windings of all of relays P1 through P5 and diodes D1 through D5 in parallel to the positive potential source.

It will be assumed that the combination being received is the figures shift combination which is Mark-Mark-Space-Mark-Mark. The selecting path corresponding to this extends through the matrix to terminal MX31 in FIG. 2. After the start pulse is received and the beam is directed to the 0 array, relay L will gate tube V5A to the On condition for pulses 1 and 2, to the Off condition for pulse 3 and to the On condition for pulses 4 and 5. As a result of this, the armatures of all relays P- except that of relay P3 are operated to close their contacts corresponding to contact P1K8 of relay P1. Contact P3K1 of relay P3 is closed. No shunting path to ground is connected to the figures shift path. Relays P1, P2, P4 and P5 which close contacts P1K8, P2K8, P4K8 and P5K8 do so due to the effect of one millisecond current pulses occurring at the time of reception of the centers of the corresponding incoming teletypewriter signal elements. Since the stop pulse is 1.42 times as long as the other unit pulses and the output pulses from the astable multivibrator are equally spaced, the sixth pulse from the multivibrator will occur at a time earlier than the time of reception of the center of the stop pulse. This leaves an interval equal in duration to about two-thirds of the duration of the stop pulse to perform all of the functions required before the start of reception of the next combination.

Due to the smaller magnitude of spade resistor 79, when the beam switches to array 6 it will be extinguished. Target current, therefore, is drawn through resistors 80 and 81 only until the beam switches and clears. The unused spades and targets, Nos. 7, 8 and 9, are connected to prevent false switching to them. When current flows through target 6 and resistor 79, the target voltage falls producing a sharp negative pulse at the grid of tube V5B through capacitor C26. This produces an inverted and amplified pulse at the anode of tube V5B. This pulse is coupled to the pin 1 grid P1G of tube V10 through capacitor C25 and resistor 72 which causes tube V10 to fire resulting in the following:

(a) A heavy surge of current flows through tube V10 and capacitor C27 connected in its cathode circuit. This negative surge is impressed from the anode of tube V10 through resistors 9 and 10 on the grid of tube V3 causing tube V3 to cut off.

(b) As capacitor C27 charges, a current flows through the winding of relay SP, FIG. 1, in series with the parallel combination of resistors and varistors of the matrix. The potential of the selected output lead, that is, the lead which is not grounded through any varistor, and the contacts of any relay P- will rise to about 85 volts, for instance. The right-hand terminals MX1, MX2, MX3 . . . MX32 of the matrix will be connected individually to the control anode of one of the cold cathode tubes such as SD, FD, LTR, FL, CR, XO, UV, FH and others, not shown. The starter gap of the individual tube will ionize. Transfer to the main gap will occur within a few milliseconds thus energizing the winding of the selector relay connected between the main anode and a source of positive battery which may be 130 volts, for instance. These relays are SD, FD, LTR, FL, CR, XO, UV and FH, respectively, and others not shown. Certain of these relays are arranged so that they first close

locking circuits for themselves and then open the paths to the main anodes of their respective cold cathode tubes. Others are arranged so that they trigger another cold cathode tube through a timing circuit and operate a second relay in the output circuit of the second tube. This second relay is provided with a locking arrangement for itself and means for extinguishing the second tube. Thus, storage is provided for the selecting circuit through the matrix. The selected relays may fully operate after a new receiving cycle is initiated.

(c) At the instant tube V3 was cut off as described in the foregoing, the pin 7 grid P7G of tube V6 swings negative holding tube V6 cut off. This prevents any further output pulses until the next starting pulse is received.

(d) A short time after the selected cold cathode tube has fired, relay SP will operate. This closes contact SPK3 which grounds the anode of tube V10, extinguishing tube V10. When tube V10 is extinguished relay SP releases. Tube V10 will not re-fire because of negative potential on the pin 1 grid P1G of tube V10.

When the beam in tube V8 clears as described in the foregoing, relay RS starts to release. Contact RSK1 of relay RS will not close, however, until after the cold cathode tube selected through the matrix has fired. When fully released, contact RSK1 connects ground through resistor 82 to the common side of the windings of relays P1 through P5 causing them to be reset. This prepares them to register the next code combination. A current of approximately two milliamperes, for instance, will continue to flow through each relay P- until relay RS operates on receipt of the start pulse of the next combination. The release of the operated external selector relays is controlled by external circuitry. For each successive combination the action is as described for the complete cycle of operation of the circuits as described in the foregoing.

When the present selector circuit is employed to select a teletypewriter station in an automatic switching system a circuit such as the one described herein would be connected to each line of the system. Each selector circuit would scan all teletypewriter combinations on its own line to determine whether a connection to another line should be made. Also, each group of call directing characters would be checked for validity. If a non-valid code is received, the present circuit is arranged to intercept the message following the code directing characters to prevent the message from being lost or misdirected.

It is emphasized that the present selector may be employed in other types of service, such as in telemeter service and in remote control service. Code combinations in such service could be interpreted and used to control such functions as positioning valves, regulating speeds of electric motors or generators and connecting encoding devices to the line to return code combinations defining any information stored at a called station, such as temperature, pressure, the level of gauges, etc.

The manner in which the present selector operates in teletypewriter service to effectively connect a station to a line in response to the reception of valid code combinations of call directing characters and to intercept a message in response to the reception of invalid code combinations of call directing characters will now be described.

It will be assumed that the electronic selector portion of the circuit is reading all line signals. In response to each received combination some one of the cold cathode tubes connected to the diode matrix will fire thus initiating the desired action.

A message format must be rigidly adhered to in the application of the selector to be now described to provide means of intercepting messages having invalid combinations of code directing characters. A properly addressed message will always be preceded by several combinations defining what is termed Letters Shift in teletypewriter code. When applied to a teletypewriter in a

well-known system such a combination adjusts the teletypewriter to print what follows in the lower case. In this instance, however, these combinations are being employed in a teletypewriter station selecting and intercept circuit as the preliminary part of a sequence of combinations which includes call directing characters which latter may be valid or invalid.

Following these Letters Shift combinations will be the first of two call directing characters. For a station on a given line, the first combination of the two combinations required to identify the station will always be the same character such as A, for instance, identifying a station as being on line A. Next follows the second of the two call directing characters which may be any character of a group assigned to the given line as combinations for valid station calls such as B, C, E, G, I, K, etc. All other unassigned codes would be treated as non-valid and if received would control the present circuit in such manner that the message headed by the non-valid code would be directed to a position called in intercepting position where it would be recorded on tape by a perforating machine or on a page by a teletypewriter receiver.

It is pointed out that, in the system presently being described, the same message may be directed to a number of receiving stations simultaneously. One or more of the stations to which the same message is directed may be connected to the same lines and one or more may be on another line or lines.

Certain of the symbols used to identify certain of the functions individual to combinations employed in the present system are shown in the following table.

Function	Printed Symbol
Letters Shift.....	↓
Figures Shift.....	↑
Carriage Return...	<
Line Feed.....	≡

The notation corresponding to the appearance of an encoded message directed to three stations on line A, the stations being B, C and E, is as follows

↓↓↓AB↓AC↓AE↓<≡

This is followed immediately by the text of the message. Immediately after the message the symbols ↑H appear. The first four symbols ↓ appearing at the head of the symbol train represent four successive combinations for Letters Shift. This is followed by AB representing line A, station B. Then comes another symbol ↓ representing Letters Shift. This is employed to separate each station designation from the following station designation. Then there appears AC representing line A, station C, then another ↓, then AE representing line A, station E, then the Letters Shift symbol ↓ once more, preceding < for Carriage Return and then ≡ for Line Feed. Now comes the text of the message. Immediately thereafter the symbol ↑ for Figures Shift appears and finally H which is the last symbol of a train. The reception of the code signal combination Figures Shift, H or ↑ at the end of the message controls the present circuit to effect the disconnection of the present selector circuit from the line.

If a station on line A wants to send a message to several stations on its own line and to several stations on lines B and C, a cross office code combination, such as the code combination for R, would be inserted in the tape, directly after the Letters Shift combination, following the last call directing characters (CDC's) for other stations on line A, to which the same message is directed. The present circuit connects to a so-called Cut-On and Intercept position. At this position there is assumed to be located a reperforator-transmitter having a selector magnet. This selector magnet is shown connected to the cathode of tube 4V3 in FIG. 4. Both the

Cut-On and Intercept functions are accomplished by applying proper voltages to the control grid of tube 4V3. The cathode current of this tube flows through the winding of the selector magnet of the reperforator-transmitter. Normally, tube 4V3 conducts holding the selector magnet of the reperforator-transmitter energized and operated. This corresponds to the line closed condition. whenever the grid of tube 4V3 is driven sufficiently negative, current flow in the cathode circuit ceases, deenergizing and releasing the selector magnet. This is equivalent to the line open condition. The selector magnets of the reperforator-transmitter follow the signals on the grid of tube 4V3 and punch and print the tape in accordance with these signals.

Perhaps the best way to understand how the Cut-On and Intercept portions of the circuit function is to use a typical message format and follow the operation of the circuit in sequence, step-by-step. It will be assumed that station A on line A has just been polled for traffic to transmit. All relays in this circuit are released. It will be assumed that the transmitter at station A has a tape perforated with call directing characters and a message text to be transmitted. The message is to be sent to stations B and C on line A, to stations C and D on line B and to stations C and L on line F. Remembering that an R is employed, following the call directing characters of the station on line A to introduce the call directing character of the first station on another line, it will be understood from the foregoing that the perforations in the tape are identified by the symbols

↓↓↓AB↓AC↓RBC↓BD↓FC↓FL↓<≡Text of message ↑H.

It was explained in the foregoing that each incoming signal combination is impressed on line relay L, shown in FIG. 1. To anticipate, each incoming signal combination is impressed also on auxiliary line relay 4L in FIG. 4 and contact 4KL1 in FIG. 4 closes in response to each spacing signal condition. Each valid combination actuates relays P1 through P5 to effect a selection by establishing an effective individual closed path through the resistors and diodes in the selecting matrix, which is shown in FIG. 2. Dependent on which path is selected some one of the vertical array of cold cathode tubes shown at the left in FIG. 3 is activated and a relay individual to the tube is operated. In addition to the foregoing in order to perform the Cut-On and Intercept functions the incoming signal combinations actuate the relay designated 4L in FIG. 4. When no current flows in the upper or line winding of relay 4L, the effect of current in its biasing winding closes contact 4LK1.

The circuit shown in the upper portion of FIG. 4, which is responsive to relay 4L, is primarily responsible for the control of the Cut-On and Intercept functions. Tube 4V3 is arranged under certain conditions to follow the signals of relay 4L. Normally, these signals have no effect on tube 4V3 since relay XO, the winding of which is shown in the lower middle portion of FIG. 3, and relay UB, the winding of which is shown in the lower right-hand portion of FIG. 4, are both normal and contacts XOK1 and UBK1, shown in the upper left-hand portion of FIG. 4, in the input circuit of tube 4V3 are both open.

In response to the reception of a Letters Shift combination, a selecting path will be established through a particular one of the matrix selecting circuits to some one of the terminals of the group MX1 through MX32. This particular terminal will be connected to the starting anode of the letters cold cathode tube LTR in FIG. 3. As a result:

(a) Tube LTR will fire. It is to be understood that when any one of the selecting paths through the matrix is established in response to the reception of a particular combination, positive battery is supplied through resistors 7 and 8, in FIG. 1, tube V10, winding of relay SP, conductor CDR2, which extends from FIG. 1 into FIG.

2, and then through the established path through the matrix and some one of terminals MX1 through MX32 to the starting anode of some one of the cold cathode tubes in the vertical array at the left in FIG. 3, across the tube to its cathode and to ground. In certain cases the ground on the cathode is direct, in other cases the ground extends through a contact of some relay depending upon the individual circuit. In the case of the letters cold cathode tube LTR, the circuit extends from the cathode of tube LTR through contact RLK6 to ground. In the designation RLK6, and in corresponding designations of relay contacts herein the symbols preceding the K correspond to the designation of the relay with which the contact is associated. The numeral following the K identifies a particular contact on the relay.

(b) Dry reed relay LTR will operate from positive battery through the winding of relay LTR, main anode of tube LTR, cathode of tube LTR and contact RLK6 to ground. This circuit through the main anode of tube LTR will replace the circuit previously traced through the starting anode of the tube.

(c) The operation of relay LTR establishes a circuit from battery in the lower portion of FIG. 4 through contact LTRK4, varistor AD, winding of relay A, contact RC1K3 and contact CRK7 to ground, operating relay A. When relay A operates, it locks from battery through contact AK1, the winding of relay A, contact RC1K3 and contact CRK7 to ground. Varistor AD blocks the path from positive battery through contact AK1 from passing back through other portions of the circuit, thus preventing the establishment of sneak paths.

(d) The operation of relay LTR applies positive battery through contact LTRK1 and variable resistor 311 to the junction of capacitor 3C3 and resistor 312 which connects to the starting anode of cold cathode tube RL. This initiates a timing interval which is introduced prior to the activation of tube RL.

(e) The operation of relay LTR applies positive battery by way of contact LTRK4 and varistor UB1D, in the lower portion of FIG. 4, to the junction of the winding of relay UB, varistor UB2D and resistor 449.

Each time a signal combination is received and simultaneously with the establishment of a corresponding selecting path through the matrix, a path is established through resistor RUV shown at the top in FIG. 2 to terminal MUV, which is cross-connected to the starter anode of tube UV in FIG. 3. Tube UV will fire under control of contact UVRK5. In response to this, relay UV will operate. It is particularly pointed out that tube UV will fire and relay UV will operate in response to the reception of every permutation code combination received by the present selector. The operation of relay UV closes positive battery through contacts UVK1 and CRK8 in the lower right-hand portion of FIG. 4 to the right-hand terminal of the winding of relay UB. The operation of relay UV also established a circuit from positive battery in the lower portion of FIG. 3 through contact UVK6 and variable resistor 316 to the junction of capacitor 3C4 and resistor 317 which connects to the starting anode of cold cathode tube UVR. Variable resistor 316 and capacitor 3C4 constitute a timing circuit which introduces an interval before tube UVR fires. This timing circuit is adjusted so that it measures an interval equal to that introduced by the timing circuit comprising resistor 311 and capacitor 3C3 before the operation of relay RL. It will be observed that both of these intervals were started at the same instant and tubes RL and UVR will therefore fire at the same instant. Variable resistors 311 and 316 may be adjusted as necessary to insure this. This timing interval may be approximately 50 milliseconds, for instance. Since both tubes LTR and UV were triggered on simultaneously, relay UB cannot operate since positive battery is connected to both sides of its winding simultaneously, as a result of the operation of relays LTR and UV simultaneously.

During this timing interval, relays LTR and UV will still be operated because tubes LTR and UV have not yet been extinguished. About 1 millisecond after tubes RL and UVR fire, relays RL and UVR will have operated. The operation of relay RL by opening its contact RLK1, through which positive battery is supplied to the main anode of tube, RL, extinguishes tube RL. Correspondingly, the opening of contact UVRK1 extinguishes tube UVR. The operation of relay RL closed a holding path for this relay through contact RLK2 and capacitor 3C1 and resistor 313 in parallel to ground. The operation of relay UVR established a holding path through contact UVRK2 and capacitor 3C2 and resistor 318 in parallel to ground. Capacitors 3C1 and 3C2 allow increased current to flow during their charging intervals through the windings of their respective connected relays. This makes relay RL and UVR more positive in their action to insure that tubes RL and UVR will both extinguish. Since the operating path for relay LTR is through tube LTR and contact RLK6 of relay RL, the operation of relay RL releases relay LTR and extinguishes tube LTR. Similarly, the operation of relay UVR by opening its contact UVRK5 releases relay UV and extinguishes tube UV. As a result of the foregoing, it should be apparent that the operated contacts of relays LTR and UV remain closed for the same interval, which may be about 50 milliseconds, for instance.

If the message format had not been corrected, some combination other than that for Letters Shift would have been received. In that case, relay UV would have operated, since it operates in response to the reception of every combination, but relay LTR would not have operated. Relay UB would have operated. Reference to the circuit in the upper portion of FIG. 4 indicates that a normally open contact UBK1 on relay UB is connected in the input circuit of tube 4V3. When this contact is closed, and contact 4LK1 is also closed in response to a spacing signal received by relay 4L, tube 4V3 which normally is conducting, will be cut off. As a result of this, as will be clear hereinafter, the following message would be perforated in a tape by a reperforator-transmitter associated with the line on which the station sending the incorrect format is located.

When relay LTR operated it caused relay A to operate and lock as described. Varistor AD prevents positive battery through contact AK1 of the operated relay A from falsely shunting relay UB when relay UV operates on receipt of the next character. The operation of relay A prepares a path through contact FDK3 so that the first digit relay FD, that is, the relay which is operated in response to the first of the received call directing characters, can apply battery by way of varistor UB2D again preventing the operation of relay UB. If a character other than the correct first character is received, tube FD and relay FD will not operate. In this case, relay UB will again operate as a result of the operation of relay UV and the closing of contact UVK1. The action is the same for relay FD as for relay LTR as far as relay RL is concerned. Also, each time relay UV operates, relay UVR operates and releases as described. When relay FD operates, relay B operates as a result of the closure of contact FDK3. The operation of relay B prepares a path through varistors SDD and UB2D which shunts relay UB when relay UV next operates in order to prevent the operation of relay UB. When relay FD releases, relay B1 operates and locks in series with the winding of relay B. The operation of relay B1 grounds the starter anode of tube FD by closing contact BIK3 to prevent the refiring of tube FD and the operation of relay FD if another first digit is sent in error.

The next combination which should be received is the second combination of the first group of call directing characters. It has been assumed that the first combination, that is, the combination which has just been received, is the combination which designates the line. The sec-

ond combination which we are about to consider identifies the station on the line. As explained there may be a number of stations on each line each one identifiable by an individual combination corresponding to a letter such as the letters B, C, E, G, I, K, etc. as mentioned in the foregoing. The reception of each of these second letters will establish a path through the matrix at each station. At the station designated B, the particular matrix terminal of the groups MX1 through MX32 in FIG. 2, which is connected to a closed path through the matrix when the letter B is received, will be connected to the terminal SDTB in the upper left in FIG. 3. The path is then extended through varistor SDVB, starting anode and cathode of second digit tube SD and contact RLK6 to ground, activating tube SD. This establishes a circuit from positive battery through contact CRK1, winding of relay SD, main anode of tube SD, cathode of tube SD and contact RLK6 to ground, operating relay SD and maintaining tube SD activated. The operation of relay SD establishes a circuit, shown in the right-hand middle portion of FIG. 4, from positive battery through contact SDK2, varistor SDD, contact BK2, relay B being operated, and varistor UB2D to the left-hand terminal of relay UB. This will prevent the operation of relay UB. If any combination other than the correct combination assigned for the station were received at this time, relay UB would operate. This is true of the reception of an unassigned combination, a combination corresponding to that of the line if repeated or the combination for Letters Shift. The operation of relay UB, indicating reception of an erroneous second combination, would initiate the intercept action. The operation of relay SD, shown at the top in FIG. 3, in turn operates relay RC, shown in the right-hand middle portion of FIG. 4, by closing contact SDK2 which closes a path from battery through contact SDK2, varistor RCD, winding of relay RC and contact RC1K2 to ground. Relay RC locks over an obvious circuit. When relay RL operated, as described, it operated relay RC1 by closing a circuit from battery through the winding of relay RC1 and contacts RCK1 and RLK7 to ground. The operation of relay RC1 releases relay A by opening contact RC1K3. It also releases relay RC by opening contact RC1K2. By opening its contact RC1K1 which is in series with the windings of both relays B and B1 it also releases these relays. Relay RC1 then releases as contact RCK1 opens. The circuit is then in condition to scan the next set of combinations comprising a group of call directing characters. As long as these combinations are correct the operation of relay UB will be prevented.

There may be as many as ten or more terminals, for instance, such as terminals SDTB, SDTC, SDTD, etc. through SDTK connected to the starting anode of tube SD. Each of these may be connected to a different matrix terminal of the group of matrix terminals MX- shown in FIG. 2 which are valid for stations on the same line, assumed in this case to be line A. The reception of any of these combinations at any station on line A would prevent the operation of relay UB and thus prevent an intercept operation.

If a non-valid combination or incorrect format is received relay UB will operate as described. In order to use the intercept circuit which is part of the automatic switching equipment, it is necessary to convert the first combination which will be perforated in the reperforator-transmitter to the combination for a Blank character. This is necessary to supply the automatic switching equipment information that what is to follow is to be intercepted. This combination is not set up on the reperforator-transmitter as the select magnets of the reperforator-transmitter are held inoperative. Therefore, the combination following the erroneous combination is the first one which will be punched. However, the following combination may be valid for some other line served by the switching office. Therefore, the first combination to be punched must be converted to one which is non-valid

for all lines. The combination corresponding to Blank can be used for this.

Assume that a non-valid combination has been received. Relay UB will operate at a time shortly before the middle of the stop pulse of the non-valid combination is received. It is thus necessary to start the reperforator-transmitter before the reception of the stop pulse terminates. It is also necessary to convert the combination following the non-valid combination into the combination for Blank.

Tubes 4V1A and 4V1B are connected as a first multivibrator and tubes 4V2A and 4V2B are connected as a second multivibrator, both monostable. The period of vibrators 4V1A and 4V1B is adjusted by means of variable resistor 420 to equal the time remaining between the operation of relay UB and the termination of the stop pulse. The period of the vibrator comprising tubes 4V2A and 4V2B is adjusted to equal the duration of one entire start-stop combination minus the duration of the stop pulse. As mentioned heretofore, relay 4L in FIG. 4 associated with the reperforator-transmitter follows all signals received from the line. However, unless relay UB is operated to close contact UBK1 or relay XO is operated to close contact XOK1, tube 4V3 will not be affected as the incoming signals will not reach the grid of tube 4V3.

At the instant that relay UB operates, as a result of the reception of a non-valid combination, contact UVK2 closes and negative battery is impressed through these contacts and capacitance 4C5 on the grid of tube 4V1A. This triggers the multivibrator comprising tubes 4V1A and 4V1B and causes conduction to suddenly shift from tube 4V1A to tube 4V1B. The anode of tube 4V1A is connected through capacitor 4C6 to the grid of tube 4V2A in the second multivibrator circuit. The negative pulse when applied through capacitor 4C5 cuts off tube 4V1A producing a positive pulse on its anode and on the grid of tube 4V2A. The sudden transfer of conduction to tube 4V1B produces a positive pulse in the anode of tube 4V1A and on the grid of tube 4V2A. Tube 4V2A is normally conducting and is unaffected by the first or positive of these two pulses. The second or negative pulse cuts off tube 4V2A. The second or negative pulse occurs at the end of the period of the multivibrator comprising tubes 4V1A and 4V1B. This interval is equal, as stated to the time remaining between the operation of relay UB and the end of a stop signal element of a combination.

Thus, the multivibrator comprising tubes 4V2A and 4V2B is started on its cycle at the time of reception of the end of the stop pulse of the non-valid combination. The multivibrator comprising tubes 4V2A and 4V2B operates in substantially the same manner as does that comprising tubes 4V1A and 4V2A, except for the difference in the duration of its cycle, as described, and except that the anode of its tube 4V2B is connected to the grid of tube 4V3. The anode of tube 4V2B is direct coupled to the grid of tube 4V3 so that the grid will be held negative of the entire time that tube 4V2B conducts. The constants of the timing circuit are so chosen that tube 4V2B conducts for a time interval equal to the duration of a start signal and all of the intelligence-determining signals of the combinations being received. This is equal to the duration of an entire start-stop combination minus the stop signal. It is pointed out that the intelligence-determining signals for a five-element Blank combination are all spacing signals, that is, SSSSS. Since the first or start signal of any combination is always a spacing signal and the last or stop signal is always a marking signal, the seven-element start-stop combination of Blank is SSSSSSM.

The signal combinations of the intercepted message are to be produced in the reperforator-transmitter by means of the selector magnet SEL MAG, the winding of which is connected to the cathode of tube 4V3. When tube 4V3 is inactivated the selector magnet SEL MAG

is not energized and a spacing signal element is produced. When tube 4V3 is activated this magnet is energized and a marking signal is produced. Tube 4V3 is held inactivated for the entire time that tube 4V2B conducts. This will produce the start spacing signal and the five spacing signals of the Blank combination. Then tube 4V3 is activated to operate select magnet SEL MAG which produces a mark signal as the last or stop signal element of the combination.

Even though relay 4L may be following the signals and applying negative voltage to the grid of tube 4V3 for each spacing signal, the negative voltage at the anode of tube 4V2B holds tube 4V3 cut-off until tube 4V2B flips back to its stable state at which time relay 4L is in the marking condition due to the reception of the stop pulse of the combination. Thus, the multivibrator comprising tubes 4V2A and 4V2B nullifies the normal action of relay 4L and substitutes the combination for Blank for the combination following the reception of a non-valid combination in the format of the call directing characters. The selector magnet SEL MAG sets up the combination for Blank in the reperforator-transmitter which punches the tape accordingly.

Relay UB will remain operated during the transmission of the entire message. Therefore, since contact UBK2 remains closed and no pulses can be applied to the grid of tube 4V1A, the first multivibrator comprising tubes 4V1A and 4V1B and the second multivibrator controlled by it cannot again function and both will remain in their stable states. Thus, one Blank combination only will be sent to the reperforator-transmitter and all succeeding combinations will also be perforated in the tape.

When the cross-office switching equipment scans the contents of the tape, the first character encountered is a Blank which is recognized as a non-valid code. It then causes the message to be routed to intercept. If other call directing characters follow, as may be the case in multiple address, the present electronic selector equipment will continue to scan each group for validity and correct format. Relays LTR, FD, SD and UV function for each code group as described in the foregoing. However, the first error causes relay UB to operate and lock with the consequence that succeeding erroneous combinations occurring, if any, are punched in the tape. After all call directing characters have been scanned, as will be seen from reference to the format in the foregoing, a pair of combinations in sequence Carriage Return and Line Feed are received. These are represented in the format by the symbols <≡. These two combinations in sequence are termed the End of Codes signal.

When the combination for Carriage Return is received tube CR is activated and relay CR is operated and locked. When relay CR operates, it releases relay SD by opening contact CRK1. It also releases relay FD by opening contact CRK2. It releases relay A by opening contact CRK7. It releases relays B and B1 by opening contact CRK6. And finally, it releases relay UB by opening contact CRK8. This indicates to the scanning equipment that no more call directing combinations are to be examined and what follows is straight text. When the reperforator-transmitter is called in, as described in the foregoing, everything after the first error is treated as text. However, relays SD, FD, A, B and B1 are released when relay CR operates. If no errors were encountered and no provisions were made to indicate the end of the call directing characters, the equipment would have no way of differentiating between a non-valid combination in the call directing code group and the same combination appearing in the text. In normal operation when no error occurs, the appearance of the Carriage Return combination causes the scanning equipment to ignore all following combinations as these combinations are text. The final or Line Feed combination following the Carriage Return combination performs no useful function in the present circuit.

Every message terminates with two successive combina-

tions termed the End of Transmission code. These are the combinations for Figures and H. When the combination for Figures is received, tube FL is activated and relay FL is operated. The path for the operation of relay FL is from positive battery through its bottom winding and through tube FL to ground. When relay FL operates it locks from battery through its bottom winding and contact FLK1 to ground. Relay FL, in operating by closing contact FLK2, prepares a path for the activation of tube FH and the operation of relay FH. Tube FH is activated and relay FH operated in response to the reception of the combination for H. Several combinations for Letters usually follow the combination for Figures and H. In response to the reception of the first combination for Letters, tube LTR is activated and relay LTR is operated. The operation of relay LTR by closing contact LTRK2 establishes a path from battery through contact LTRK2, top winding of relay FL and contact FLK1 to ground. The current flowing in this path is in such a direction and of such magnitude to overcome the effect of current flowing in the bottom winding of relay FL and relay FL is actuated to the opposite condition. The circuit is thereby restored to normal and to a condition to scan call directing codes of another message.

Consider now a multiple address message originating on a given line, say line A, intended for several stations on line A and for other stations on other lines. To reach the lines other than line A a cross-office connection is required as mentioned in the foregoing. This cross-office code, the combination for R, for instance, is punched in the tape just ahead of the first station code requiring a connection through the office. Attention is called to the fact that in transmitting or receiving from any station on the same line it is not necessary to pass through an office or station having cross-office equipment. However, when a connection must be established from a station on one line to a station on another line, it is necessary to introduce cross-office equipment giving access to the other line. This is well understood in the art.

Assuming that all call directing codes for the originating line are valid and that the format is correct. The reperforator-transmitter will remain in the Off Line condition ignoring all signals. When the cross-office code R is received the cross-office tube XO will be activated and its associated relay XO will be operated and locked over obvious circuits. This will occur, as should be apparent from the foregoing during the reception of the stop signal of the combination for R. In response to the start pulse of the succeeding combination on its mark-to-space transition and for all succeeding signals, tube 4V3 repeats the signals to the selector magnet SEL MAG of the reperforator-transmitter causing it to punch all succeeding characters in the tape. The call directing codes requiring cross-office switching can now appear in the tape on the input side of the reperforator-transmitter. The cross-office equipment can now read the various call directing codes and make the proper connections to the required lines, in a well-known manner. When the last call directing code has entered the reperforator-transmitter the End-of-Codes signal consisting of the two successive combinations for Carriage Return and Line Feed is received. These cause the electronic scanning equipment to ignore all following combinations until the text of the message has been completed and the End-of-Message code signal Figures and H has been received. This restores the circuit in the same manner as described for an intercepted message.

What is claimed is:

1. A circuit for intercepting misdirected telegraph messages in accordance with multielement, two-condition, start-stop permutation code signal combinations, said circuit comprising a receiving relay responsive to said combinations, a first electronic multivibrator having means responsive to said receiving relay for producing a potential condition at the middle of the start signal of each

said combination, an electronic distributor having an individual group of elements therein for the start signal, for each of the intelligence-determining signals and for the stop signal of said combinations, each said group comprising a grid, a second control element and an output element, means responsive to the production of said condition for impressing said condition on said second control element individual to said start signal, a second electronic multivibrator responsive to said first multivibrator, said second multivibrator having means connected thereto for producing other individual potential conditions in succession in the middle of each of said intelligence-determining signals and during said stop signal, means responsive to the production of said other conditions for impressing them in sequence on said second control elements individual to said intelligence signals and individual to said stop signal, third electronic multivibrator means responsive to said second multivibrator for impressing a condition on said grids, means jointly responsive to said condition on said grids and on said second control elements for directing current through each of said output elements in succession, an individual encoding relay having a winding thereon connected to each of said output elements individual to each of said intelligence-determining signals, and a plurality of separate individual selecting paths, responsive to said encoding relays, one of said paths establishable for each different one of said combinations, another path establishable simultaneously with the establishment of each of said paths, a first and a second space discharge device actuable simultaneously in response to the establishment of each said selecting path and said other path, respectively, and electronic means responsive to the non-activation of said first device due to an erroneous selection and the activation of said second device for intercepting a misdirected message.

2. A circuit in accordance with claim 1 having a buffer tube responsive to said third multivibrator, a space discharge device responsive to said buffer tube and an output circuit of said space discharge device connected in series from a source of positive potential through said winding on each of said relays and the respective output element connected to each of said relays in said electronic distributor.

3. A circuit in accordance with claim 1 in which odd and even ones of all of said grids, arranged in sequential order in said electronic distributor, are connected to the output of a first and a second space discharge device, respectively, in said third multivibrator.

4. A circuit for detecting misdirected telegraph messages in start-stop multielement two-condition permutation code signal combinations, said circuit comprising a receiving relay, a first multivibrator responsive to said receiving relay, said first multivibrator having a cycle equal to the duration of one-half of a start signal element of a combination, a second multivibrator, responsive to said first multivibrator, said second multivibrator having a cycle equal to the duration of a permutation code signal element, a beam switching tube electronic distributor, responsive to said first and said second multivibrators, a number of relays, equal to the number of permutative elements in said multielement code signal combination, said relays selectively responsive jointly to said receiving relay and said distributors, a diode matrix having a plurality of selecting paths therethrough, said paths selectively establishable by the cooperative operation of said relays, an array of space discharge devices, an individual one of said devices selectively activated through the establishment of each of said paths, another common space discharge device responsive to said receiving relay upon the reception of each of said combinations, said common device activated simultaneously with said activation of any individual one of said array of devices, a reperforator transmitter, means responsive to the simultaneous activation of a particular one of said devices in said array and

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said common device for disabling said reperforator transmitter, and means responsive to the activation of said common device and the nonactivation of said particular device for enabling said reperforator transmitter.

5 5. A circuit in accordance with claim 4, said circuit including electronic means responsive to the nonactivation of said particular device for generating a particular pre-assigned permutation code signal combination, to denote the reception of an erroneously directed message.

10 6. A circuit in accordance with claim 5, in which said electronic means are a plurality of other multivibrators, responsive to the nonactivation of said particular device, for timing the generation of the signal elements of said preassigned permutation code signal combination.

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