Jan. 4, 1949. W. T. REA 2,458,030

SELECTIVE SIGNALING APPARATUS AND SYSTEM

Filed Aug. 29, 1944 6 Sheets-Sheet 1

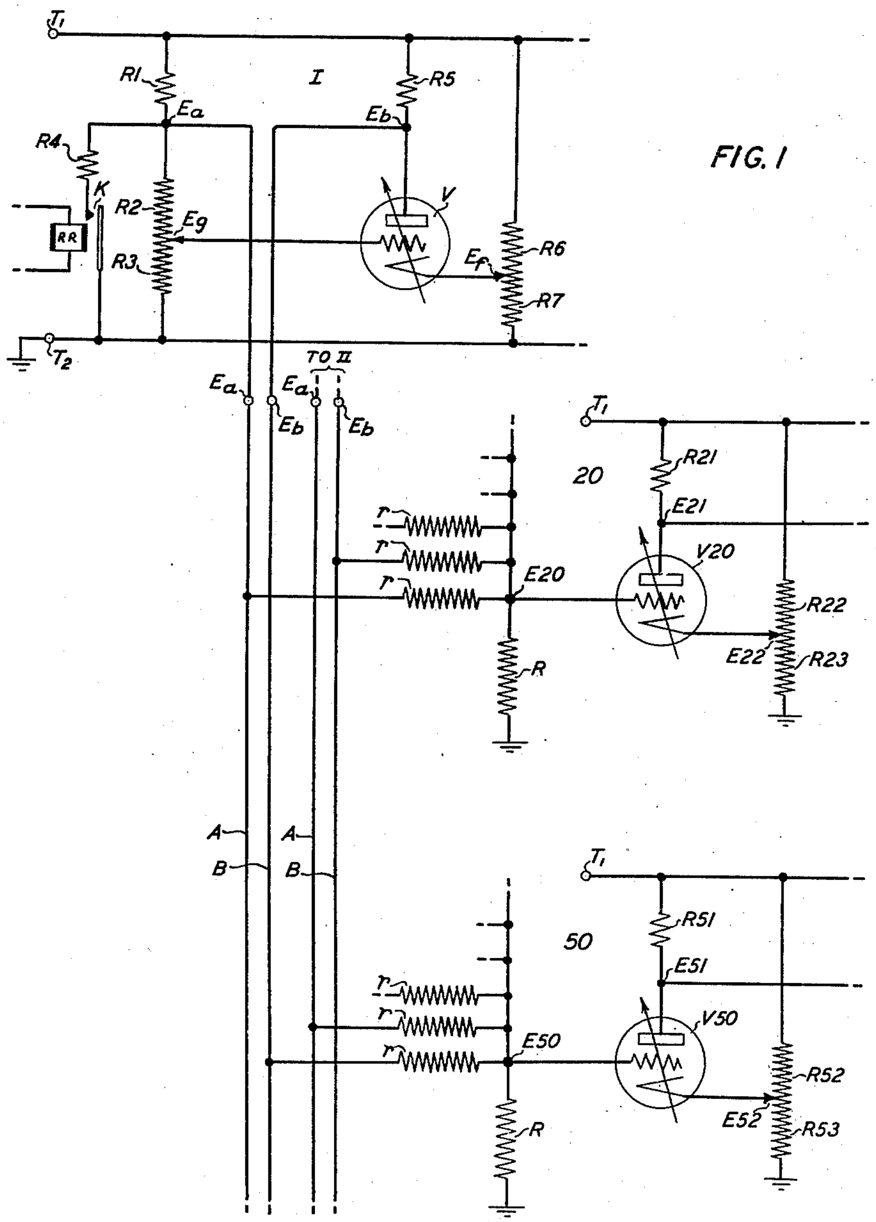

FIG. 1

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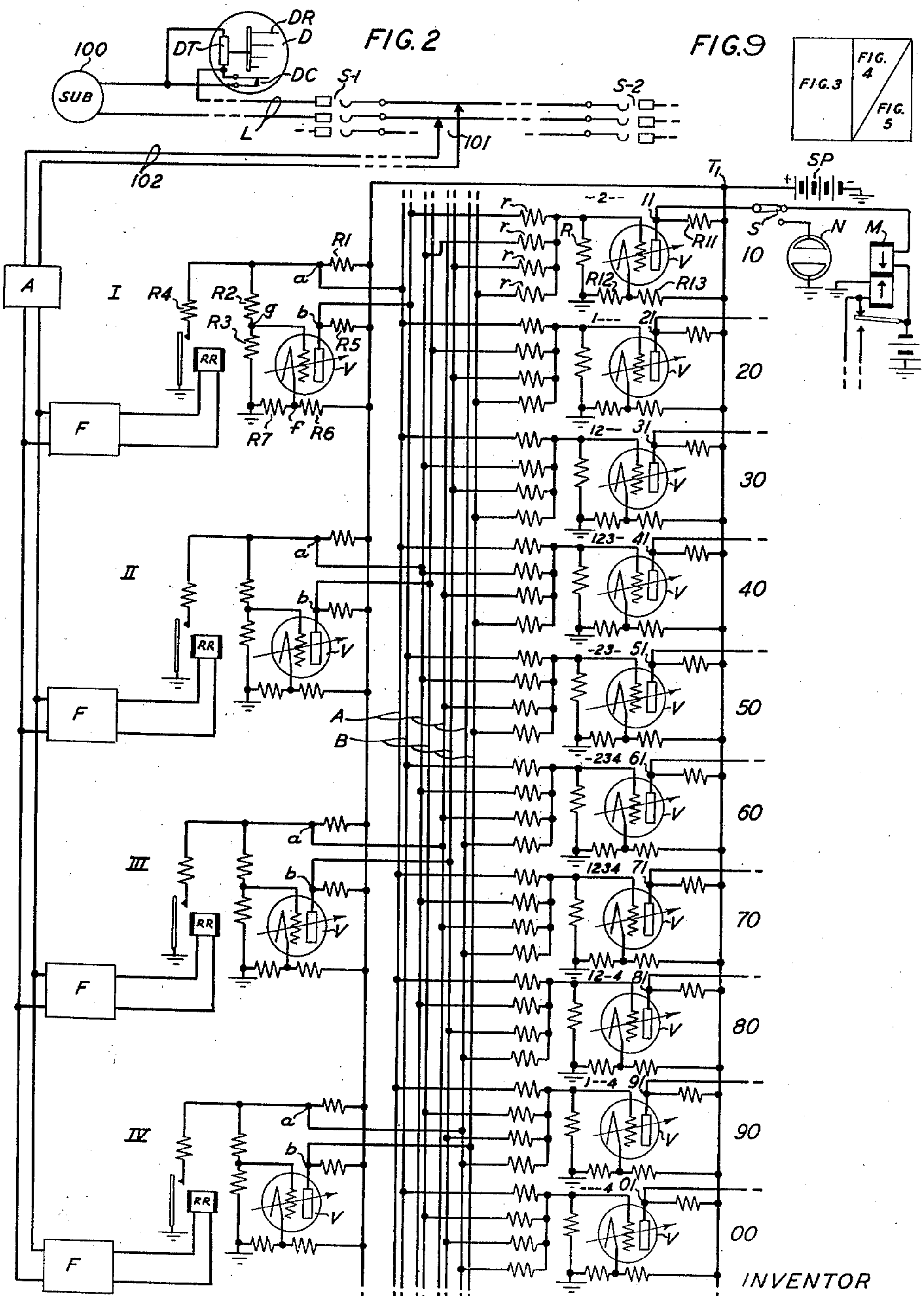
SELECTIVE SIGNALING APPARATUS AND SYSTEM

Filed Aug. 29, 1944 6 Sheets-Sheet 2



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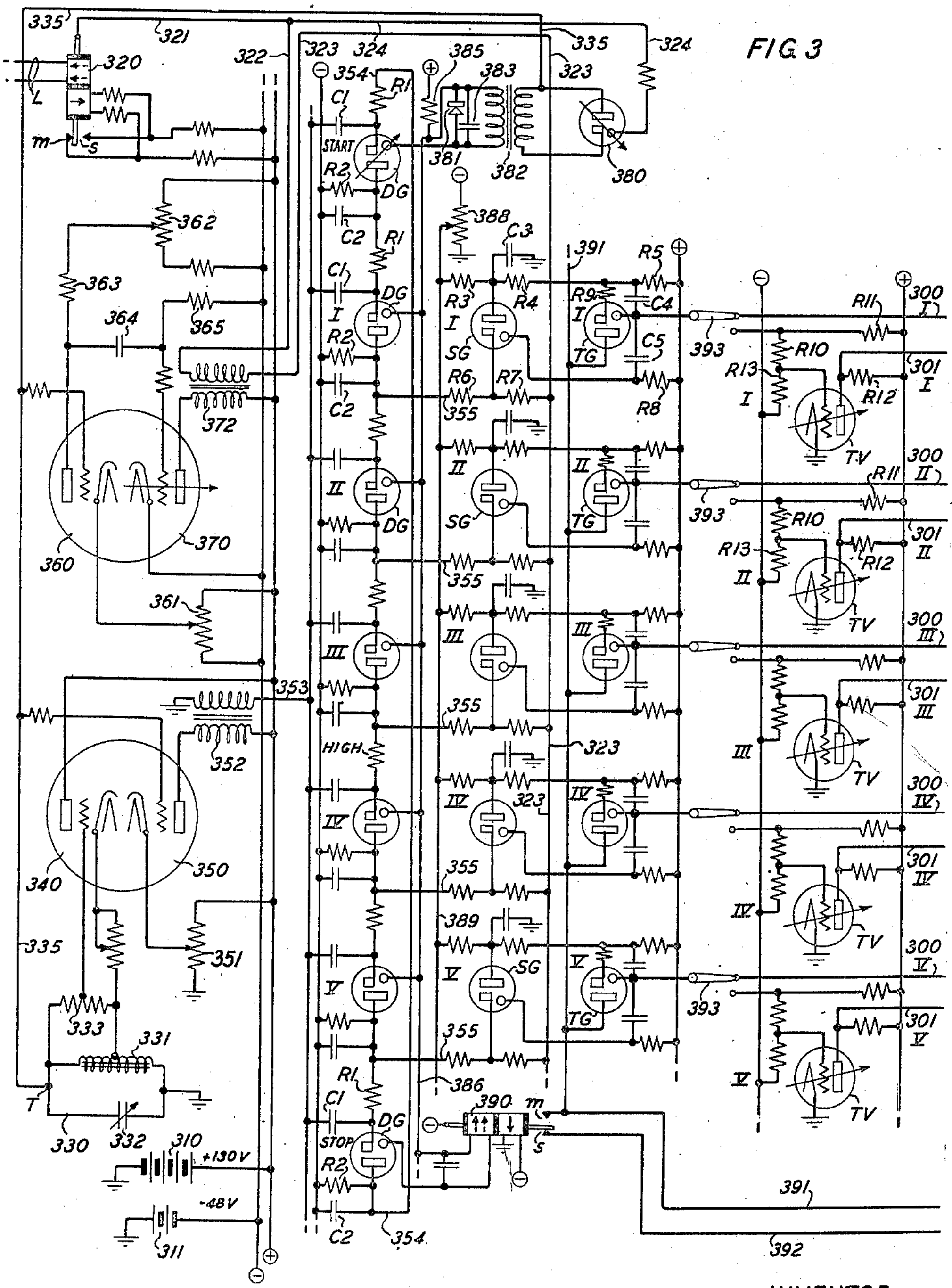
SELECTIVE SIGNALING APPARATUS AND SYSTEM

Filed Aug. 29, 1944 6 Sheets-Sheet 3

FIG. 3



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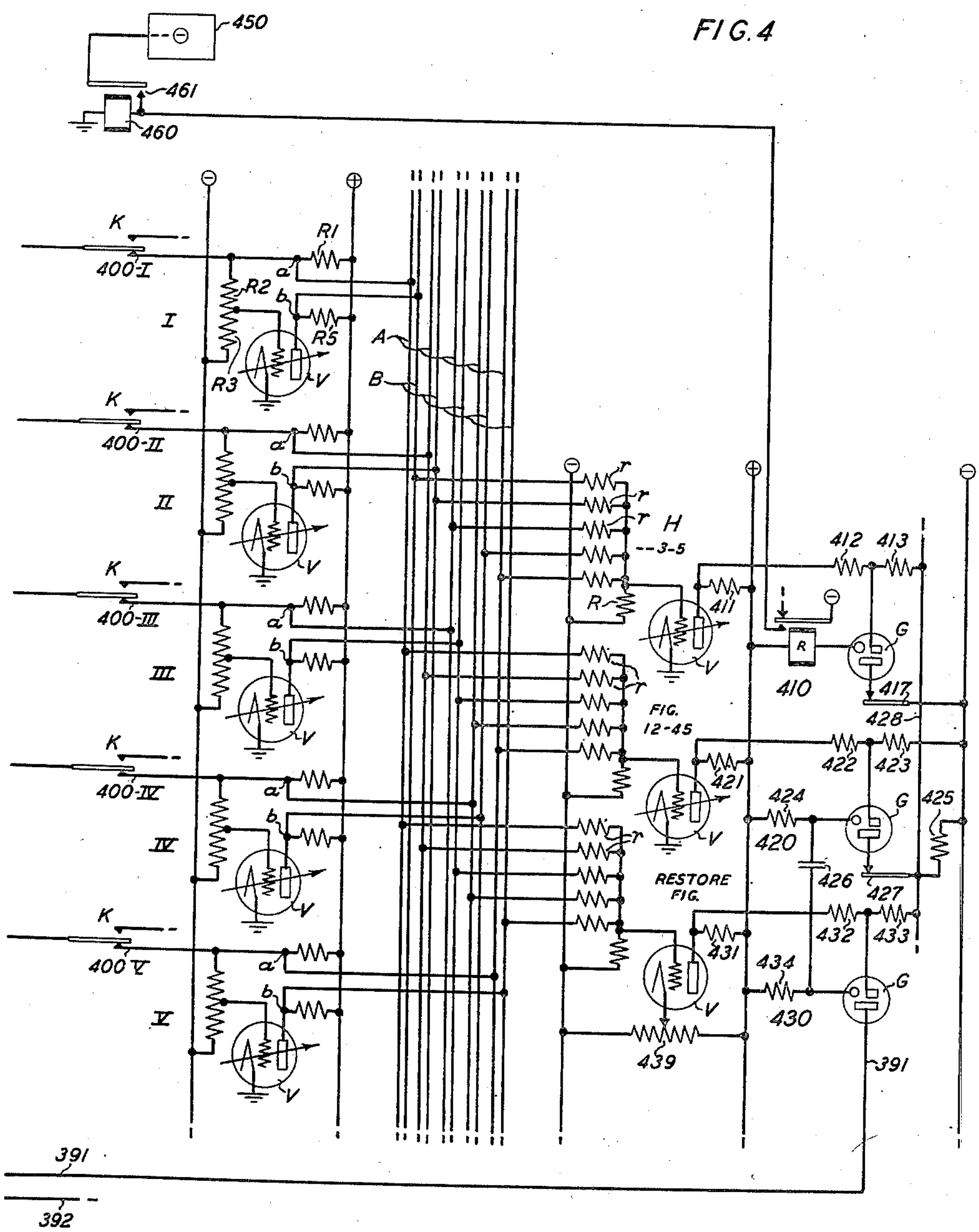
SELECTIVE SIGNALING APPARATUS AND SYSTEM

Filed Aug. 29, 1944 6 Sheets-Sheet 4

FIG. 4



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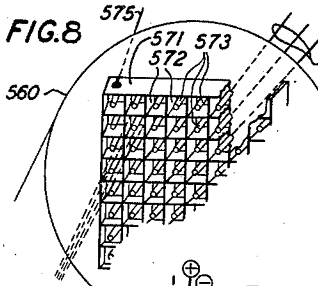
Filed Aug. 29, 1944

6 Sheets-Sheet 5

FIG. 8



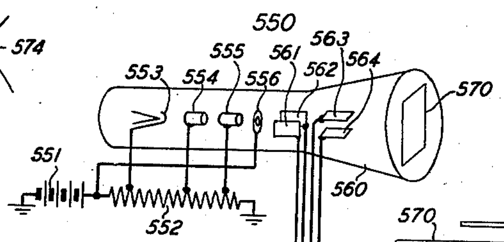
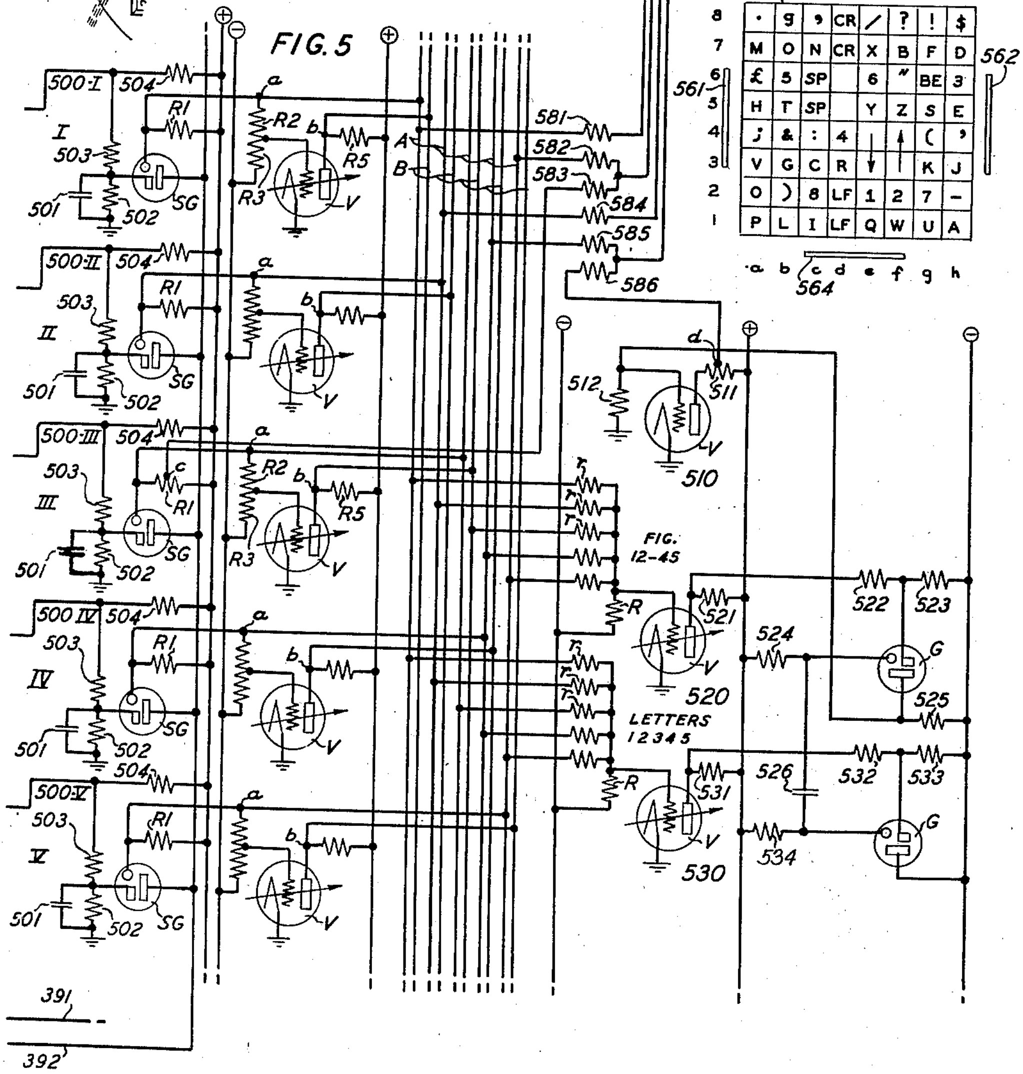


FIG. 5

FIG. 6



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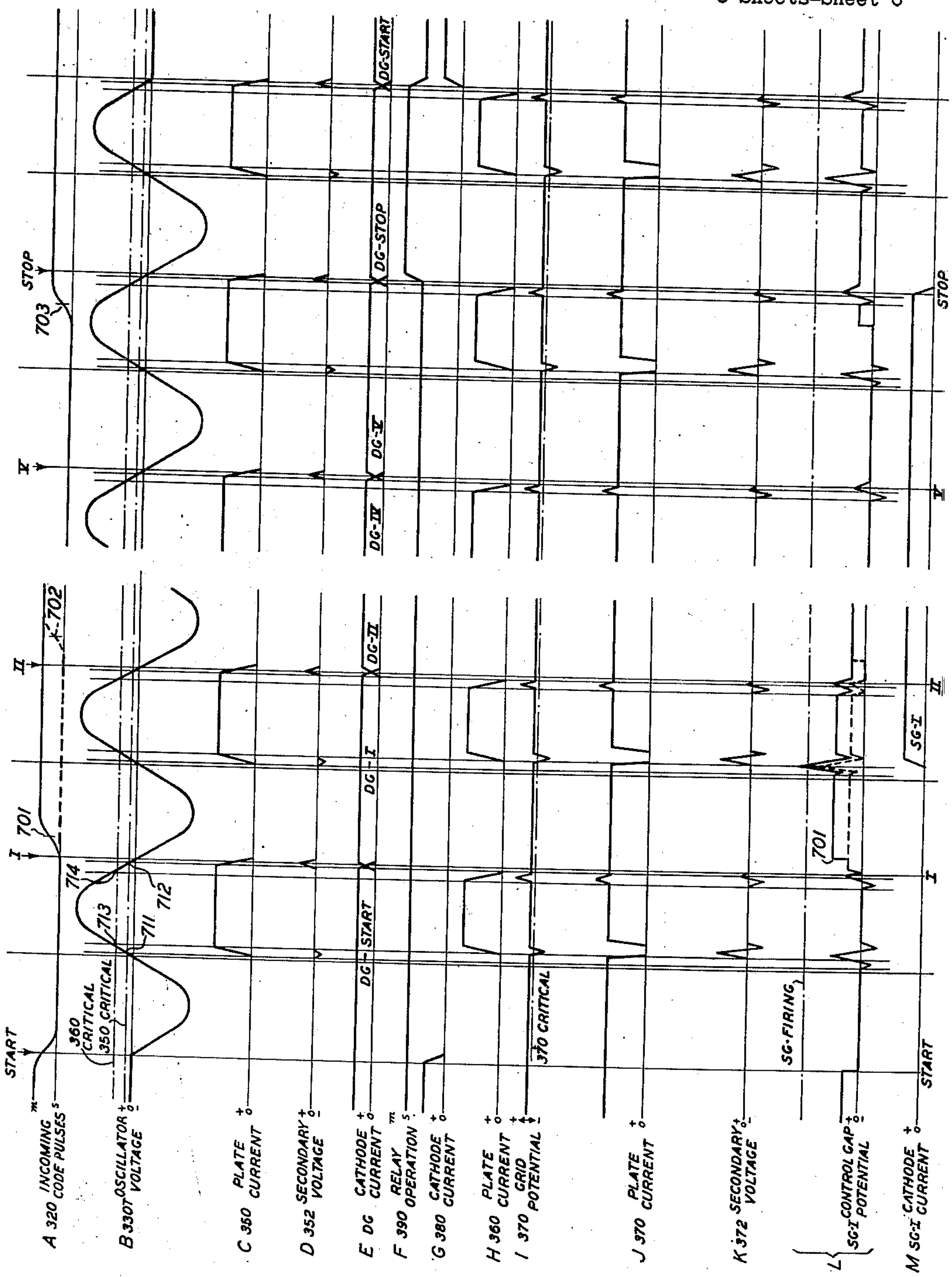

FIG. 7

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Patented Jan. 4, 1949

2,458,030

UNITED STATES PATENT OFFICE

2,458,030

SELECTIVE SIGNALING APPARATUS AND SYSTEM

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Application August 29, 1944, Serial No. 551,674

15 Claims. (Cl. 177—353)

1

This invention relates to signalling apparatus and systems and more particularly to circuit selecting or decoding arrangements used in such systems.

It is a principal object of the invention to provide a code receiving and decoding arrangement in which the control of current in the system is accomplished by electronic discharge devices substantially throughout the system rather than by contacting devices, with the purposes of avoiding mechanical wear and tear, of permitting high speed of operation, and of securing a high degree of accuracy and efficiency of operation.

It is a further object of the invention to provide a circuit selecting or decoding arrangement in which the various code permutations are represented by distinct potential differences of sufficient magnitude to insure accurate discrimination in any one of the discriminating circuits in the system.

It s a more specific object to provide a type of circuit selecting system which may be effectively used in code signalling systems of different kinds, such as the dial control circuits for the selective operation of telephone switches or teletype switches, or the message circuits in telegraph systems in which the coded message is to be interpreted.

In accordance with the invention the system includes a circuit selecting arrangement the main features of which are a code unit circuit for each unit of the code adapted to respond to the alternate characteristics of its assigned code unit, and a code discriminating circuit for each possible combination of the code or for each circuit to be selected or for each symbol which it is desired to translate from the code. Each code unit circuit has two output conductors one of which has a high potential and the other a comparatively low potential, under marking condition, these potentials being interchanged between the two conductors under spacing condition. Each code discriminating circuit includes a potential gradient network with a plurality of branches connected to the output conductors from the code unit circuits in accordance with the code requirements for the particular symbol represented by the code discriminating circuit. The arrangement of the potential gradient circuit is such that an intermediate control potential is established at an output terminal thereof which will have different distinct values in accordance with the different code combinations impressed upon the circuit by the code unit circuits. By this arrangement it is possible to select a particular potential for any code combination to which the code discriminating circuit should respond for selection or translation by impressing the potentials at the output terminal upon a sensitive discriminating device which is made selectively responsive thereto. For individual selection, as for the selection of a single symbol out of a plurality of symbols, either the maximum or the minimum potential established at the output terminal by a code combination may be used.

2

Further objects and features of the invention will appear from the following detailed description of specific embodiments of the invention.

In the following description reference will be made to the drawings in which:

Fig. 1 is a diagrammatic view of a simplified circuit arrangement illustrating the main features of the decoding system;

Fig. 2 shows a decoding system particularly adapted for operation with a telephone switching system for the translation into ten digits of the dialing code of four code units;

Fig. 3 shows a telegraph signal receiving system adapted for operation on a seven unit START-STOP telegraph code for setting up the five selecting code units on five output conductors respectively;

Fig. 4 shows a decoding circuit having five input conductors for connection to the five output conductors of Fig. 3 and particularly arranged for a specific double code combination utilized in teletype operation and known as FIG—H;

Fig. 5 shows a decoding circuit having five input conductors also adapted for connection to the output conductors of Fig. 3 and arranged for translation of a telegraph message into symbols made visible by means of a cathode ray tube;

Fig. 6 shows diagrammatically a field of letters, numerals and signs which may be arranged on the reading surface of the cathode ray tube in Fig. 5 for visible display of the symbols of a message;

Fig. 7 is a diagram of operations for the system shown in Fig. 3;

Fig. 8 is a fragmentary perspective view of the cathode ray tube showing an alternative arrangement of the reading surface with electrodes instead of symbols; and

Fig. 9 is a diagram showing how Fig. 3 should be placed in relation to Figs. 4 or 5 for a proper reading of the circuits.

It should be understood that the invention is adapted for operation on codes of different types. Thus the code may have a fixed number of code units or it may have a variable number of code units within a prescribed maximum. Each unit will have two alternate conditions, hereinafter termed marking and spacing, which may be established in any conventional manner. Each character code may be impressed upon the decoding system either by applying all the code units thereto simultaneously or by applying the code units in succession. The code may include auxiliary units, such as START and STOP pulses. Thus a character code may be set up by simultaneously applying a plurality of different frequencies in a combination corresponding to the assigned symbol; each frequency thus would represent a code unit. A telephone switching system using this type of code has been disclosed in U. S. Patent 2,153,129, issued to H. M. Bascom on April 4, 1939. The code may be set up in the well-known manner of a telegraph code by impressing a series of successive code pulses upon the system, the pulses being present or absent from any particular unit period in accordance with the marking or spacing condition, respectively, of the unit. The number of selecting units is usually five but may be greater or smaller and for start-stop operation the selecting units are preceded by a START and succeeded by a STOP pulse. In the following description the code units and their individual circuits or circuit groups will be designated I, II, III, etc, whether the units for each character code be applied simultaneously or in succession.

Referring now particularly to the circuit arrangement shown in Fig. 1, this arrangement is not intended to show a complete selecting system but rather to emphasize the principal elements provided in accordance with the invention for such a system. Thus the circuit I represents a code unit circuit which will be assumed to be responsive to the first code unit, and the circuits 20 and 50 are two code discriminating circuits representing two different code combinations or symbols. The circuit I has a pair of output conductors A, B which are common to the circuits 20 and 50 or any other similar code discriminating circuits which may be included in the system. Another similar code unit circuit II (not shown) has two similar output conductors A, B (shown) also common to the code discriminating circuits 20, 50, etc.

It will be assumed that a constant plus potential P from a suitable direct current source is supplied to the terminals T1 of the different parts of the circuit shown in Fig. 1 and that the other terminal T2 of the source is grounded.

The circuit I comprises a potential gradient circuit of low resistance R1 and high resistances R2 and R3 connected in series across the potential P thereby normally establishing a potential Ea with respect to ground nearly equal to potential P, Ea being normally applied to the output conductor A. It will be assumed that normal condition is represented by marking and alternate condition by spacing in the code. It should be understood that any other type of conventional potential gradient circuit may be used instead of the potentiometer of resistances R1, R2, R3.

The circuit I includes a second potential gradient circuit of low resistance R5, cathode-anode path of normally conducting vacuum tube V, and resistance R7. The tube V is preferably a hot cathode electron discharge vacuum tube having a control grid, but other conventional types of electron discharge tubes may be substituted therefor. With current normally flowing in this potential gradient circuit and with resistance R5 equal to the resistance R1 a potential Eb will be applied to the output conductor B, this potential being apprcciably lower than the potential P.

It will be observed that by means of the potentiometer R6, R7, a suitable potential Ef is applied to the cathode of the triode V and that the control grid is connected to a point on the potentiometer R1, R2, R3, having a potential Eg with respect to ground which normally is sufficiently more positive than the potential Ef to render and maintain the tube V conducting. The current through resistance R5 is adjusted by adjustment of the cathode connection to resistance R7 to secure a desired potential drop in resistance R5.

Thus the comparatively higher potential Ea is supplied from circuit I during marking to the circuit 20 and the comparatively low potential Eb to the circuit 50.

With similar conditions prevailing in circuit II during marking the higher potential Ea may be applied to the circuit 50 and the lower potential Eb to the circuit 20.

An alternate or spacing condition may be imposed upon the circuit I by establishing a by-path, such as resistance R4, across the resistances R2, R3. This may be accomplished by means of current control means, such as a relay RR responsive to code unit I from any suitable signaling system, the relay having contacts K which are open during marking and closed during spacing. Thus when the contacts K are closed an increased current will flow in resistance R1 thereby increasing the potential drop therein and reducing the potential on conductor A to be equal to the normal value of potential Eb. At the same time the potential Eg applied to the grid of triode V is reduced to a value which is low enough to render the tube non-conducting; thus the potential Eg on the grid may be made negative with respect to the potential Ef of the cathode. With no current flowing in the resistance R5 the potential on conductor B will be equal to potential P, or practically equal to the normal value of Ea.

Thus for code units having the spacing characteristic the potentials on conductors A and B from the corresponding code unit circuits will be exchanged, the conductors A being at the lower potential and the conductors B being at the higher potential.

Each code discriminating circuit, such as the circuit 20, includes a potential gradient circuit containing a plurality of high resistance branches or sections r joined at one end to a common resistance R connected to ground. The free ends of the multiple branches r are connected to the output conductors A and B from the code unit circuits in different manners depending upon the assigned code combination. There is one branch r for each code unit circuit which thus is subjected to the higher or the lower selective potential depending upon the condition of the incoming code unit. An output terminal at the junction point between the resistances will thus at any time have a potential E which depends upon the combination of potentials impressed upon the network.

The code discriminating circuit 20 further includes a potential gradient circuit comprising resistance R21, the vacuum tube V20 and resistance R23. Normally current may be flowing in this circuit, thereby establishing a potential drop in the resistance R21 so that the output potential E21 will be appreciably lower than the potential P; the potential applied to the cathode of the triode V20 may be adjusted relative to the grid potential E20, so that the tube will be conducting above a predetermined value of the potential E20 and non-conducting for lower values. Thus the tube may be conducting whenever the grid is more positive than the cathode and may be non-conducting when the grid is less positive than the cathode. When in response to a reduction in the potential E20, the triode V20 is rendered non-conducting, the potential E21 on the output conductor will increase to be equal to the potential P. Thus when a code combination is received which will cut off the flow of plate current in tube V20, the potential E21 will be higher by a fixed amount than for other code combinations, which condition may be utilized for the selection of suitable operating means.

Assuming that the circuit 20 includes n multiple sections r and that the series section R is equal to

$$\frac{r}{n}$$

and further assuming that x branches out of the total are subjected to the higher voltage P from the code unit circuits in response to an incoming code combination and that the remaining circuits are subjected to the lower voltage p, then it can be shown that the voltage E applied to the grid of the tube in the discriminating circuit will be

$$E=\frac{1}{2}\,\frac{x}{n}(P-p)+\frac{1}{2}p$$

For each additional branch which will receive the higher potential, the increase in the voltage E will be

$$e=\frac{1}{2n}(P-p)$$

For the condition of all branches in the circuit 20 receiving the potential P through some combination of code units, that is, for $x=n$, then

$$E\ \max=\frac{1}{2}P$$

and for all branches receiving the potential p, for $x=0$,

$$E\ \min=\frac{1}{2}p$$

E max is thus obtained when all branches of circuit 20 receive the high potential and E min when all branches receive the low potential. It is evident that each of these two conditions can be established in only one manner by the code units, since all the branches r will have the same potential in either case. Therefore, either of these conditions may be used for complete decoding of a symbol. The condition of some branches receiving high potential and the remainder low potential may, of course, be set up in different manners. Thus, for example, any one branch of circuit 20 may have high potential applied thereto and the remainder have low potential, but in any of these possibilities the resultant potential E would be the same. While such a condition may be used for group discrimination, it could not be used for singling out individual circuits or symbols in a code utilizing all possible permutations.

As will appear from the formulas given above, the resultant or discriminating potential E is a linear function of the number of branches x which receive high potential; therefore, the E max or E min obtained from this potentiometer arrangement differs by the same increment or decrement e from the nearest potential secured by other code combinations so that a clear-cut discrimination may be secured without the necessity of using highly sensitive responsive devices.

From the formula given above, it will be apparent that the potential change e available for discrimination decreases as the number of branches increases and therefore as the number of digits in the code increases and will be less also as P—p is decreased. It is therefore advisable to use a large potential variation P—p for a large number of units in the code. For this purpose the potential p may be at ground potential, in which case

$$e=\frac{1}{2n}P$$

or p might be negative and equal to —P in which case

$$e=\frac{1}{n}P$$

The ground branch R of the potentiometer may be greater than

$$\frac{r}{n}$$

an increase in this resistance resulting in an increase in the resultant potential E but in a decrease in the potential variation e. It is furthermore possible to connect the output terminal from the grid to any intermediate point on the grounded branch R to obtain a lower potential than the potential E referred to above.

From the description given above, it will be apparent that the potentials E20, E50, etc., on the code discriminating circuits continually vary in steps between the maximum and the minimum values, as the different code combinations are being received by the code circuits. The vacuum tubes V20, V50, etc. are so adjusted that for any code combination all of them, except one, will have their cathodes at a potential more positive than the potential E min and all the tubes except one will be conducting; and the single remaining tube having the potential E min applied to the grid, which thus is less positive than the cathode, will be non-conducting; the output lead from this single tube thus will have its potential increased to P for operation of a suitable responsive device.

Alternatively, the cathode potential of the tubes V20, V50, etc. may be so adjusted that for any code combination all the tubes except one will be non-conducting, and the single remaining tube, having the potential E max applied to the grid, which thus is more positive than the cathode, will be conducting; the output lead from this single tube thus will have its potential decreased to p for operation of a suitable responsive device.

In general it may be said that for a code of n code units each of two different characteristics and capable of 2^n permutations there may be 2^n discriminating circuits representing the 2^n permutations, each having n receiving multiple sections connected in different manners in accordance with the permutation requirements to high and low potentials supplied normally or reversed by n code unit circuits in response to the alternate characteristics of the individual code units, thereby establishing n different resultant potentials in each discriminating circuit for selective action. By proper adjustment of the discriminating devices for marginal operation predetermined groups of the resultant potentials may be selectively singled out.

The principles of the decoding system described above in connection with Fig. 1 will now be described as applied to a telephone switching arrangement. In this description reference will be made to Fig. 2 which at its upper portion shows a diagrammatic representation of a telephone exchange system connected to a subscriber.

The subscriber's station includes the usual telephone set 100 and a dial D connected over a line L to an automatic exchange. At the exchange the line appears in a line-finder switch S—1 which serves to connect the calling lines to a selector switch S—2 for extending the call.

At the point 101 between the two switches provision is made for automatically associating with the line circuit a circuit 102 leading to a registering equipment adapted to respond to the dialing from the subscriber station for the purpose of storing the number of the called station.

The system shown in Fig. 2 is based upon the use of four different frequencies for the transmission of the desired number by the calling subscriber. For this purpose the subscriber's dial is equipped with four differently tuned dial reeds DR, which may be sprung in different combinations for each digit 0–9. The vibrations of the reeds are impressed upon a dial transmitter DT for simultaneous transmission over the line to the exchange. Dial contact DC is automatically operated to remove a normal short-circuit from the dial transmitter each time the dial is moved from its resting position.

At the exchange the dial frequencies pass over the circuit 102 through a suitable amplifying equipment A and into four filters individually tuned to the respective frequencies produced by the dial reeds to pass an alternating current to the associated code unit responsive means, indicated in the drawing as receiving relays RR.

A dialing system of this kind has been disclosed in Patent 2,153,129 to Bascom, referred to above. For a description of a dialing device suitable for use in this system reference may be had to United States Patent 2,190,307, issued to H. M. Bascom on February 13, 1940, or the British Patent 418,004, complete accepted October 17, 1924. Whereas the telephone exchange shown in Fig. 2 is assumed to be automatic in operation and to include a register for control of the selective operations of switches in extending the call, it is also possible to utilize applicant's invention in a manual system in which number indicating arrangements are used for transmitting the called line designation from one operator to another by transmission of four frequencies in different combinations. Such a system is shown in United States Patent 1,859,475, issued to T. S. Skillman et al. on May 24, 1943. Thus the receiving relays RR in Fig. 2 for receiving their individual frequencies may correspond to relays 133, 134, 135 and 136 in the patent to Bascom or to relays 104, 105, 106 and 107 in the patent to Skillman et al.

Referring again to Fig. 2 in the drawing the relays RR are associated with four code unit or inverter circuits I, II, III, IV each corresponding to the code unit circuit I shown in Fig. 1 and comprising substantially the same elements. Each circuit thus has a pair of output terminals a and b connected to a corresponding pair of conductors A and B common to a plurality of code discriminating circuits 10, 20—00.

Each code discriminating circuit corresponds to those shown in Fig. 1 and comprises substantially the same elements. For a decimal numbering system there will be ten code discriminating circuits. The output terminals 11, 21, 31, etc. may be connected to a suitable receiving or operating device, which in the case of an automatic exchange would be a register relay M for control of automatic switches, and in the case of a manual exchange would be a visible display device such as a neon lamp N. Such two devices are diagrammatically indicated in connection with the code discriminating circuit 10 and the switch S is indicated to show that either device may be connected to the system. Similar devices will, of course, be connected to each of the other code discrimination circuits 20, 30, etc.

The code discriminating circuits 10, 20, 30, etc. are connected through their individual potentiometer networks to the conductors A and B. Each potentiometer network comprises four receiving sections r in series with the common resistance R. There is thus one resistance r for each code unit circuit, so that sixteen different potentials may be impressed upon the control grid of the tubes V—10, V—20, etc. depending upon the combination of frequencies received by the system.

Referring to the expression given above

$$e=\frac{1}{2n}(P-p)$$

the difference between the potential steps produced in the present system where $n=4$, will be

$$e=\frac{1}{8}(P-p)$$

P is substantially equal to the potential supplied by the source of potential SP to the terminal T1; $P-p$ is the potential drop in resistance R1 or R5 for the condition of current flowing in those resistances; and

$$p=P\frac{R4}{R1+R4}$$

assuming that R2 and R3 are so large compared to R1 and R4 that their shunting effect is negligible. In the preferred arrangement R1=R5, so that it will be required that the same current flow be established by the vacuum tubes V—I, V—II, etc. in the conducting condition through resistances R5 as that caused to flow through resistances R1 by the insertion of resistances R4 in multiple to R2 and R3.

With the circuit in rest condition, as shown in the drawing, all the relays RR are released and the vacuum tubes V—I, V—II, etc. are conducting because the low current flow in the circuit R1, R2, R3 impresses a comparatively high potential upon point g to the grid which thus will be more positive than the cathode. With no current in the circuit R1, R2, R3 the point a will be at comparatively high potential substantially equal to P. The current flowing through the vacuum tube and resistance R5 will establish a potential p at point b which will be comparatively low. Thus normally all the A conductors will be at high potential and the B conductors will be at low potential.

The vacuum tubes V—10, V—20, etc. will all be conducting under this condition thereby impressing a comparatively low potential over the output terminals 11, 21, etc. upon the indicating device, which will be assumed to be a differential relay M. The relay M will be assumed to have a normal operating current flowing in its lower winding and, under the assumed conditions, the current in the upper winding will be insufficient to release the relay. A neon lamp used at this point for illuminating a numeral would be extinguished.

Assuming now that the subscriber 100 dials the number 2 thereby transmitting only the frequency corresponding to the code unit I, the relay RR—I will be operated, thereby rendering the vacuum tube V—I non-conducting and inverting the potentials at the points a and b in circuit I.

The circuit **20** has three of its resistances r connected to the conductors B from the circuits II, III, IV which are at low potential. The fourth resistance r is connected to conductor A from circuit I, which conductor now is also at low potential. Thus the minimum potential is applied to the grid of tube V—**20** which becomes non-conducting, thereby raising the potential at terminal **21**. In response thereto the associated relay M will receive enough current in its upper winding to release and close a suitable operating circuit, or an associated neon lamp M would be lighted. At the end of the period of dialing the digit **2**, relay RR—I will release and circuits I and **20** will be restored to normal.

On inspection of the connections from the different code discriminating circuits to the conductors A and B it will be found that no other circuit will have minimum potential applied to the grid; thus all the remaining nine circuits will be unaffected by the selection.

Assuming that the next number dialed is **5**, the frequencies II, III will be simultaneously transmitted over the circuit thereby inverting the potentials at the points a and b in the circuits II and III. The only code discriminating circuit corresponding to this selection is the circuit **50** which has two resistances r connected to the B conductors of circuits I and IV, normally at low potential, and two resistances r connected to the A conductors from the circuits II and III, which conductors now also are at low potential. Thus minimum potential is impressed upon the circuit **50** and upon no other circuit.

In this manner each digit dialed by the subscriber may be made to release a corresponding relay M or light a corresponding neon lamp N. However, as indicated in the patents to Bascom and Skillman et al. referred to above, provision is usually made for switching successive digits into different registering circuits or number indicating circuits, one for each digit. Since such switching forms no part of the invention it has not been shown in the drawing.

The application of the principles and features of the invention to a START-STOP telegraph system will now be described in connection with Figs. 3, 4 and 5.

Fig. 3 shows a receiving circuit arranged to receive START-STOP pulses from any suitable telegraph circuit and for storing each received code combination for retransmission during the STOP pulse;

Fig. 4 shows a decoding circuit for translation of a special UPPER—H combination which is used to precede the transmission of a station selecting code in private wire teletype automatic switching systems. This circuit may be connected to the receiving circuit in Fig. 3 to receive the stored code combinations; and

Fig. 5 shows another decoding arrangement adapted to receive any stored combination from the circuit in Fig. 3 and to translate it into readable characters or symbols made visible by means of a cathode ray tube, and with a separate control circuit for proper translation in the upper and lower cases.

The receiving circuit shown in Fig. 3 includes a receiving relay **320** having an upper winding connected to an incoming circuit L for receiving marking and spacing pulses. It will be assumed that the marking condition is established by current in the circuit L and the spacing condition by no current therein. The relay has a lower biasing winding continuously energized to hold the relay armature against the spacing contact when the upper winding is currentless. A marking current in the upper winding will be strong enough to overcome the biasing winding and operate the relay to marking. The relay **320** has a marking and a spacing contact connected to plus and minus potentials, respectively, for application to the circuit.

The system includes a grounded source of direct current **310**, which applies +130 volts to parts of the system, and another grounded source of potential **311** applying a potential of −48 volts to other parts of the system. For the sake of simplicity, all conductors shown in Figs. 3, 4 and 5 which are directly connected to the source **310** are terminated in a (+) symbol indicating that they are to be interconnected directly and all conductors connected directly to the source **311** are terminated in a (−) symbol indicating that they are to be directly interconnected.

The circuit in Fig. 3 includes an oscillatory circuit **330** and a vacuum tube **340** associated therewith for feedback to produce sustained oscillations. Other vacuum tubes **350**, **360** and **370** are provided to apply impulses to other parts of the circuit in synchronism with the oscillations. These vacuum tubes, and other vacuum tubes used in the system and referred to hereinafter, may be of conventional type, each including the heated cathode or filament, the control element or grid and the anode or plate, mounted in a highly evacuated container or tube. With a substantially constant potential applied between the plate and the cathode, the current in the cathode-anode circuit is controlled by the potential difference between cathode and grid, becoming less as the grid becomes less positive or more negative with respect to the cathode. Thus for any particular tube there will be a certain critical grid potential at which the plate current is so small that for the purposes of the system the tube may be considered extinguished or non-conducting; at grid potentials above the critical value the tube may be considered fired or conducting.

The circuit further comprises an electronic distributor including a series of distributor gas-filled tubes DG, one of these tubes being associated with the START pulse and another with the STOP pulse and the five intervening tubes DG being associated with the five significant or selecting pulses I, II, III, IV and V, respectively. The latter five tubes DG are each associated with a storing gas tube SG and a transfer gas tube TG. The gas-filled tubes DG, SG and TG, and other gas-filled tubes used in the system and referred to hereinafter, may be of conventional type, each including a narrow control gap between the cathode and the control anode and also including a main gap between the cathode and the main anode or plate. These elements are included in a sealed vessel or tube containing a suitable inert gas at low pressure. A comparatively high firing potential is required to break down the control gap for firing of the tube, and with a comparatively low sustaining potential applied to the main gap the discharge will automatically switch to the main gap. In order to extinguish the tube the firing potential and the potential across the main gap must be reduced below their sustaining values. From each of the storing tubes TG an output conductor **300** is provided for impressing the stored combination upon other circuits, such as those shown in Figs. 4 and 5. A relay **390** is arranged for operation during the STOP pulse and serves to control the transfer of the stored combinations into the circuits in Fig. 4 or 5 during the STOP pulse.

The circuit in Fig. 3 is shown in normal stop condition with relay **320** in marking position and relay **390** in spacing position.

The oscillatory circuit **330** and its associated feedback tube **340** and output tube **350** are particularly arranged for operation on a start-stop basis and for the production of short impulses evenly and accurately spaced apart in synchronism with the standard frequency of the telegraph signals received over the circuit L. Such a START-STOP pulse producing circuit, substantially identical with that shown in Fig. 3, has been disclosed in the copending patent application, Serial No. 432,823, filed on February 28, 1942 by W. T. Rea and J. R. Wilkerson and issued as Patent No. 2,370,685 on March 6, 1945.

The circuit **330** includes an inductance **331** divided into two closely coupled halves and a condenser **332**. A potentiometer **333** is bridged across the left half of the inductance to apply oscillatory potential to the control grid of the vacuum tube **340**; the cathode-anode circuit of tube **340** is connected across the right-hand of inductance **331** through plus battery and ground for energy feedback during each oscillation. The oscillatory circuit **330** is normally held cocked against oscillation by the application of plus potential over marking contact of relay **320**, conductors **321** and **324**, gas tube **380** and conductor **335** connected to the output terminal T of the oscillatory circuit; the gas tube **380** is normally in conducting condition. The circuit is so adjusted that under this condition a current flows through inductance **331** of the same magnitude as the maximum current flowing during oscillations.

Upon receipt of a START pulse, which is a spacing pulse, relay **320** operates to spacing and opens the cocking circuit, just traced, thereby removing the plus potential from the terminal T. The stored energy in inductance **331** now transfers to condenser **332** and a first cycle will be produced without any superimposed transients and the system continues to produce identical cycles until the arrival of the next STOP pulse when it will again be cocked over the marking contact of relay **320**, the cocking circuit in the meantime having been kept open by the tube **380**, as will be described hereinafter.

The oscillations are impressed upon the control grid of the output tube **350** which for certain values of the varying voltage applied to the grid becomes conducting and non-conducting, at each change producing a short impulse in the secondary winding of the transformer **352**, which impulses are impressed upon the distributor circuit over conductor **353**.

The oscillations are also impressed upon the grid of tube **360** which similarly becomes conducting and non-conducting at predetermined values of the oscillating potential. When the tube **360** is non-conducting the condenser **364** is charged from minus over resistances **365**, **363** and to plus potential on the potentiometer **362**. The moment the tube **360** becomes conducting the condenser **364** temporarily impresses a negative potential on the grid of the normally conducting tube **370** which thereby is temporarily extinguished. This shift of the condenser voltage is caused by the drop in potential over resistance **363** due to the rising plate current in tube **360**; as condenser **364** discharges to the reduced potential the grid potential in tube **370** is restored to its former value and the tube again becomes conducting. When tube **360** is extinguished at a later instant of the cycle of oscillations, the drop over resistance **363** disappears and the condenser voltage is shifted toward plus, thereby making the grid of tube **370** more positive and temporarily increasing the plate current, without significant effect, until the condenser resumes its new charge. Each time the tube **370** is rendered conducting or non-conducting an impulse is produced in the secondary of transformer **372** which is applied to the control anodes of storing gas tube SG over a circuit from marking or spacing contacts of relay **320**, conductors **321** and **322**, secondary winding of transformer **372** and conductor **323**; the impulses from transformer **372** thus are superimposed upon the plus or minus potentials applied by relay **320** to the storing tubes.

In the following description of the operation of the different parts of the system shown in Fig. 3, reference will also be made to the diagram of operations shown in Fig. 7.

This diagram includes a set of horizontally disposed curves A to M representing corresponding functions occurring at different points of the system during the reception of a series of pulses of an incoming code signal. The code signal comprises the START transition, the selecting or character transitions I, II, III, IV, V and the STOP transition and the arrival times of these transitions are indicated by correspondingly identified vertical lines extending across all of the curves, transitions III and IV having been omitted for simplification. The transition lines indicate the standard arrival times for the system in accurate relation to the arrival time of the START impulse of the received signal and thus do not indicate bias or other distortion.

The curves C to M are not intended to show accurately the details of variations in currents or voltages, but merely serve to indicate the instants at which changes take place and the general nature of the changes.

Curve A shows the pulses of the signal incoming to relay **320**. Thus normally a marking condition is received until the START pulse operates the relay to spacing and thereby establishes the reference instant for the succeeding operations. The code will, for the sake of example, be assumed to be as follows: the START pulse; selecting pulse I, which is marking and is delayed; pulses II and III, which are marking; pulses IV and V, which are spacing; and the STOP pulse which is assumed to arrive early. The relay **320** thus will operate from spacing to marking at the times **701** and **703** marked on the curve A.

Curve B shows the oscillating voltage at the terminal T of oscillator **330**. During rest condition the potential at T will be slightly positive due to the resistance drop in inductance **331**. Upon arrival of the START transition the oscillator produces a series of seven substantially pure harmonic voltage oscillations, each odd half cycle being negative and each even half cycle being positive. The duration of each cycle equals the standard pulse period.

Curves C, H and J show the variation in plate current in tubes **350**, **360** and **370**, respectively, as controlled by the oscillations, and curves D and K show the corresponding voltage impulses produced in the secondary windings of transformers **352** and **372**, respectively. The critical grid potential for tube **350** is shown in connection with curve B by the dot-dash line "**350**-critical," being more positive than the normal plus potential at point T before the START, so that the tube is normally non-conducting. At the time 711 during the positive half cycle and near the center of the START pulse tube 350 becomes conducting, and at the time 712 near the end of the cycle the tube again becomes currentless. The critical potential may be changed by adjusting potentiometer 351. The critical grid potential of tube 360 is similarly shown with curve B by dot-dash line "360-critical" and thus the tube, being normally currentless, becomes conducting at the time 713 and currentless at time 714 during the positive half cycle. The variations in grid potential for tube 370 relative to the critical potential are shown in curve I.

For the purpose of orientation during operation the instants at which the tube 360 becomes non-conducting may be phased relative to the standard transition instants established by the oscillators circuit 330 by means of the potentiometers 361 and 362, the adjustable contacts of which may be ganged together for simultaneous adjustment, so that the cathode-anode potential may be kept constant, once adjusted, while it is shifted relative to the grid potential. Accordingly, the potential line "360-critical" may be shifted above or below the zero line for curve B, with the object of securing the best operation for any general bias or other distortion of the signals.

The operations referred to above as taking place at the instants 711, 712, 713 and 714 during the first cycle of oscillations will, of course, be repeated at corresponding instants during each succeeding cycle.

Curve E shows the times of current flow in or firing of each of the distributor gas tubes DG. The tube DG—START is normally fired.

Curve F shows the operation of transfer relay 390 to marking during the STOP pulse.

Curve G shows the firing of the STOP gas tube 380 at the end of the signal.

Curves L and M relate to the functions of the storing gas tubes SG and, for the sake of clearness, these curves show the variations in control potential and the firing times, respectively, for only the tube SG—I, which stores the selecting pulse I.

The operations of the impulse producing circuit will now be briefly traced.

Upon operation of the receiving relay 320 to spacing at the START transition the STOP tube 380 is extinguished and the oscillator 330 enters its first negative half cycle. No change takes place in the impulse producing circuit until the time 711 during the positive half cycle when tube 350 becomes conducting. The rise in plate current produces a short negative pulse in the secondary winding of transformer 352 which has no effect.

At instant 713 tube 360 becomes conducting, thereby temporarily shifting the grid potential for amplifying tube 370 through condenser 364 and momentarily rendering tube 370 non-conducting. This causes the transformer 372 to produce a short strong positive impulse, followed by a short weak negative impulse in its secondary winding. The positive impulses produced by transformer 372 in this manner are used for the selective control of the storing gas tubes SG, as will be described hereinafter; since no tube SG is assigned to the START pulse the impulse produced during the START pulse will have no effect. Any negative impulse produced by transformer 372 will have no effect.

At instant 714 the tube 360 again becomes non-conducting, thereby temporarily making the grid potential of tube 370 more positive, through condenser 364. The tube 370 is operated on a portion of its characteristic near saturation so that an increase in grid potential will result in a comparatively small increase in plate current. The resultant negative and positive impulses produced at this time in the secondary winding of transformer 372 therefore will have no effect.

At the time 712 the tube 350 is rendered non-conducting thereby producing a positive impulse in the secondary winding of transformer 352 which is utilized for control of the gas tube distributor, as will be described hereinafter.

The operations just described will be repeated during subsequent cycles and under the control of the oscillator, these operations being independent of the incoming pulses and the operations of relay 320. Seven complete similar cycles will be produced in this manner, and exactly at the end of the seventh cycle, which occurs during the STOP pulse, the oscillator is cocked by the refiring of STOP tube 380, as will be described later, and the impulse producing circuit is restored to its normal or waiting condition.

It will thus be seen that an effective impulse is produced by transformer 352 at each standard transition instant for advancement of the distributor circuit, and that other effective impulses are produced by transformer 372 at orientable instants near the middle of the standard selecting pulse periods for control of the storing circuit.

The electronic distributor circuit, as already stated and as shown in Fig. 3, includes seven gas tubes DG. Each tube has associated therewith a resistance R1 and condenser C1 connected to the control anode and a resistance R2 and condenser C2 connected from minus to the cathode; the main electrode is connected over the common resistance 385 to plus. The resistance R1 connects the control anode with the cathode of the preceding tube and the condenser C1 connects the control anode to the impulse conductor 353 from transformer 352.

Still assuming that the system is in stop condition, all the distributor gas tubes DG are non-conducting except the tube DG—START.

Considering any one of the currentless tubes, such as DG—I, full minus potential is applied over resistance R2 to the cathode and plus potential is applied over common resistance 385 to the main anode; condenser C2 is discharged over resistance R2. Full minus potential is applied over resistances R2 and R1 in series to the control anode; condenser C1 is charged from minus over resistances R2 and R1 and the secondary of transformer 352 to ground. Thus the main gap has ample sustaining potential, whereas the control gap has direct minus potential on both sides.

Considering now the current condition in the tube DG—START, electron current flows from minus over resistance R2, the cathode and main anode, primary winding of transformer 382, common resistance 385 to plus; the potential drops in resistances R2 and 385 reduce the voltage across the main gap to near the sustaining value. Condenser C2 is charged across resistance R2. A biasing plus potential is thus applied to the control anode of tube DG—I through resistance R1—I. The condenser C1—I was previously discharged from its minus potential and has been subsequently recharged from the biasing plus potential and through the secondary of transformer 352 to ground. The circuit remains in this condition until the arrival of the START pulse.

Upon the arrival of a START pulse relay 320 operates to its spacing contact, thereby applying negative potential to the conductors 322 and 324. The tube 380 is extinguished and the oscillator circuit 330 is uncocked so that the first cycle of oscillations will operate the tubes 350, 360 and 370 as described above.

The first short plus impulse from transformer 352 is applied to all the condensers C1. This plus potential thus is momentarily added to the biasing plus potential already present on the control anode of the tube DG—I, the total potential being sufficient to fire the control gap, thereby firing the main gap; the plus impulse is deducted from the minus potential on all the other condensers C1 without effect.

The firing potential established at the control anode of DG—I by the short impulse is also applied back over resistance R1—I to the cathode of DG—START, thereby reducing the potential across the main gap of this tube below the sustaining value and extinguishing the tube; at this time the firing potential is also applied to condenser C2—START which temporarily charges and thereafter discharges over resistance R2, thereby delaying the restoration of full minus potential to the control anode of tube DG—I, and thus insuring the firing of the main gap in DG—I. When DG—I is fired the drop caused thereby in common resistance 385 aids in reducing the potential across the main gap in DG—START, thus further insuring the return to nonfired condition of the DG—START. With DG—I fired the drop in resistance R2—I applies a plus biasing potential to the control anode of tube DG—II for firing of the control gap only in this tube when the next impulse is applied.

It may be noted here that the varistor 381 and condenser 383 connected across the primary winding of transformer 382 are provided to reduce the rate of change of current in that winding when the main gap in tube DG—START is extinguished, the purpose being to prevent the impulse in the secondary winding from firing the control gap of the STOP tube 380 and react upon the oscillatory circuit at this time. However, due to the unilateral characteristics of the varistor 381, the suddenly rising current at the time of firing the main gap of DG—START during the Stop pulse will be forced through the transformer, inducing a potential in the secondary winding high enough to fire tube 380 and cock the oscillator.

In the manner described above, the next short impulse from transformer 352 will fire tube DG—II and extinguish the tube DG—I, and subsequent impulses from transformer 352 will successively fire the tubes DG—III, IV, V and DG—STOP, in each case extinguishing the preceding tube, so that at any time only one tube will be fired and during the time of a complete character code of seven pulses one tube will be fired at any time. The tubes DG will be fired at exactly equal intervals as determined by the short impulses from transformer 352 and the phase relation of the firing relative to the arrival over the circuit L of the front of the START pulse may be determined by adjustment of the potentiometer 351. The firing in succession of the DG tubes is indicated by curve E in Fig. 7.

The circuit through the main gap of tube DG—STOP may be traced from minus, over resistance R2—STOP, main gap, left winding of relay 390, resistance 385 to plus. Relay 390 is normally operated to its spacing contact by the right-hand biasing winding, and when tube DG—STOP is fired operates to marking, thereby removing minus potential from conductor 392 and applying it to conductor 391 for control of the storing and transfer tubes, as will be described hereinafter. While tube DG—STOP is fired it causes the biasing potential to be applied over conductor 354 and resistance R1—START to the control anode of tube DG—START. At the end of the seventh cycle the tube DG—STOP is extinguished and relay 390 is restored to spacing. The timing of these relay operations is indicated by curve F in Fig. 7.

As referred to above, the firing of the tube DG—START at the end of the seventh cycle causes an impulse to be produced in the secondary winding of transformer 382 which fires the control gap of STOP tube 380, thereby firing the main gap of this tube and cocking the oscillator 330. The impulse producing circuit and the distributor circuit thus will be restored to normal at the end of the seventh cycle and in time for the arrival of the next START pulse.

The receiving circuit shown in Fig. 3 further includes five sets of storing gas tubes SG and transfer gas tubes TG, each adapted to store the corresponding selecting pulse and transfer it to the output conductor 300 for use in any desired manner. These tubes are normally in nonconducting condition.

As shown in Fig. 3, the cathode of each storing tube SG is connected to a potentiometer circuit from negative potentiometer 388, over resistances R3, R4, R5 to plus. The control anode of each tube SG is connected to a control potentiometer circuit from minus, over resistances R2, R6, R7, conductor 323, secondary winding of transformer 372, conductor 322 and contacts of relay 320 to plus or minus. The potential across the control gap of each tube SG thus depends on the conditions in the control potentiometer circuit traced above.

In the following description simple values will be assumed for the various potentials involved; these figures are given for the sake of illustration of the general principles involved. Other suitable values may be worked out by those skilled in this art without a departure from the invention.

With relay 320 in spacing position the potential at the control anode of the SG tubes would be full minus (or about −40 volts); with relay 320 in marking position the potential at the control anode would be more positive (being changed by about +20 volts). With the cathodes of tubes SG at −40 volts the potential across the control gap would be zero for spacing, and for marking condition it would be about 20 volts.

With one of the distributor tubes DG—I to V in conducting condition the plus biasing potential due to the drop (20 volts) in resistance R2 will be superimposed upon the already established potential in the associated control potentiometer, rendering it more positive (by about 20 volts).

These conditions are represented by curve L of Fig. 7 as applied particularly to the storing tube SG—I for storing of the selecting pulse I. As shown by this curve the potential across the control gap is normally determined by the marking position of relay 320 (20 volts). After the Start transition the potential reduces to zero. At transition I the tube DG—I is fired (see curve E) and the resulting biasing potential raises the control gap potential (to 20 volts). When relay 320 goes to marking (delayed) the control gap potential is further increased (to 40 volts). When tube DG—I is extinguished at transition II the potential is reduced (to 20 volts) and remains at this value except while relay 320 goes to spacing, as during the pulses IV and V which are being assumed to be spacing pulses, when the potential becomes zero.

Thus it will be apparent that the tube SG—I is specially conditioned by the firing of tube DG—I, and that the control potential on the tube SG—I is further increased at this time (from 20 volts to 40 volts) if relay 320 is in marking position. With the firing potential assumed to be about 70 volts the tube still remains currentless. The firing potential is indicated on curve L, Fig. 7, by a dot-dash line "SG-firing."

Since the transformer 372 is included in all the control potentiometer circuits for the SG tubes it is evident that the impulses produced by the transformer at about the center of each cycle will make all the SG control anodes more positive (by 40 volts). Only the SG tube which is in a conditioned state can be fired by the impulse, and only during a marking pulse. Thus, as shown by curve L, three conditions of positive potential add up during the impulse from transformer 372 to exceed (by 10 volts) the firing potential of tube SG—I. If, as indicated by dotted line curve portions in curves A and L, the pulse I had been spacing, the potential across the control gap during the impulse would have been insufficient (60 volts) to start the tube SG—I.

Thus any one of the SG tubes may be started during a marking pulse provided the tube is conditioned by the distributor. The firing of the control gap automatically switches to the main gap, where the main anode is connected over resistance R8 to plus. The tube remains fired until the STOP pulse. These conditions are indicated for tube SG—I by curve M in Fig. 7.

Inasmuch as the biasing potential from any particular distributor tube DG contributes to the building up of the potential on the control anode of the associated SG tube, the further change toward positive of the biasing potential due to an impulse from transformer 352 at the end of the cycle will increase the control potential on the SG tube. To again consider tube SG—I, with this tube already fired the impulse would have no effect. With the tube currentless during a spacing pulse I and with the impulse from transformer 352 of a voltage not in excess of that from transformer 372 (40 volts) the combined potential applied across the control gap of tube SG—I at the end of the cycle would be insufficient to fire the tube.

Considering the particular condition of a marking pulse arriving early, it will for the sake of example be assumed that pulse I is spacing, tube DG—I is fired and tube SG—I is conditioned but not fired (control gap potential 20 volts). Shortly before instant II the relay 320 operates to marking, bringing the control gap potential on SG—I closer to firing value (40 volts). At instant II the impulse from transformer 352 is added to the control potential. Therefore, in order to prevent untimely firing of SG—I the voltage (20 volts) of this impulse must be appreciably less than that from transformer 372 (40 volts), so that the SG tube may be adjusted to discriminate between them. The firing potential of the SG tubes may be adjusted at potentiometer 388; if necessary a potentiometer 388 may be provided for each SG tube, to make the firing potential independent of the load from the fired tubes.

The operations of relay 320 also react to some extent through resistances R6 and R7 upon the biasing potential established by a fired DG tube for the succeeding DG tube. The change in biasing potential due to this cause should be appreciably less than the voltage of the impulse from transformer 352 to insure that the next DG tube will be fired by the impulse while relay 320 is in spacing, and also to prevent the conditioned tube from firing if relay 320 should go to marking. The biasing potential normally applied to tube DG—I while tube DG—START is fired is of course independent of relay 320 (the drop in resistance R2—START will still be assumed to be about 20 volts). When the impulse from transformer 352 (20 volts) arrives the sum of the two potentials (40 volts) exceeds the firing potential (30 volts) for the control gap; tube DG—I is fired and DG—II is conditioned. The biasing potential applied to tube DG—II is, however, made up of the drop in resistance R2 (20 volts) with the plus or minus potential from relay 320 superimposed thereon. In the case of a spacing pulse the biasing potential would be reduced (to about 15 volts, more positive than full minus) and in the case of a marking pulse it would be increased (to about 25 volts) the resultant potential in either case should be in sufficient to fire tube DG—II. With the impulse (20 volts) added from transformer 352, either of the resultant potentials (increased to 35 and 45 volts, respectively), should be sufficient to fire tube DG—II.

In the manner described above, an incoming signal may be stored on the storing gas tubes SG, any one tube being fired during a corresponding marking pulse at the proper time, as controlled by the distributor tubes DG, and the remaining tubes being left currentless. Thus, for the assumed signal the tubes SG—I, II, III will be fired and tubes SG—IV, V will be extinguished.

Each of the five transfer tubes TG has its control anode connected to the potentiometer R3, R4, R5, and its cathode is connected over conductor 391 and normally open marking contact of relay 390 to minus. The potential across the control gap, when relay 390 goes to marking position, will normally be too low for firing of the TG tube. However, when the associated SG tube is fired the consequent drop over resistance R3 will drive the control anode of tube TG enough toward positive to permit firing. Thus, when relay 390 operates to marking, as tube DG—STOP is fired, any TG tube which is connected to a fired SG tube will have its control gap fired.

The main anode of each TG tube is connected over an output conductor 300 to a suitable circuit which normally supplies +130 volts thereto. Thus, the arc in the fired tubes will automatically switch to the main gap, thereby establishing an operating curent over each conductor 300 associated with a received marking pulse.

The firing of the TG control gap tends to immediately increase the drop over resistance R5; however, the charge on condenser C3 insures complete firing of the main gap by temporarily maintaining the potential across the control gap. When the main gap is fired the main gap potential reduces to the sustaining value (about 32 volts), due to the resistance included in the circuit from conductor 300, as will be described hereinafter. Due to the charges on condensers C4 and C5 the potentials on the TG control anode and on the SG main anode will temporarily be driven more toward negative thereby extinguishing these two gaps. Thus, the storing tubes, which were fired, are extinguished at the beginning of the STOP pulse. After the passing of the seventh cycle the tube DG—STOP is extinguished and relay 390 returns to spacing position, thereby extinguishing the TG tubes and conductors 300 will be restored to their normal potential of +130 volts.

With the tube DG—START fired and the oscillator 330 cocked the entire receiving circuit is restored to normal ready for the next START pulse, having passed a marking current over conductors 300—I, II, III to the associated circuit, and no current over conductors 300—IV. V.

It will be noted from the description given above that the tubes TG responding to a spacing pulse will apply full plus potential to the output conductors and responding to a marking pulse will apply a reduced plus potential to the output conductor during the STOP pulse. This condition is conveniently utilized in the circuit arrangement shown in Fig. 4, as will be described hereinafter. However, for the purpose of establishing the reverse condition in the output conductors from the distributor circuit in Fig. 3, a set of transfer vacuum tubes TV is provided, with a second set of output conductors 301. For convenience in describing the system a set of two position switches 393 have been shown for switching the distributor circuit from one set of output conductors to the other. However, the system may readily be arranged for simultaneous use of both sets of output conductors in circuits requiring the two modes of operation.

For the present purpose the switches 393 will be assumed to be in their lower position in which case plus potential is normally supplied through resistance R11 to the main anode of the transfer gas tubes TG so that the TG tubes which have been conditioned by a marking pulse will be fired during the STOP pulse. Each vacuum tube TV has its control grid connected to an intermediate point of the potentiometer R13, R10, R11, connected from minus to plus, and normally the potential applied to the grid is high enough to cause a flow of plate current from plus through the resistance R12 and the cathode-anode path of the tube to ground, thereby establishing a potential drop in resistance R12. Thus, under normal conditions the output conductors 301 will be at a potential lower than the plus potential.

Again, assuming that the storing tubes SG—I. II, III will be fired and that the tubes SG—IV, V will be extinguished at the time the STOP pulse arrives and operates relay 390 to marking, the corresponding TG tubes will be fired and extinguished, respectively. Thus, considering the code unit I, the current flow in the resistance R11 will be increased thereby driving the grid potential of tube TV—I less positive. The tube becomes currentless, thereby eliminating the drop in resistance R12 so that full plus potential will be applied to conductor 301—I. In the case of the code unit IV the TG tube will not be fired so that the tube TV—IV will continue to carry plate current and to maintain the reduced plus potential on output conductor 301—IV.

In this manner the TV tubes responding to a marking condition will apply high plus potential to the output conductors and those responding to spacing will apply a reduced plus potential to the output conductors during the STOP pulse. This mode of operation is particularly suitable for the circuit arrangement shown in Fig. 5, as will be described hereinafter.

The circuit arrangement shown in Fig. 4 is adapted to respond particularly to the combination FIG—H, as received by the receiving circuit shown in Fig. 3. This combination signal is transmitted by a subscriber to a teletype automatic exchange before the sending of the called station code, the object being to automatically operate a switching arrangement for temporarily associating a register circuit with the line which will respond to the immediately following station code for control of selector switches. Upon reception of the station code the register is adapted to again cut the line circuit through for sending of the message proper.

This circuit must be continuously associated with a seized line through the receiving circuit in Fig. 3 in order to respond any time when the FIG—H combination is transmitted for the selection of a station. The arrangement has the important advantage of having no moving mechanical parts, which obviously would be subject to constant wear, though effectively used only at comparatively great intervals.

The system in Fig. 4 is based on the features shown in Fig. 1, and thus includes a plurality of code unit or inverter circuits I to V, there being one inverter circuit for each of the five units of the code; the system further includes three code discriminating and responsive circuits 410, 420 and 430 assigned to the symbol H (code—3—3), the symbol FIG (code 12—45) and a symbol RESTORE FIG, respectively.

Each code unit circuit includes a vacuum tube V and resistances R1, R2, R3 and R5 arranged as in Fig. 1 relative to the two output terminals *a* and *b* connected to a pair of conductors A and B for cross-connection to the code discriminating circuits. The input conductor 400 connects to the corresponding conductor 300 in Fig. 3, and includes normally closed contacts K of the common switching relay 460. For the operation of the circuit in Fig. 4, the switches 393 in Fig. 3 should be in their upper position.

Thus +130 volts is normally supplied over resistance R1 to the conductor A and over conductors 400 and 300 to the main anode of the corresponding tube TG in Fig. 3. With the tubes V normally in conducting condition, the drop in resistances R5 will cause a reduced plus potential to be applied to the conductors B.

When a tube TG in Fig. 3 is fired by code selection the consequent drop in resistance R1 will reduce the potential on the conductor A and also on conductor 400 thereby extinguishing the associated tube SG in Fig. 3, as already explained. The potential applied to the grid of tube V will also be reduced, thereby rendering the tube nonconducting. The drop in resistance R5 will disappear and full plus potential will be applied to the conductor B.

These operations take place at the beginning of the seventh cycle. At the end of the seventh cycle the TG tubes in Fig. 3 are extinguished by the return of relay 390 to spacing. With current over conductors 400 interrupted by relay 390 the code unit circuits I to V in Fig. 4 will be restored to normal, thereby inverting the potentials on conductors A and B to their normal disposition. In this manner a signal received and stored by the circuit in Fig. 3 is impressed during the seventh cycle upon the conductors A and B for operation of the code discriminating circuits 410, 420, 430.

Each of these circuits includes a potentiometer of five branches r and a common branch R, as shown in Fig. 1, the resistances r being connected in accordance with the code requirements to either conductor A or conductor B from each code unit circuit. The vacuum tube V of each code discriminating circuit may be normally conducting and responds to the minimum grid potential applied to the potentiometer r, R to become currentless, thereby conditioning its associated gas tube G for firing. However, as explained hereinafter, the tube V—430 is normally non-conducting.

Referring particularly to the code discriminating circuit 420 the control anode of the tube G is connected to a point of intermediate potential on a potentiometer circuit from plus over resistances 421, 422, 423 to minus. The cathode is connected over contact 427, resistance 425 to minus. When tube V—420 becomes currentless the drop over resistances 421 disappears thereby driving the control anode more positive and firing the control gap. With the main anode connected over resistance 424 to plus the main gap is automatically fired. The potential drop over resistance 425 places a biasing or conditioning potential on the conductor 428. At the end of the seventh cycle the tube V—420 is again rendered conducting by the restoration of normal voltage disposition on all conductors A and B. The firing of tube G—420 thus takes place every time the UPPER CASE or FIG code is received and normally continues until the RESTORE FIG is received.

The code discriminating circuit 410 and 430 are arranged similarly to the circuit 420 except that the potentiometers for the control gaps of tubes G—410 and G—430 include the resistance 425, so that those control gaps are driven more positive by the firing of tube G—420, a condition which is necessary for the subsequent firing of either tube G—410 or G—430 by their respective vacuum tubes in response to their assigned codes. Thus, the reception of the codes for H or RESTORE FIG will not fire the corresponding gas tube G unless those codes have been preceded by the code for FIG.

The tube G—430 has its cathode connected over conductor 391 and marking contact of relay 390 in Fig. 3 to minus. This circuit will be closed during the seventh cycle, so that the tube may be fired only during that interval. With the tube G—420 already fired the condenser 426 will be charged due to the drop over resistance 424 so that upon firing of tube G—430 the potential across the main gap in tube G—420 will momentarily be driven below the sustaining value, and tube G—420 will be extinguished. At the end of the seventh cycle relay 390 opens the circuit for tube G—430 and the system is restored to normal.

When the combination for H is received immediately after the tube G—410 has been conditioned by the firing of tube G—420, the consequent firing of tube G—410 will cause the operation of relay R connected in the main anode circuit. This operation of relay R in response to FIG immediately followed by H may be utilized in different manners and for different purposes. Thus, relay R may operate the gang relay 460, thereby switching all five conductors 300 from the code unit circuits to a suitable receiving or registering circuit for the immediately following station calling code still incoming over the receiving circuit in Fig. 3. The relay 460 may lock itself over a suitable control circuit 450 which

may form part of the register circuit, and which may be opened when the register has been satisfied, that is, completely set. Thus, at the end of the called station code the circuit in Fig. 4 will be restored to normal for continued checking of the following message. Contacts 417 and 427 may be provided for automatically extinguishing the tubes G—410 and G—420, upon operation and locking of relay 460. Thus, these contacts may be directly operated by relay 460.

It should be noted that it is desirable to have available for use in the messages the combination UPPER CASE—H or FIG—H, and that therefore this combination should be available for the present purpose only when the code for H follows immediately upon the code for FIG. In order to accomplish this the arrangement is such that the tube G—430 will be fired in response to any code, except the code —3—5 for H, immediately following the firing of tube G—420, thereby extinguishing tube G—420.

This mode of operation is attained by the adjustment of the cathode potential of tube V—430 on potentiometer 439 to a comparatively low value, so that for all potentials, except the maximum, applied to the grid by incoming codes the tube will remain non-conducting and condition the tube G—430 for firing to in turn extinguish tube G—420. The maximum potential will be applied to tube V—430 only when the code —3—5 for H is received which thus at the same time applies minimum potential to tube V—410 and maximum potential to tube V—430. For this purpose the cross-connections to conductors A and B from the resistances r—430 will be the reverse of those from resistances r—410. As a result the tube V—430 will be non-conducting when the circuit is in selected condition between Stop pulses, but is prevented from firing tube G—430 by the opening of the cathode circuit at relay 390 until the Stop pulse.

The decoding circuit shown in Fig. 5 is at least in part based upon the principles of the circuit shown in Fig. 1. Thus, the circuit of Fig. 5 includes five code unit or inverter circuits I, II, III, IV and V connected over pairs of conductors A and B to two code discriminating circuits 520 and 530 responsive particularly to the codes for FIG and LETTERS, respectively. The system, as shown, also includes a translating arrangement connected to the conductors B and terminating in the deflecting plates of a cathode ray tube 550 for selective deflection of the beam in accordance with each incoming code and for display of the corresponding symbol.

This circuit is also adapted for operation with the distributor circuit shown in Fig. 3, in which the switches 393 should be operated to their lower position.

Each of the inverter circuits I to V thus includes a vacuum tube V and resistances R1, R2, R3 and R5 connected to plus and minus potential and to a pair of conductors A and B, substantially as shown in Fig. 1. For the control of each inverter circuit current control means, such as a storing gas tube SG is provided, which during the seventh cycle will respond to the condition imposed upon its input conductor 500 by the corresponding transfer vacuum tube TV in Fig. 3 over a conductor 301. When the tube SG in Fig. 5 is non-conducting the tube V will be conducting and the conductor A will have high potential and the conductor B will have low potential.

The control anode of tube SG is connected to a point of the potentiometer circuit formed by resistances 502, 503 and 504 connected between ground and plus and thus has a positive potential applied thereto (of 30–40 volts); under this condition the condenser 501 is charged to the same potential. The cathode is connected over the conductor 392 and over the normally closed spacing contact of relay 390 to minus.

Assuming the circuit as shown in Fig. 5, to be in the condition prevailing during the seventh cycle, when relay 390 is operated to marking thereby disconnecting minus from the cathodes of the SG tubes, these will all be extinguished. Further assuming that the pulse I is marking and that consequently the transfer tube TV—I in Fig. 3 is non-conducting during the seventh cycle, then the potential on the condenser 501—I and on the control anode of tube SG—I will be sufficient for firing of the tube when at the end of the seventh cycle relay 390 again applies minus to the cathode. The condenser 501 will retain a sufficient charge during the travel time of relay 390 to insure proper firing of the tube. As a result the main gap is fired over resistance R1—I to plus, which causes the inversion of the potentials on the conductors A—I and B—I in the manner described for Fig. 1. The tube SG—I will remain fired until the next seventh cycle, thus storing the marking condition until the STOP pulse of the succeeding signal.

Further assuming that the pulse II is spacing, the tube TV—II in Fig. 3 will be conducting during the seventh cycle, in which case the potential on condenser 501—II and the control anode of tube SG—II will be low and insufficient to fire the tube, when relay 390 returns to spacing and completes the cathode circuit to minus. The conductors A—II and B—II thus retain their normal potentials undisturbed.

Similar functions take place in all the code unit circuits I to V depending upon the marking and spacing condition of the corresponding pulses of the code signal, so that the potentials on the conductors A and B will be correspondingly disposed and will retain such disposition during the reception of the succeeding signal until the STOP signal thereof.

The cathode ray tube 550 may be of conventional type and includes the usual elements, such as cathode 553 and elements 554, 555 and 556 for projecting and focusing the beam, these elements being connected to suitable potentials on potentiometer 552 connected to the source of direct current 551. A pair of horizontal positioning or deflecting plates 561 and 562 and a pair of vertical positioning or deflecting plates 563 and 564 are arranged for deflecting the beam horizontally and vertically, respectively, in accordance with marginal potentials impressed upon these plates through resistances 581, 582, 583, 584, 585 and 586 by the code responsive circuits. The tube elements are enclosed in a sealed vessel 560, usually of glass, containing an inert gas at low pressure. The enlarged end of the tube 560 is coated with a suitable material adapted to be activated by the beam for luminous display of the beam spot. The reading surface thus provided has a display screen 570 incorporated therein containing the upper and lower case symbols represented by the code, these symbols being arranged in horizontal and vertical lines, as shown more in detail in Fig. 6. The object is to deflect the floating beam in accordance with each incoming code signal to strike a corresponding symbol on the screen 570 and thereby make the symbol visible or optically effective for recording. The screen may be placed in any convenient manner to either produce a shadow of a symbol on an illuminated background outlined by the beam or to produce an illuminated symbol on a dark background. The beam will be at rest on a selected symbol at least during the first six cycles of operation of the circuit Fig. 3 and the luminous material in the screen 570 may have sufficient persistance of luminosity to permit the reading of successive symbols by the eye, even at the speed of normal teletype operation.

The field of symbols, shown in Fig. 6 includes a plurality of horizontal rows 1 to 8 and vertical rows *a* to *h*. The LETTERS are disposed in the odd numbered rows and the FIGS in the even numbered rows. Other arrangements of the two cases may however be provided. The deflecting plates 561, 562, 563 and 564 are indicated in this diagram in their relation to the rows. The adjustments in the circuit are such that the beam will be focused on the vacant space 5, *d* in response to an all spacing code, for which condition all the deflecting plates receive high potential. The vacant space may, of course, be differently chosen, if desired.

The plate 561 is connected through resistance 581 to the conductor A—1 and thus will have high plus potential for a spacing pulse I and low plus potential for a marking pulse I. The change from high to low potential will cause the beam to be deflected four spaces to the right from any position it may happen to occupy.

The plate 562 is connected through resistance 582 to conductor A—V and through resistance 583 to a point *c* on resistance R1—III. Thus for a marking pulse III the point *c* on resistance R1 will be at an intermediate potential and for a spacing pulse III the point *c* will be at high plus potential. For a marking pulse V the resistance 582 will receive low plus potential and for a spacing pulse V resistance 582 will receive high plus potential. The combination of these potentials applied to resistances 582 and 583 will variously affect the potential applied to the plate 562. Thus with both resistance 582 and 583 receiving high potential for spacing pulses III and V there will be no effect on the beam. With high potential on resistance 583 and low on resistance 582, half of the difference will be applied to plate 562, causing the beam to move two spaces to the left. With intermediate potential on resistance 583 and high potential on resistance 582, only half of the difference between these potentials will be applied to plate 562, causing the beam to move one space to the left. With intermediate potential on resistance 583 and low potential on resistance 582 the beam will move three spaces to the left. This general principle of potential division may, of course, be extended to include control of plate 562 by one or more additional code units, either within the five-unit code or in a code with six or more units.

The plate 563 is connected over resistance 584 to the conductor A—II to receive high potential for a spacing pulse II and low potential for a marking pulse II. The change from high to low potential will move the beam four spaces down.

The plate 564 is connected through resistances 585 and 586 to receive combination potentials from the conductor A—IV and from the point *d* on resistance 511 in the circuit 510. As will be explained hereinafter, the tube V—510 will be in spacing condition, that is, non-conducting when the LETTERS condition is established and in marking or conducting condition when the FIG condition is established. The point *d* thus will be at high plus potential for LETTERS and at intermediate potential for FIG. Thus with low potential on resistance **585** for a marking pulse IV and high potential on resistance **586** for LETTERS the beam will move up two spaces. With LETTERS changed to FIG there would be an intermediate potential on resistance **586** which with low potential on resistance **585** will move the beam up three spaces. With a spacing pulse IV and FIG the high potential on resistance **585** and intermediate potential on resistance **586** will move the beam up one space.

Thus for the sake of example, it will be assumed that the beam is focused on the space **5**, *d* for an all spacing code. For the first signal having the code 1 — — — —. the beam will move to the space **5**, *h* displaying the corresponding symbol "E". For the next signal having the code 12 — — —, the beam moves four spaces down, showing the corresponding symbol "A". For the next code 123 — —, the beam moves one space left, showing the symbol "U." For the next code 1234 —, the beam moves two spaces up, showing the symbol "K." For the next code being 12345, the beam moves to the space **3**, *e* corresponding to "LETTERS."

In a similar manner the operations for any other code combinations may be traced.

Generally speaking a reduction in potential on a plate in the cathode ray tube equal to the full difference between high and low plus potential will deflect the beam four spaces away from the plate. When the reduction in potential is applied through a pair of resistances, such as **582** and **583** or **585** and **586**, the deflection will be only two spaces away from the plate. When the reduction is further divided as by the resistance **583** being connected to the mid-point of resistance **R1** or as in the case of resistance **586** being connected to the mid-point of resistance **511**, then the beam will be deflected only one space away from the plate.

It should be understood that the shifting of the beam over **1**, **2** and **4** spaces in different combinations by a pair of plates may be accomplished by applying corresponding potentials to one of the plates and maintaining a constant potential on the other plate, or that these three selective actions may be apportioned between the two plates of a pair in any manner, the starting point of the beam being changed accordingly.

It will thus appear that with two pairs of positioning elements arranged in quadrature about the floating beam and with suitable use of potential dividers as described herein to supply the required marginal positioning forces, a single tube may be used for selective action in response to codes of more than five units. Thus with a code of *n* units, the field may contain 2^n spaces. Of these, 2^m spaces may be selected in response to *m* units of the code applied to one pair of plates, and the remaining 2^{n-m} spaces may be selected in response to $n—m$ units applied to the other pair.

It will be noted that the operations traced above result in the display of symbols only in odd numbered horizontal lines in which the letters are displayed. In order that the symbols in the even numbered rows, viz., the figures, may be displayed by corresponding codes it will be necessary to temporarily shift the beam upward one space. This will be accomplished by the transmission before the symbol of the code **12—45** for FIG which will be received in the circuit **520** where the tube V would become non-conducting. When this happens the potential applied from the potentiometer of resistances **521**, **522**, **523** to the control anode of the associated gas-filled tube G will be made sufficiently positive to fire the control gap and consequently fire the main gap of this tube. The current in the main gap flows from minus over resistance **525**, main gap, resistance **524** to plus. Resistance **525** being included in a potentiometer circuit with resistance **512**, the potential drop therein makes the grid potential in the tube V—**510** more positive, thus rendering the tube conducting; the consequent drop in resistance **511** will decrease the plus potential applied over resistance **586** to the plate **564** which thus will shift the beam upward one space. The tube G—**520** will remain fired during subsequent signals; thus upon the reception of the code for FIG all subsequently received codes will cause the beam to display the corresponding symbol in any of the even numbered rows.

When at any time thereafter the code for LETTERS is received the tube V—**530** will be rendered non-conducting, thereby firing the tube G—**530** in the same manner as explained for the tube G—**520**. The condenser **526** having been charged by the potential drop in resistance **524** since the firing of the tube G—**520**, its potential at the time of firing of tube G—**530** drives the potential on the main anode of tube G—**520** to a value less than the sustaining potential thereby extinguishing the tube G—**520**. As a result the tube V—**510** is again rendered non-conducting, thereby increasing the plus potential on plate **564** and lowering the beam one space for subsequent display of symbols in the odd numbered rows.

The gas tubes G—**520** and —**530** are mutually extinguishing through the condenser **526** which will be charged alternately across the resistances **524** and **534**.

It should be understood that the gas tube G—**520** and the vacuum tube V—**510** may be arranged as tubes SG—VI and V—VI for direct response to a sixth code unit, in which case the LETTERS circuit **530**, of course, would be unnecessary.

It should furthermore be understood that the positioning plates in the cathode-ray tube may be connected to the B conductors instead of the A conductors for each code unit, or that some of the connections may be made to the A conductors and the others to the B conductors, with corresponding relocation of the symbols on the display screen **570**.

The system, as shown in Fig. 5, may, of course, be used for selecting other circuits, besides the circuits **520** and **530**, in response to other code combinations. Thus, a circuit may be provided which will operate an audible signal in response to FIG—S in accordance with general practice.

The cathode-ray tube **550** may be readily adapted for circuit selection instead of for decoding into visible symbols. For this purpose the field of letters **570**, shown more in detail in Fig. 6, should be replaced by a field of separate circuit elements mounted on the end surface of the tube and connected for selective control of corresponding circuits in response to contact with the floating beam. The energization of individual circuits by the beam for the duration of a signal may be accomplished by different means.

Reference may be had to United States Patent 2,057,773, issued to Finch on October 20, 1936 which in Fig. 1 shows single contact elements transmitting impulses into separate circuits by direct contact with the beam. In the United States Patent 2,195,098, issued to Skellett on March 26, 1940 a similar but intensified action is secured by secondary ionization between double contact elements under impingement by the beam. Any well-known means may be used to establish a time margin in each circuit to insure positive control during the exposure time, and to exclude control while the beam travels between positions during the stop pulse.

A diagrammatic showing of such an arrangement is given in Fig. 8. Only a portion of the field of contacts or electrodes is shown. The common electrode **571** provides a plurality of compartments **572** arranged in rows similar to those shown in Fig. 6. Within each compartment an individual electrode **573** is mounted and is connected through the tube wall to an external circuit **574**. Each compartment and its electrode is aligned with the direction of the beam so that when struck the space between them will be ionized and cause a current to flow between the common conductor **575** and the individual conductor selected.

For number checking or identification on a 10-digit basis, the tube may have 10 x 10 targets selectable by a 7-unit permutation code. With two such tubes in cooperation, 10,000 numbers could be checked or selected by two 7-unit codes.

What is claimed is:

1. A circuit selecting system comprising a source of potential, a plurality of receiving circuits, one for each code unit, each comprising a first potentiometer circuit connected across said source, a second potentiometer circuit connected across said source, current control means responsive to impressed alternate characteristics of the assigned code unit for changing the potential gradient in said first potentiometer circuit between alternate conditions and potential responsive means included in said second potentiometer circuit for changing the potential gradient in said second potentiometer circuit between alternate conditions in response to the alternate potential conditions in said first potentiometer circuit, said decoding system further comprising a plurality of code discriminating circuits each including a third potentiomter circuit having a potential gradient section for each unit of the code connected to one or the other of said first and second potentiometer circuits of the corresponding receiving circuit in accordance with an assigned code combination to establish in said third potentiometer circuit an intermediate potential successively changed in accordance with the successively received code combinations and circuit selective means connected to said third circuit and adjustable to be responsive only to a selected one of said intermedate potentials in said third potentiometer circuit for selection of a preassigned circuit.

2. A circuit selecting system in accordance with claim 1 in which said first potentiometer circuit includes a by-path for a portion of said first potentiometer circuit and said control means is connected to render said by-path alternately non-conducting and conducting for the said change of potential gradient in said first potentiometer circuit and in which said potential responsive means comprises an electron discharge tube connected to be rendered alternately conducting and non-conducting, respectively, in response to the alternate potential gradients in said first potentiometer circuit.

3. A circuit selecting system in accordance with claim 1 in which said first potentiometer circuit includes a by-path about a portion thereof and said control means includes relay means having contacts for alternately opening and closing said by-path to establish normally a high and alternately a low potential at an intermediate point of said first potentiometer, and in which said second potentiometer circuit includes two series sections, and said potential responsive means includes a triode tube having a control element connected to said first potentiometer circuit to receive alternately high and low potentials and having a cathode-anode circuit adapted to be controlled by said control element to be alternately conducting and non-conducting, respectively, and said cathode-anode circuit being included in one of said sections to change the potential across said section normally to low and alternately to high value.

4. A decoding system comprising a receiving circuit for each unit of the code having a first potentiometer circuit with a first output terminal, a second potentiometer circuit with a second output terminal, code unit responsive means connected to said first potentiometer circuit to establish alternately high and low potentials at said first output terminal in response to alternate characteristics of the assigned code unit, and potential responsive means included in said second potentiometer circuit and connected to said first potentiometer circuit to establish substantially the same low and high potentials, alternately, at said second output terminal as at said first output terminal and in response to the alternately high and low potential conditions, respectively, in said first potentiometer circuit, said decoding system further comprising a plurality of code discriminating circuits connected to the said first and second output terminals in accordance with code requirements, to each respond to a predetermined combination of said high and low potentials representing its assigned code combination by establishing a corresponding discriminatory potential within said code discriminating circuit.

5. A decoding system for a code with a fixed plurality of code units comprising a source of potential, a receiving circuit for each code unit including relay means responsive to alternate characteristics of the assigned code unit to open or close its contacts, a first potentiometer circuit connected across said source and having a first point normally of high potential, a second point normally of lower potential and a low resistance path connected through said relay contacts in closed condition for changing said first point to alternate low potential, a second potentiometer circuit connected across said source and having a third point normally of said low potential and a normally conducting triode tube with an anode-cathode circuit connected to said third point and with a control element connected to said second point, the potential at said second point being alternately reduced for rendering said tube non-conducting when said contacts are closed, said third point being alternately of said high potential when said tube is non-conducting, said decoding system further comprising a plurality of code discriminating circuits connected to said first and third points in said receiving circuits in accordance with code requirements, to each

establish a discriminatory potential representing its assigned code combination in response to a predetermined combination of said high and low potentials.

6. A decoding system comprising a plurality of code unit receiving circuits each including a first potentiometer circuit having a first output terminal, current control means responsive to alternate characteristics of the assigned code unit to establish normally a high and alternately a lower potential at said first terminal, a second potentiometer circuit having a second output terminal, and other current control means responsive to potential changes in said first potentiometer circuit to establish normally said lower and alternately said high potential at said second terminal, said decoding system further comprising a plurality of code discriminating circuits each including a third potentiometer circuit having a common section, a receiving section for each of said code unit receiving circuits and a third output terminal at the junction between said sections, said receiving sections in said code discriminating circuits being connected to the said first or the said second terminal of their corresponding code unit receiving circuits in accordance with code requirements to establish at said third terminals potentials successively changing in accordance with the successively received code combinations, and a plurality of symbol selective means connected for individual selection in response to selected potentials at said third terminals to establish corresponding decoded symbols.

7. A decoding system in accordance with claim 6 in which certain of said symbol selective means are selectable by only the minimum potential established at their associated said third terminal by incoming code combinations.

8. A decoding system in accordance with claim 6 in which one of said symbol selective means is selectable by all potentials except one established at the associated said third terminal by incoming code combinations.

9. A decoding system in accordance with claim 6 in which one of said symbol selective means is selectable by all potentials except the maximum potential established at the associated said third terminal by incoming code combinations to establish the decoded symbol corresponding to said maximum potential.

10. A decoding system in accordance with claim 6 in which each symbol selective means includes operating means responsive to the selection of said symbol selective means, a first of said operating means being operable in response to a first code combination for conditioning a second operating means and for establishing a first decoded symbol, said second operating means being operable in response to a second code combination only when conditioned by said first operating means for restoring said first operating means to normal condition and establishing a second decoded symbol.

11. A decoding system in accordance with claim 6 in which each symbol selective means includes operating means responsive to the selection of said symbol selective means, a first of said operating means being operable in response to a first code combination for conditioning a second and a third of said operating means, said second operating means being operable in response to a second code combination only when conditioned by said first operating means for controlling a switching circuit, and said third operating means being operable in response to any code combination except said second code combination and only when conditioned by said first operating means for restoring said first operating means to normal condition.

12. A selective system responsive to permutation code signals comprising a plurality of receiving means each including first circuit means including first electronic means for establishing normally a high and alternately a low output potential in accordance with the alternate characteristics of the code units of the signals, said receiving means also including second circuit means including second electronic means for establishing normally a low and alternately a high output potential in accordance with the alternate conditions of said first electronic means, and said selective system further comprising a plurality of circuit networks each connected in accordance with the code requirements to said first and said second circuit means in all of said receiving means and being adapted to combine said output potentials into distinctly different discriminatory potentials for the corresponding different permutation codes and a selecting circuit for each of said networks including electronic means having a control element responsive to one predetermined said discriminatory potential for selective action.

13. In a signaling system, signal receiving means for each unit of a permutation code and responsive to the alternate characteristics of said unit to establish alternately a high and a low output potential, auxiliary receiving means for each code unit including electronic circuit closing means responsive to the alternate conditions in the associated said signal receiving means to establish alternately a low and a high output potential, a plurality of operating circuit means, and a circuit network connected to receive and combine said high and low output potentials from all of said receiving means for any one code permutation and to apply simultaneous discriminatory resultant potentials of different values to all of said operating circuit means, said operating circuit means each including electronic circuit control means capable of being conditioned alternately into a conducting and a non-conducting state and all of said electronic control means being adjusted to change between said states in response to a common predetermined range of discriminatory potentials applied by said network for selective operation of at least one of said operating circuit means.

14. Apparatus for receiving permutation code signal units each having two selecting characteristics, comprising an electron discharge tube for each code unit having a characteristic condition of conductivity for each of said two selecting characteristics, potential divider means associated with each of said tubes for supplying concurrently a high potential at one dividing point and a low potential at another dividing point for one of said conditions of conductivity and conversely for supplying a low potential at the first-mentioned dividing point and a high potential at the second-mentioned dividing point for the other of said conditions of conductivity, a plurality of circuit networks each connected in accordance with the code requirements to said first-mentioned and said second-mentioned dividing points of said potential divider means and being adapted to combine the potentials supplied thereat into distinctively different discriminatory potentials for the corresponding different permutation codes, and a selecting circuit for each

of said networks including electronic means having a control element responsive to one predetermined discriminatory potential for selective action.

15. Apparatus for receiving permutation code signal units each having two selecting characteristics, comprising an electron discharge tube for each code unit having a characteristic condition of conductivity for each of said two selecting characteristics, potential divider means associated with each of said tubes for supplying concurrently a high potential at one dividing point and a low potential of the same polarity at another dividing point for one of said conditions of conductivity and conversely for supplying a low potential at the first-mentioned dividing point and a high potential at the second-mentioned dividing point, both of said same polarity, for the other of said conditions of conductivity, a plurality of circuit networks each connected in accordance with the code requirements to said first-mentioned and second-mentioned dividing points and being adapted to combine the potentials supplied thereat into distinctly different discriminatory potentials for the corresponding different permutation codes, and a selecting circuit for each of said networks including electronic means having a control element responsive to one predetermined said discriminatory potential for selective action.

WILTON T. REA.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,938,899	Gilman	Dec. 12, 1933
2,053,156	Livingston	Sept. 1, 1936
2,099,065	Holden	Nov. 16, 1937
2,210,576	Fitch	Aug. 6, 1940
2,267,827	Hubbard	Dec. 30, 1941
2,275,017	McNaney	Mar. 3, 1942
2,361,766	Hadekel	Oct. 31, 1944
2,381,920	Miller	Aug. 14, 1945
2,407,320	Miller	Sept. 10, 1946

FOREIGN PATENTS

Number	Country	Date
355,705	Great Britain	Aug. 24, 1931