Feb. 22, 1949. J. R. DESCH ET AL 2,462,613

COMMUNICATION SYSTEM

Original Filed Sept. 16, 1942 9 Sheets-Sheet 1

FIG. I

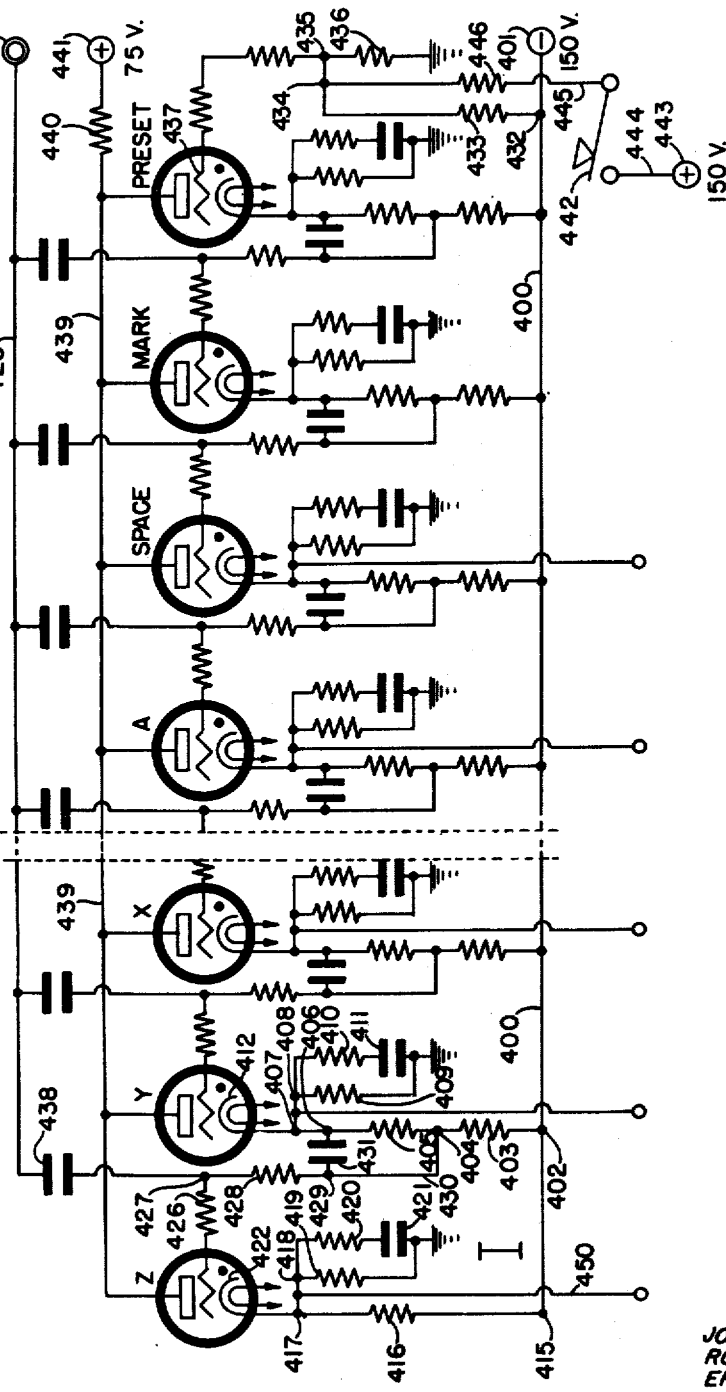

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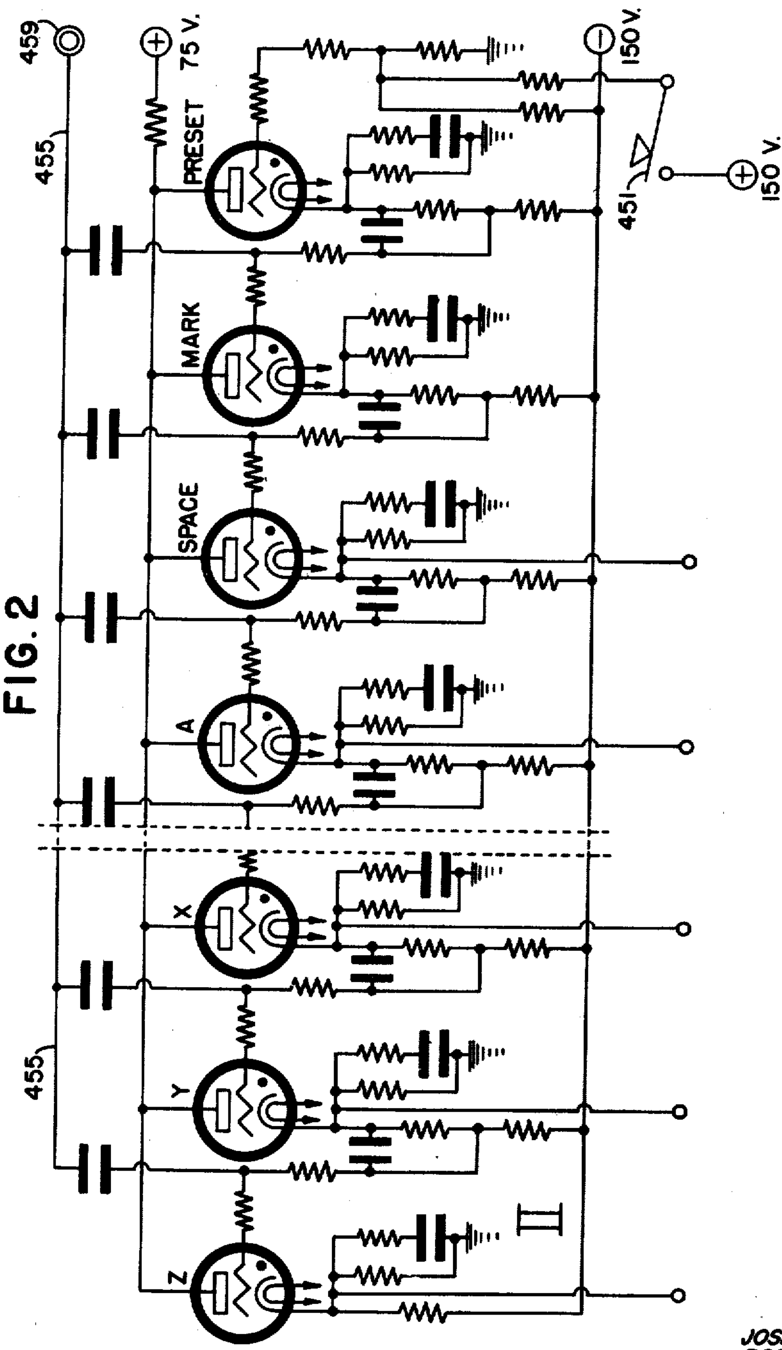
FIG. 2



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COMMUNICATION SYSTEM

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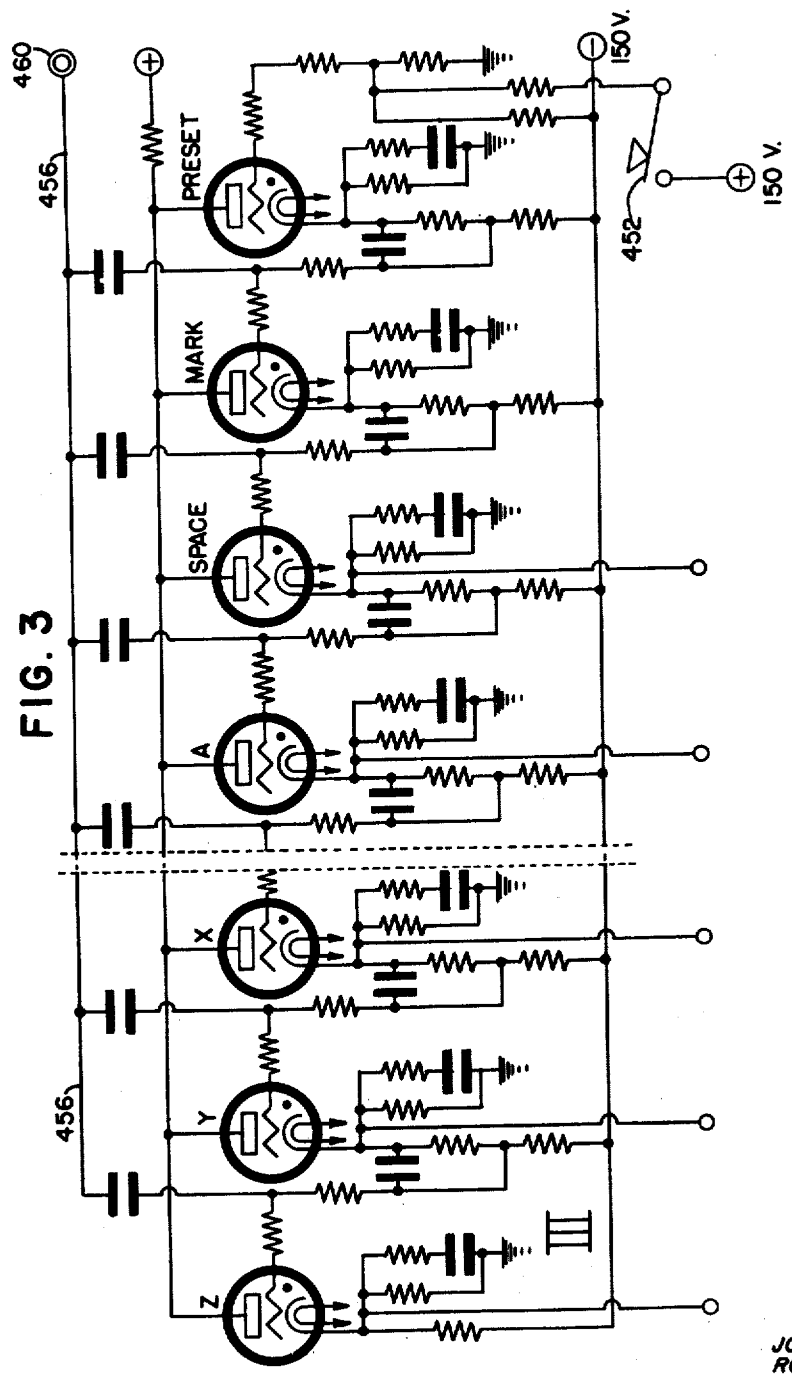

FIG. 3

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COMMUNICATION SYSTEM

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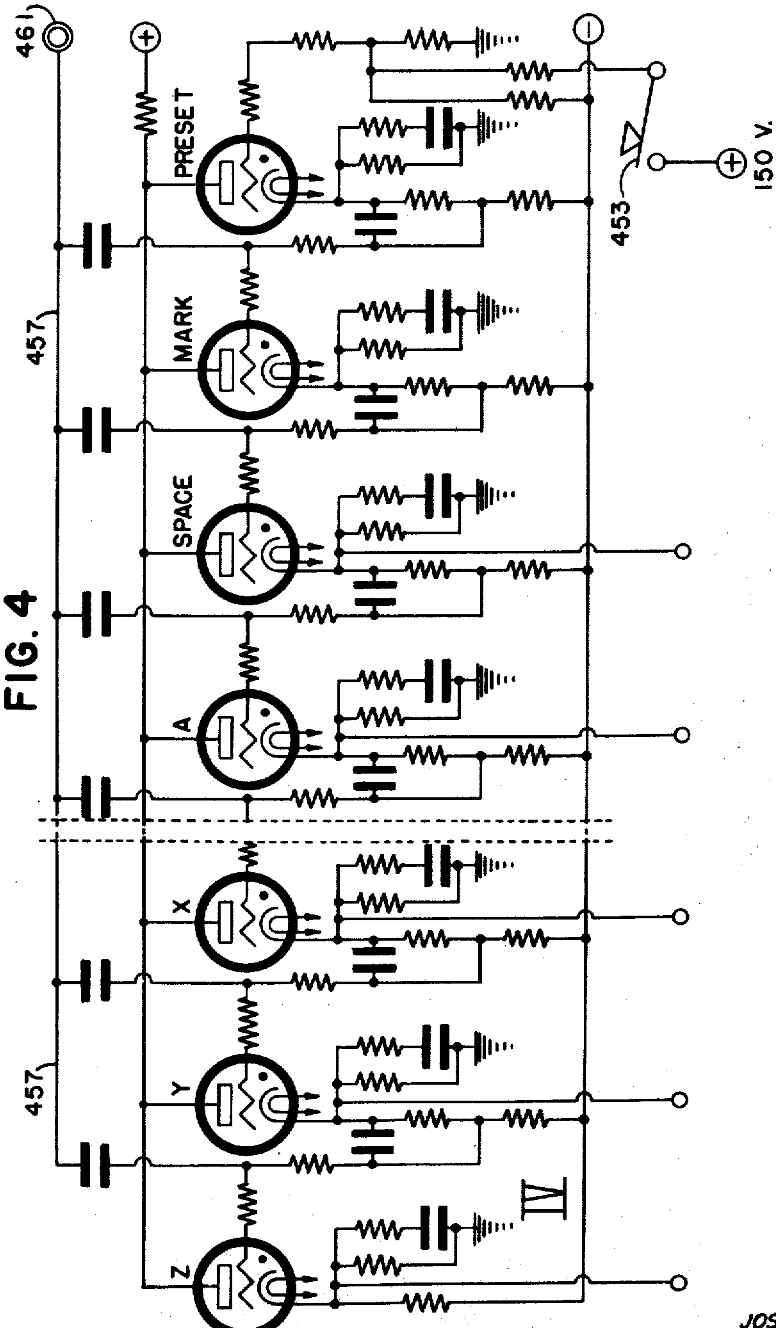

FIG. 4

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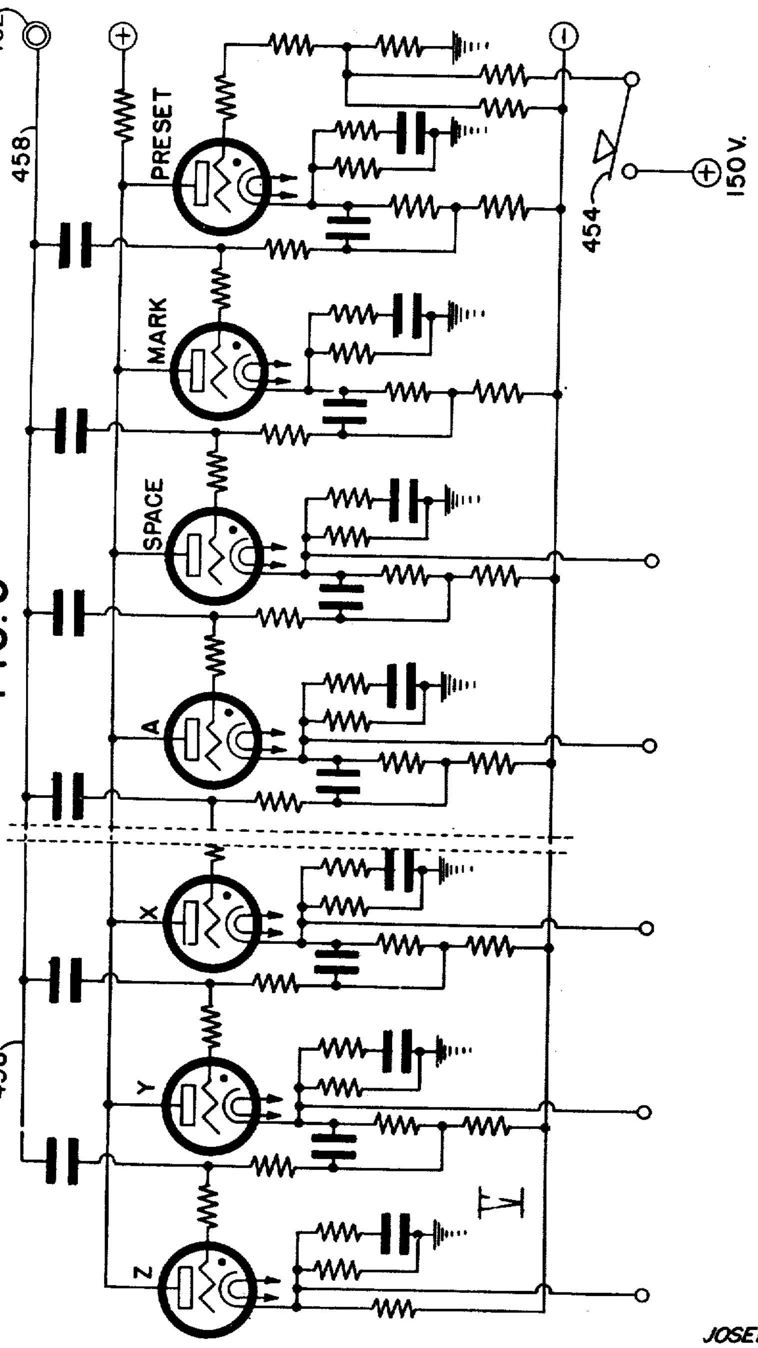
FIG. 5



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COMMUNICATION SYSTEM

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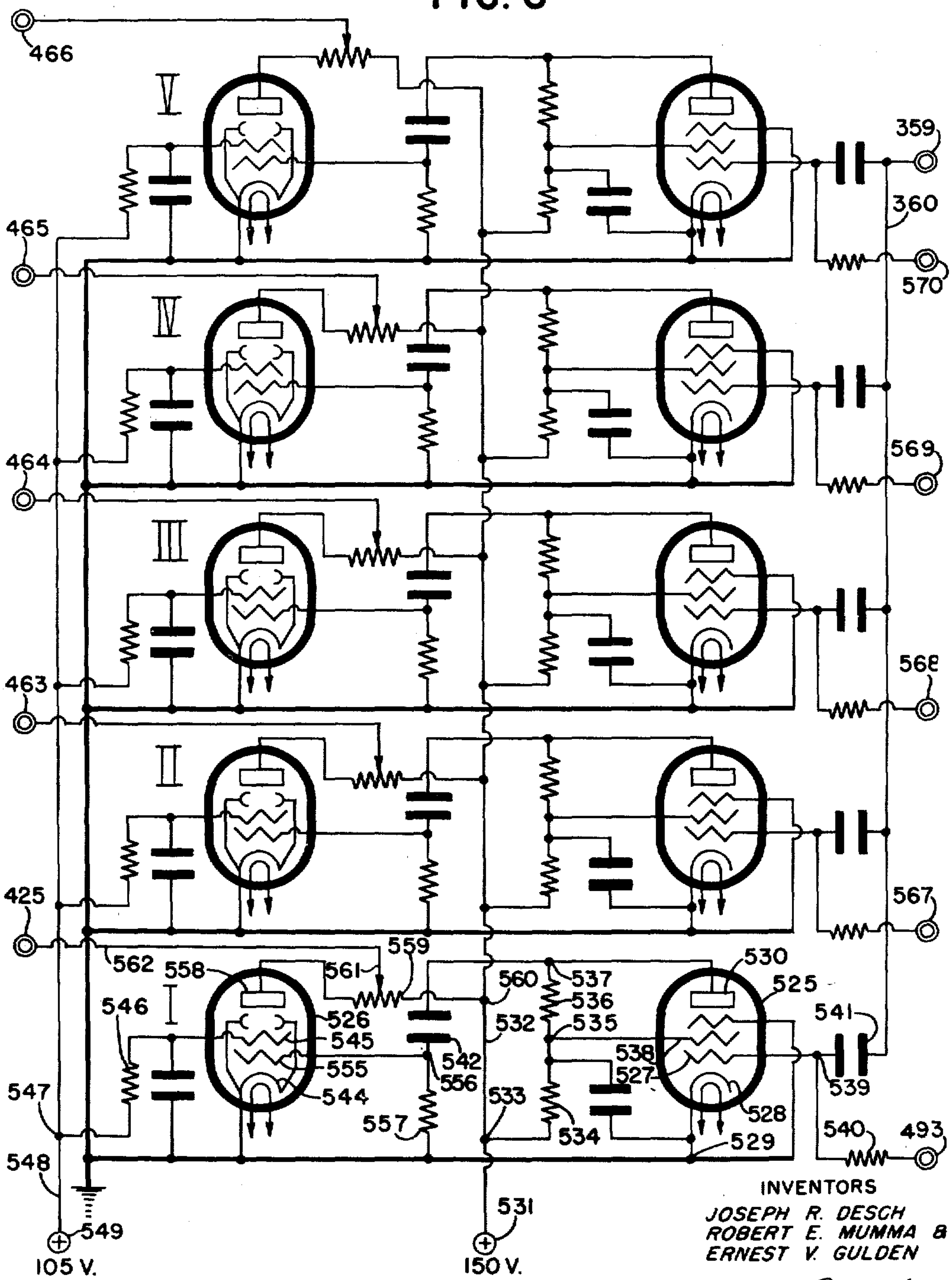
FIG. 6



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COMMUNICATION SYSTEM

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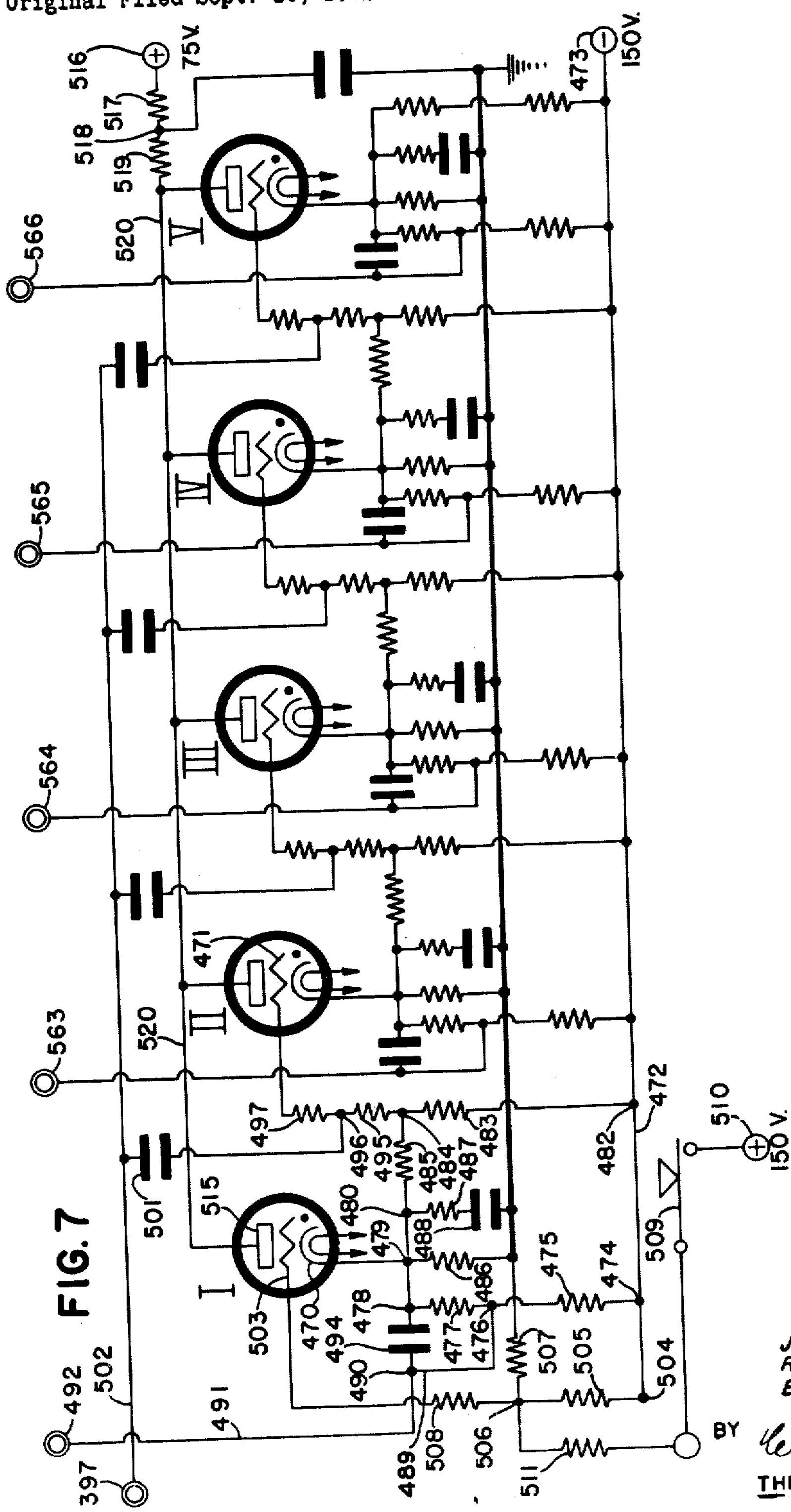

FIG. 7

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COMMUNICATION SYSTEM

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FIG. 8

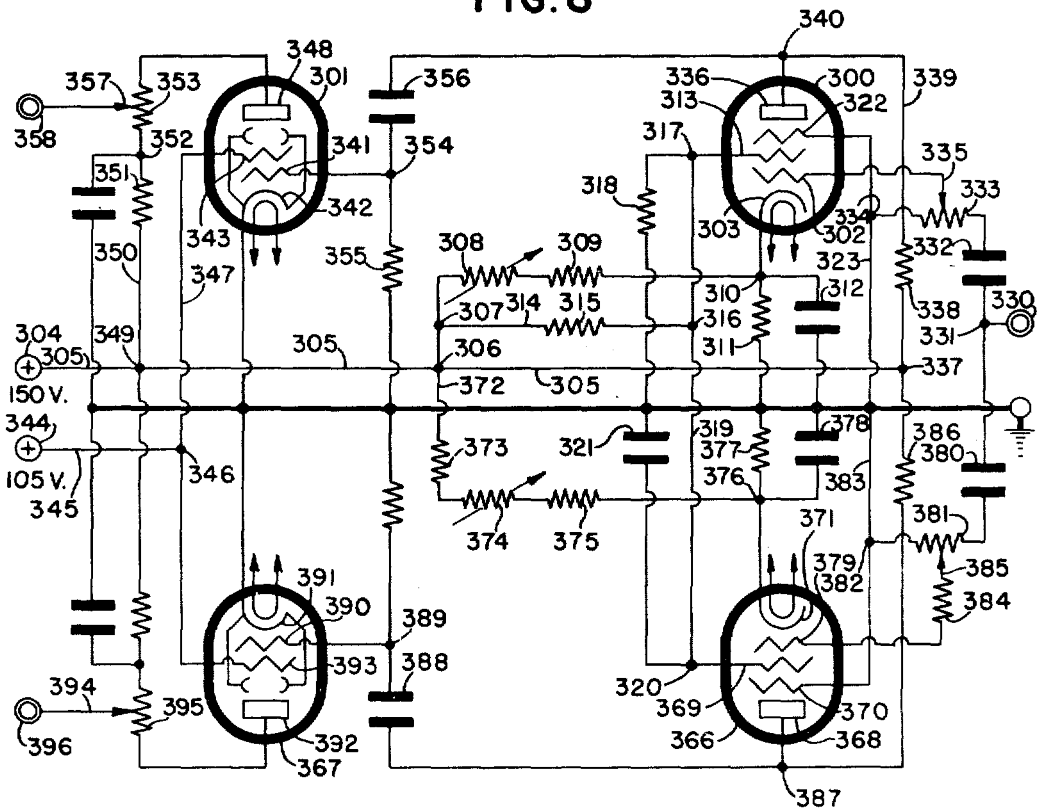
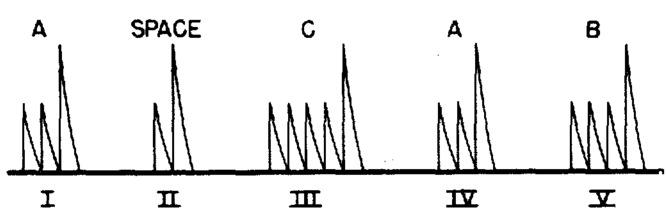


FIG. 9



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COMMUNICATION SYSTEM

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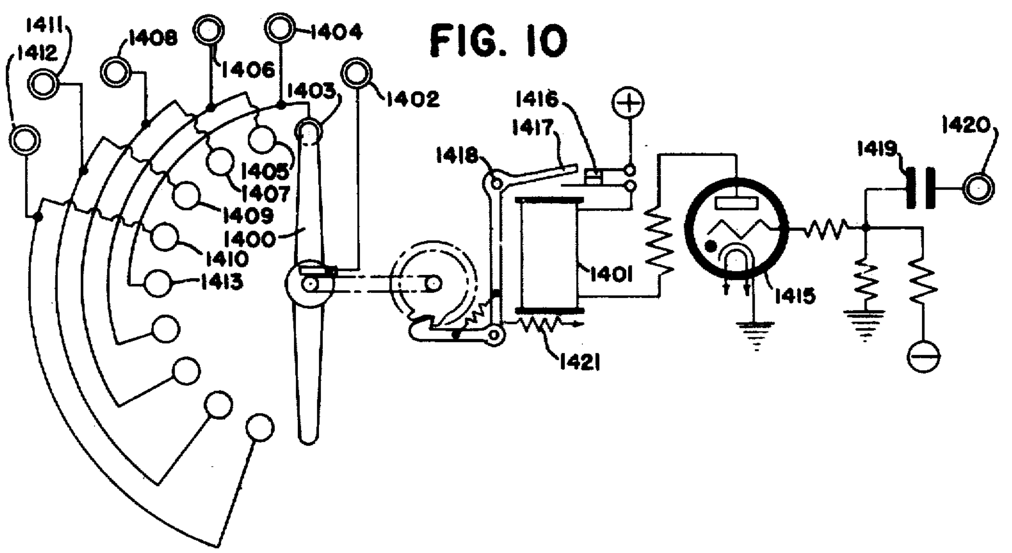
FIG. 10



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UNITED STATES PATENT OFFICE

2,462,613

COMMUNICATION SYSTEM

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Original application September 16, 1942, Serial No. 458,546, now Patent No. 2,425,307, dated August 12, 1947. Divided and this application February 19, 1944, Serial No. 523,025

14 Claims. (Cl. 177—353)

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This invention relates to communication systems and is directed particularly to a receiving apparatus for use in a system in which various symbols making up the data to be transmitted are transformed into bursts or trains of discrete rapidly recurring signals, the number of signals in each burst being dependent upon the symbol which it represents. The bursts representing the different symbols are sent one after another over a single communication channel, with suitable spacing between bursts, and a marking signal is provided for each burst to indicate the completion of the burst. The marking signal is used to control the receiving apparatus to govern the allocation and storage of the symbols therein. The signals by which the symbols may be represented may take various forms, as, for instance, interruption or modulation of a continuous carrier wave and/or discrete rapidly recurring impulses, or representations thereof.

This application is a division of the application for United States Letters Patent, Serial No. 458,546, which was filed by Joseph R. Desch, Ernest V. Gulden, and Robert E. Mumma on September 16, 1942, and which issued on August 12, 1947, as Patent No. 2,425,307.

The sending apparatus used in the system is provided with means for generating the spaced bursts of signals, and controls the number of signals in each burst according to the symbol being sent. The signals can be transmitted by any convenient means—for instance, over a wire or by radio—to the receiving and storing apparatus, where they are transformed back into single representations of the symbols and are stored.

The receiving apparatus contains a plurality of transforming and symbol-storing means, each consisting of a group of devices, which transforming and symbol-storing means may be selectively and successively rendered effective under control of the marking signals to receive the symbol-representing signals and which devices of a group represent the symbols and are differentially operated according to the number of signals in a burst to transform the signals back into a single or direct representation of the symbol and to store this representation.

The receiving apparatus responds to the signals when they are received, and, since it is the number of signals and not their position in a fixed cycle which is the controlling factor, there is no need to synchronize the operation of the sending and receiving apparatus either before or during a transmitting operation.

High-speed communication of data is obtained

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with applicants' novel arrangement because the sending and receiving apparatus can generate and respond to the signals at a high frequency and because the signal bursts which are used to represent the various symbols require only the time necessary to produce the number of signals needed to represent the symbols and can follow one after the other in transmission without unnecessary loss of time between bursts.

Furthermore, there is no particular sequential relation between the various symbols and the number of signals which may be used to represent them, so that the number of signals which represent any symbol may be chosen arbitrarily. Because of this condition, the symbols used most frequently can be represented by the smaller number of signals, and this will also reduce the time required for transmitting data.

It is an object of the invention, therefore, to provide means for receiving different numbers of discrete signals which represent symbols and transforming the signals into a representation of the symbols.

A further object of the invention is to provide a receiving means for receiving bursts of signals consisting of signals having one characteristic and signals having a distinctive characteristic, and having discriminating means to distinguish between the signals having different characteristics and to control the receiving means accordingly.

A further object of the invention is to provide a means for receiving and transforming bursts of symbol-representing signals into direct representations of the various symbols, each of said bursts containing a number of similar discrete signals and a control signal, and said receiving means containing a plurality of transforming means for setting up direct representations of the various symbols according to the number of signals in a burst and a routing means controlled by the control signals to route the bursts to the different transforming means.

With these and incidental objects in view, the invention includes certain novel features of construction and combinations of parts, the essential elements of which are set forth in appended claims and a preferred form or embodiment of which is hereinafter described with reference to the drawings which accompany and form a part of this specification.

In the drawings:

Figs. 1 to 5 inclusive show portions of the transforming and symbol-storing means in the receiving apparatus, which means consists of groups or banks of symbol-representing tubes which may be selectively set according to the symbols corresponding to the impulses sent by the sending apparatus.

Fig. 6 shows relay means for selectively directing or routing impulses to the various groups of transforming and symbol-storing means.

Fig. 7 shows a routing control device containing a plurality of sequentially operable tubes which are controlled by the marking signals to control the relay means which route the impulses representing various symbols into the proper groups or banks of transforming and symbol-storing means.

Fig. 8 shows means in the receiving apparatus for discriminating between symbol-representing impulses and marking impulses and controlling the receiving apparatus according to the significance of the impulses.

Fig. 9 is a representation of five bursts which may be transmitted in succession and illustrates the general character of the trains of signals by which the symbols are transmitted.

Fig. 10 illustrates an alternate form of routing means.

General Description

The symbols which may be sent to and received by the novel receiving apparatus may represent any selected data such as the digits of a numerical notation, the letters of the alphabet, or any other arbitrary data which may be chosen.

The disclosed embodiment is shown with a capacity for automatically receiving and storing five symbols in succession and is arranged to receive and store the letters of the alphabet.

For the purpose of this disclosure, the signals whereby the symbols are represented will consist of discrete, rapidly recurring impulses, and these impulses will be transmitted from a sending apparatus to the receiving apparatus over a wire. It is not intended to limit the invention to this particular form of signal and transmission medium, as the invention is capable of being carried out by using other equivalent arrangements.

The sending apparatus which generates the signals or impulses is capable of being differentially controlled to provide five groups or bursts of impulses, each burst of which contains a number of small-amplitude impulses according to the symbol represented thereby, and also contains a large-amplitude marking impulse which follows the small-amplitude impulses. The bursts are sent out one after another with a space or time interval between successive bursts, and are impressed on the input terminals of the receiving apparatus. The impulses of a burst follow each other at a frequency of 50 kilocycles, and a space or time interval of 100 microseconds occurs between bursts.

The novel receiving apparatus contains a discriminating means which receives the impulses and is capable of distinguishing between the small-amplitude and the large-amplitude impulses; a routing means; and a plurality of transforming and symbol-storing means consisting of groups or banks of gaseous electron tubes for transforming the bursts of impulses into single representations of the symbols and storing the symbols.

Each group or bank of transforming and symbol-storing tubes contains a tube representing each symbol, a tube corresponding to the marking impulse, and a presetting tube. The marking impulse and symbol-representing tubes of each bank are connected to be fired one after another in response to the impulses sent out by the sending apparatus, the order of firing beginning with the marking impulse tube, then the space symbol tube, and next the tubes for the symbols A to Z. As each tube in the bank is fired, it extinguishes any previously conducting tube in the bank, and this means that only one tube will be conducting in each bank at the end of a receiving period and these conducting tubes in the various banks will correspond to the symbols received. The conducting tubes will continue to conduct after the receiving period and serve as a means for storing the symbols.

As explained earlier, the burst of impulses representing the various symbols are sent out one after another in succession over a single wire, and, because of this, routing means must be provided in the receiving apparatus to distribute or allocate the bursts to the proper banks of transforming and storing tubes. The particular routing means shown herein includes a normally inoperative relay means for each bank of tubes, which relay means may be selectively rendered effective one after another to relay the bursts of impulses from a common impulse line to the various banks of transforming and symbol-storing tubes.

The relay means are rendered effective one after another by means of a routing control device consisting of a series of gaseous electron tubes which are connected in a chain to be fired and rendered conducting one after another in sequence in response to the marking impulses. The tubes of the routing control device are also connected so that the firing of any tube in the chain will cause any previously conducting tube of the chain to be extinguished and allow only one tube at a time to be conducting. The chain connections and extinguishing connections between the routing control tubes, therefore, enable the tubes to become conducting one at a time in sequence, and, as long as any tube is conducting, it renders its associated relay means operative to relay impulses from the common impulse line to its associated bank of transforming and symbol-storing tubes.

While the routing means is shown as consisting of a plurality of relays, it is obvious that the routing means could take other forms, such as a sequence switch which is capable of step-by-step operation to relay the impulses to the various banks.

The discriminating means in the receiving apparatus receives all the impulses which are sent from the sending apparatus and includes means which is responsive to both small and large-amplitude impulses and means which is only responsive to the large-amplitude impulses. The means which is responsive to all the received impulses passes these impulses to a common impulse conductor in the receiving apparatus, from which conductor the impulses are relayed selectively to the various banks of transforming and symbol-storing tubes. The means which is responsive to the large-amplitude impulses only, is effective to send an impulse to the routing control tubes to cause one of these tubes to be fired each time a large-amplitude impulse is received in the receiving apparatus.

The operation of the receiving apparatus is as follows:

The receiving apparatus is prepared for the reception of data by causing the presetting tube of each bank of transforming and symbol-storing tubes and the first tube in the routing control device to be fired and rendered conducting.

The firing of the presetting tube in each bank of transforming and symbol-storing tubes will, through mutual extinguishing connections, clear these banks of any previously stored symbols, and the firing of the first tube in the routing control device will likewise cause any other tube of the device to be extinguished and insure that the first entry will always be routed to the first bank of transforming and symbol-storing tubes.

The conducting presetting tube of each bank will prepare the marking impulse tube in its bank of tubes to be responsive to signal impulses and will continue to be conductive until signal impulses are relayed to that bank and cause the marking impulse tube therein to be fired and rendered conducting.

The conducting routing control tube renders the relay means for the first bank effective and prepares the routing control tube for the second bank for firing in response to the first large-amplitude impulse to be received.

The receiving device is now ready to receive signals. As the first burst of impulses is received, the small and large-amplitude impulses will be passed on to the common impulse line and relayed from the common impulse line to the first bank of transforming and symbol-storing tubes, and these tubes will be operated one after another in response to these impulses, the last tube to be operated being the symbol-representing tube corresponding to the symbol represented by the burst. The marking impulse, or large-amplitude impulse, which is the last impulse of the burst, will also be effective, through the discriminating means, to cause an impulse to be sent to the routing control tubes. The routing control tube for the second bank has been prepared for firing by the conduction in the first tube, and, when the impulse is sent to these tubes in response to the marking impulse of the burst, the second bank routing control tube is fired and rendered conducting.

The second bank routing control tube, when it is fired, causes the first bank routing control tube to be extinguished, and thereby the first bank relay means to return to its normal inoperative state; prepares the third bank routing control tube for operation in response to the next marking impulse; and renders the relay means for the second bank of transforming and symbol-storing tubes operative.

The next burst of impulses will cause the transforming and symbol-storing tubes of the second bank to be fired to set up and store the symbol represented by the second burst of impulses. As before, the last or marking impulse of this burst will cause the firing of the next routing control tube and prepare the next transforming and symbol-storing bank for reception of the next burst of impulses. In this way, the successive bursts of impulses are routed to the various banks of symbol-storing tubes and control the setting of the various symbols therein.

After the sequence of bursts has been received, the conducting tubes representing the symbols in the various banks can be used to control an indicating means or a recording means or can be used to control the transfer of the symbols directly to other storing means for future use.

The invention is not limited to the use of five banks of transforming and symbol-storing tubes, as it is obvious that more banks could be used if it were desired to increase the capacity of the receiving apparatus.

Thus it is seen that applicants have provided a novel receiving apparatus for use in a system for sending and receiving data at a high rate of speed.

Detailed Description

The disclosed embodiment of the invention is adapted to receive and store five symbols automatically in succession, which symbols are received in the form of bursts of impulses. Fig. 9 shows, in a general way, a train of impulses made up of the bursts of impulses which would be used to operate the receiving apparatus to store therein the symbols for "A," "Space," "C," "A," and "B."

A consideration of these bursts shows that the "Space" symbol is represented by a burst containing one small-amplitude symbol-representing impulse followed by a large-amplitude marking impulse; the letter "A" is represented by a burst containing two small-amplitude impulses and a large-amplitude impulse; and the letter "B" is represented by three small-amplitude impulses and a large-amplitude impulse. In the instant embodiment, this relation between the various letters and the number of small-amplitude impulses extends to the letter "Z," which would be represented by twenty-seven small-amplitude impulses followed by a large-amplitude marking impulse.

The form of impulses as shown in this figure is one form which may be used, but the invention may be carried out with other forms of impulses just as long as a distinction is maintained between the variable number of impulses and the marking or controlling impulses. The numerals "I," "II," "III," "IV," and "V" indicate the order in which the symbols are transmitted and received, and similar numerals will be applied to the various parts of the receiving apparatus which deal with these symbols.

It is not intended that the invention be limited to the use of the particular potentials and values of resistance and capacitance given in the following description, because the potentials applied to the various elements of the tubes are merely selected as convenient potentials for the disclosure, and the circuit elements of resistance and capacitance correspond in relative value to the potentials chosen. It is obvious that other potentials may be used and the values of the circuit elements adjusted accordingly to maintain the proper relation between the various parts of the circuit. Throughout the drawings, the cathode heater elements are shown conventionally.

The bursts of positive potential impulses which are generated by means at a sending station during a transmitting operation, according to the symbols of the data being transmitted, are transmitted to the novel receiving apparatus and are impressed on a signal input terminal 330 (Fig. 8) of the receiving apparatus.

The details of the sending or impulse generating apparatus will not be given herein. For details of an impulse generating means which will generate the required number of small-amplitude impulses and a marking impulse in each burst to represent a symbol of data being transmitted, reference may be had to the United States Letters Patent No. 2,425,307, of which this application is a division.

With the values of resistance and capacitance given herein, the receiving apparatus will respond accurately to impulses which follow each other in a burst at about 50 kilocycles, with about a 100-microsecond spacing between bursts.

The receiving apparatus, shown in Figs. 1 to 8 inclusive, accepts the five bursts of impulses one after another and distributes them to different transforming and symbol-storing means. Each transforming and symbol-storing means consists of a group or bank of tubes, and the impulses are effective to selectively render one of the tubes of the group conducting, thereby to indicate and store the symbol which the number of impulses in the burst represents.

In order to set up a representation of the symbols which are received, the receiving apparatus contains discriminating means which receives all the transmitted impulses and is capable of distinguishing between the small-amplitude impulses and the large-amplitude impulses; a plurality of transforming and symbol-storing means consisting of groups or banks of symbol-representing and storing tubes which are operable to transform the bursts of impulses into representations of the symbols; and routing means which is operated each time a large-amplitude or marking impulse is received and is effective to route the successive bursts into different transforming and symbol-storing means.

Discriminating means

The discriminating means is shown in Fig. 8. All of the supersonic signals which are impressed on the input terminal of the receiving apparatus are effective to control the discriminating means, which responds differently to the small-amplitude and the large-amplitude impulses.

Part of the discriminating means is responsive to both the small-amplitude and the large-amplitude impulses which are received and is capable of impressing a like number of impulses on a common impulse conductor in the receiving apparatus.

Another part of the discriminating means is responsive only to the large-amplitude or marking impulses and is effective to send an impulse to a routing control device to cause an operation thereof each time a marking impulse is received. This part of the discriminating means detects the large-amplitude marking impulse which indicates the end of a burst and causes the routing means to route the next burst to another symbol-storing group of tubes.

The part of the discriminating means which is responsive to all the received impulses consists of a pair of vacuum tubes 300 and 301 (Fig. 8), of which the tube 300 is affected by all the positive potential impulses which are received from the sending apparatus, and the tube 301 is controlled by the tube 300 and serves to change the phase of, and amplify, the potential impulses formed by the operation of the tube 300 and to impress the amplified impulses on a common impulse conductor in the receiving apparatus.

Tube 300 is normally non-conducting because of the bias on its control grid 302, but is rendered conducting each time a positive potential impulse is impressed on the control grid.

The potential supply circuit for the cathode 303 of the tube 300 starts at terminal 304, upon which is impressed a positive potential of 150 volts, and continues over conductor 305, points 306 and 307, the variable resistor 308 of 10,000 ohms, resistor 309 of 5,000 ohms, point 310, and over the resistor 311 of 1,000 ohms and capacitor 312 of .1 microfarad in parallel to ground. The cathode 303 is connected to point 310 and may be given a positive potential of from 9 to 25 volts, depending upon the adjustment of the resistor 308. The screen grid 313 also derives its potential from terminal 304 by means of a circuit which is the same as the circuit traced above to point 307 and then extends over conductor 314, resistor 315 of 10,000 ohms, points 316 and 317, and over resistor 318 of 25,000 ohms to ground. The screen grid 313 is connected in this circuit at point 317 and is given a positive potential of 43 volts. A circuit also extends from point 316, over conductor 319, point 320, and capacitor 321 of .1 microfarad to ground to absorb the shock of any abrupt application or change of potential in this circuit. The suppressor grid 322 is connected to ground over conductor 323.

The control grid 302 is connected to a circuit extending from the signal input terminal 330, over point 331, capacitor 332 of 250 micro-microfarads, resistor 333 of 10,000 ohms, point 334, and over conductor 323 to ground. A potential-tapping member 335 cooperates with the resistor 333 to enable the grid 302 to be connected to this circuit. Control grid 302 is normally at ground potential and prevents conduction in the tube 300 until the positive impulse is impressed on the signal input terminal 330 and raises the potential of the grid 302 to allow conduction to take place in the tube.

The anode 336 of the tube 300 has a normal positive potential of 150 volts applied thereto over a circuit extending from terminal 304, conductor 305, point 337, resistor 338 of 15,000 ohms, conductor 339, and point 340. As the tube 300 becomes conducting, the potential of the anode 336 will drop, due to the resistor 338, and this potential drop is impressed on the control grid 341 of the tube 301 to control the conduction in that tube.

The potential of the cathode 303 and the effect of the input signal impulses on the control grid 302 can be regulated by the adjustable resistor 308 and the potential-tapping member 335, respectively, to enable the tube 300 to respond properly to both the small-amplitude and the large-amplitube positive impulses impressed on the signal input terminal 330.

The phase-changing and amplifying tube 301 has a zero bias and is, accordingly, normally conducting. The cathode 342 of this tube is connected directly to ground. A positive potential of 105 volts is applied to the screen grid 343 of this tube by means of a circuit starting at terminal 344, upon which is impressed a positive potential of 105 volts, and continuing over conductor 345, point 346, and conductor 347.

The circuit by which potential is supplied to the anode 348 starts at terminal 304 and extends over conductor 305, point 349, conductor 350, resistor 351 of 500 ohms, point 352, and resistor 353 of 5,000 ohms to the anode 348. Since the tube is normally conducting, its anode 348 will be at approximately 50 volts due to the resistors 351 and 353 in the anode circuit. However, this potential will rise toward 150 volts as the conductivity in the tube is reduced by the control grid 341.

The control grid 341 is normally at ground potential, being connected to ground over point 354 and resistor 355 of 10,000 ohms. Point 354 in this circuit is electrostatically connected, through a capacitor 356 of 200 micro-microfarads, to the point 340 in the anode circuit for the tube 300, which connection enables the negative potential impulses caused by the conduction in tube 300 to be impressed on the control grid 341 to reduce conduction in tube 301.

A potential-tapping member 357 cooperates with the resistor 353 in the anode potential supply circuit for the tube 301 and enables the positive potential rise in this circuit as conductivity is reduced in the tube to be impressed on the common impulse conductor 360 (Fig. 6) in the receiving apparatus. The connection is from the current-tapping member 357 to the terminal 358, which terminal is connected to the terminal 359 (Fig. 6), to which the common impulse conductor 360 is connected.

This part of the discriminating means, therefore, is operated in response to both the small-amplitude and the large-amplitude impulses and impresses an impulse on the common impulse conductor 360 each time a small-amplitude impulse or a large-amplitude impulse is received at the signal input terminal 330.

The other part of the discriminating means also contains two vacuum tubes, 366 and 367, and is similar to the part described above. However, tube 366 is responsive to only the large-amplitude or marking impulses and controls the phase-changing and amplifying tube 367 to cause an impulse to be impressed on an impulse conductor for the routing control device each time a large-amplitude impulse is received.

Tube 366 is normally non-conducting but is rendered conducting each time a large-amplitude impulse is impressed on the input terminal.

The potential-supplying circuits for the anode 368, the screen grid 369, and the suppressor grid 370 of tube 366 are similar to those given above for tube 300 and provide these elements with positive potentials of 150 volts and 43 volts and ground potential, respectively.

The cathode 371 is supplied with positive potential from terminal 304 by a circuit extending over conductor 305, point 306, conductor 372, resistor 373 of 15,000 ohms, adjustable resistor 374 of 10,000 ohms, resistor 375 of 5,000 ohms, point 376, and over resistor 377 of 5,000 ohms and capacitor 378 of .1 microfarad in parallel to ground. The cathode 371 is connected to this circuit at point 376 and has a positive potential of between 21 and 30 volts impressed thereon, depending upon the adjustment of resistor 374.

The control grid 379 is connected to a circuit extending from the signal input terminal 330, over point 331, capacitor 380 of 250 micro-microfarads, resistor 381 of 10,000 ohms, point 382, and conductor 383 to ground. Control grid 379 is connected to this circuit over resistor 384 of 75,000 ohms and potential-tapping member 385 and is normally at ground potential.

The potential of the cathode 371 and the effect of the input signal impulses on the control grid 379 can be regulated by the adjustment of resistor 374 and the potential-tapping member 385, respectively, so as to prevent the small-amplitude impulses from affecting the tube and allow only the large-amplitude impulses to cause conduction to occur in the tube 366.

Whenever tube 366 is rendered conducting, the potential of its anode 368 will drop due to resistor 386 of 15,000 ohms in the anode potential supply circuit. A connection from point 387 in the anode potential supply circuit, over a capacitor 388 of 200 micro-microfarads to point 389, to which the control grid 390 of tube 367 is connected, enables the anode potential drop to control conduction in tube 367.

The phase-changing and amplifying tube 367 of this part of the discriminating means also has a zero bias and is normally conducting. The circuits for supplying potential to the control grid 390, the cathode 391, the anode 392, and the screen grid 393 are similar to those explained above for corresponding elements of tube 301. Since the tube 367 is normally conducting, its anode will normally have a potential of approximately 50 volts due to the resistors in the anode circuit. Each time a large-amplitude impulse is impressed on the receiving apparatus, tube 366 will become conducting and, through the connection between points 387 and 389, will impress a negative impulse on the grid 390, causing the grid 390 of tube 367 to acquire a negative potential and reduce conduction in this tube, thereby causing the potential of the anode 392 to rise toward 150 volts. A potential-tapping member 394 cooperates with resistor 395 of 5,000 ohms in the anode circuit and enables the potential rise in this circuit, as conduction in the tube is decreased, to be used as a positive potential impulse. Terminal 396, which is connected to the tapping member 394, is also connected to terminal 397 (Fig. 7), to which is connected an impulse conductor for the routing control device upon which the positive potential impulses are impressed.

This part of the discriminating means, accordingly, can respond to the supersonic marking impulses and can send an impulse to control the routing means each time a marking impulse is received.

The discriminating means as a whole, therefore, enables the different amplitudes of the input impulses to be utilized to provide different controls for the receiving apparatus.

Transforming and symbol-storing means

In the disclosed embodiment, the receiving apparatus contains five banks of transforming and symbol-storing means; however, the number of banks may be increased or decreased if desired. The five banks are shown in Figs. 1 to 5, inclusive, and are given the reference numerals "I," "II," "III," "IV," and "V" to indicate the order in which they operate and the symbols which they will store. Since the circuits for the various banks are similar, the operation of all the banks will be clear from a description of one of the banks.

Referring to Fig. 1, which shows the bank for transforming the first burst of impulses into a single representation of a symbol and for storing this symbol, it is seen that a bank of transforming and symbol-storing means is made up of a plurality of gaseous electron tubes. The tubes are of the type having an internal potential drop of about 15 volts, when conducting, and having an anode, a cathode, and a control grid which is given a negative bias with respect to the cathode and will prevent the tube from firing until this bias is reduced to less than 15 volts negative with respect to the cathode. Of the plurality of gaseous electron tubes in the bank, there is a presetting tube "Preset," which is fired before reception takes place, a marking impulse tube "Mark," a space symbol tube "Space," and a tube for each of the letters "A" to "Z" inclusive, although in this figure the tubes for the letters "B" to "W" inclusive have been omitted to simplify the showing of the bank, as their circuits are identical with those for the other tubes and an understanding of the operation of the bank can be had from the circuits shown.

The presetting tube "Preset" in the bank is fired before reception begins in the receiving apparatus, and is used to clear the bank of any previously stored symbol and to insure that the sequential firing of the tubes in a bank, in response to the impulses of a burst, will always begin with the same tube, which, in the instant embodiment, is the marking impulse tube "Mark."

The marking impulse tube is not a symbol-representing tube but is included in the bank because a marking impulse is a part of every burst and the discriminating means impresses the marking impulse on the banks along with the different numbers of small-amplitude impulses, and it is therefore necessary to include this tube in the bank so that the symbol-representing tubes will show the correct symbol at the end of a burst of impulses.

The tubes in the bank are connected for sequential firing in response to supersonic impulses, beginning with the presetting tube, then the marking impulse tube, and next the tubes for the space symbol "Space" and the letters "A" to "Z," in that order. The marking impulse tube and the symbol-storing tubes are fired one after another in response to impulses relayed to a firing impulse conductor from the common impulse conductor 360. As each tube in the sequence is fired, it will be operable to extinguish any previously conducting tube of the bank, the last tube to be fired in any bank remaining conducting and serving to provide for the storage of a single representation of the symbol represented by the number of impulses in the burst.

The tubes which are conducting in the various banks at the end of a transmitting operation can be inspected to directly show the symbols stored in the various banks, can be used to control a remote indicating or recording apparatus, or can be used to directly transfer the symbols to other storing means.

The circuits for supplying the potentials and the operative connections between the tubes of a bank are as follows:

Negative potential is supplied to the cathodes of the tubes of this bank (Fig. 1) by means of parallel circuits, one for each tube, extending to ground from a negative potential conductor 400, to which a negative potential of 150 volts is applied at terminal 401. The circuit for the "Y" tube is representative and extends from the supply conductor 400 at point 402, over resistor 403 of 150,000 ohms, point 404, resistor 405 of 100,000 ohms, points 406, 407, and 408 and to ground over resistor 409 of 15,000 ohms in parallel with resistor 410 of 2,500 ohms and capacitor 411 of .001 microfarad in series. Cathode 412 of the "Y" tube is connected to this circuit at point 407 and has a negative potential of approximately 8 volts when the tube is not conducting. When the tube is conducting, the cathode is also conductively coupled to its related anode by the discharge path through the tube, so that the positive potential which is applied to the anode will also be impressed on the cathode potential supply circuit and will cause the potential of the cathode 412 to rise from a negative potential of about 8 volts to a positive potential of about 50 volts.

The "Z" tube, the last tube in the sequence, has a cathode potential supply circuit which is equivalent to the other circuits. This circuit extends from point 415 on the potential supply conductor 400, over resistor 416 of 250,000 ohms, points 417 and 418, and to ground over resistor 419 of 15,000 ohms in parallel with a resistor 420 of 2,500 ohms in series with a capacitor 421 of .001 microfarad. Cathode 422 of the "Z" tube is connected to this circuit at point 417.

The cathode potential supply circuits for all the tubes except the "Z" tube are used to supply negative biasing potential for the control grids of the tubes next in the sequence, the connection being from the cathode circuit of one tube to the control grid of the next tube in the sequence. These connections enable the sequential firing of the tubes by utilizing the potential rise of the cathode of one tube to prime the next tube to be operated, so that the next tube may be fired and rendered conducting when the next impulse is impressed on the firing impulse conductor 423. The grid of the "Z" tube, for instance, is connected over resistor 426 of 50,000 ohms, point 427, resistor 428 of 500,000 ohms, point 429, and conductor 430 to point 404 in the cathode potential supply circuit for the "Y" tube, from which point it derives a normal negative biasing potential of 65 volts when the "Y" tube is not conducting. When the "Y" tube becomes conducting and its cathode potential rises, it will cause the biasing potential of the grid of the "Z" tube to be reduced to almost its critical point, so that the "Z" tube can respond to the next firing impulse which is impressed on the bank. A capacitor 431 of 250 micro-microfarads connects point 429 in the grid circuit with point 406 in the cathode circuit to speed up the application of the potential rise on the grid of the "Z" tube when the "Y" tube becomes conducting.

The presetting tube "Preset," being the first tube in the series, does not have its control grid connected to a cathode potential supply circuit, but has a negative biasing potential of 64 volts supplied thereto by an equivalent circuit extending from point 432 on the conductor 400, over resistor 433 of 120,000 ohms, points 434 and 435, and resistor 436 of 90,000 ohms to ground, to which the control grid 437 is connected at point 435.

The grids of the tubes in the sequence from the marking impulse tube to the "Z" tube are electrostatically coupled to the firing impulse conductor by means of capacitors of 10 micro-microfarads, as capacitor 438, by which point 427 in the grid circuit of the "Z" tube is connected to the firing impulse conductor 423. The firing impulse conductor 423 extends from the terminal 424, and this terminal is connected to terminal 425 (Fig. 6) of the relay means which relays the impulses from the common impulse conductor 360 to this bank. The normal negative bias of the grids of these tubes will normally render the firing impulses ineffective to cause the firing of the tubes; however, if any tube has been primed by the conduction in another tube in the sequence, the bias of the grid of the primed tube will have been reduced sufficiently that the firing impulse can cause that tube to fire and become conducting.

The anodes of the tubes of this bank are connected to a common anode supply conductor 439, which is connected over resistor 440 of 2,000 ohms to terminal 441, which has a positive potential of 75 volts applied thereto.

When none of the tubes of the bank is conducting, the anodes will have a positive potential of 75 volts; however, when any tube in a bank is conducting, the potential of the anodes will be reduced to about 65 volts due to the drop across resistor 440.

At the moment one of the tubes of the bank is fired, its cathode will remain at a negative potential of about 8 volts while the capacitor, as 411 in its cathode circuit, is charging, and, due to the resistance in the anode potential supply circuit for this bank and the internal drop of the tube, the potential of the anode will drop to within about 15 volts of the cathode potential. This will cause a corresponding drop in the potential of the common anode potential supply conductor 439 for this bank, which drop is used to extinguish any previously conducting tube of the bank. The extinguishing action occurs because the potential of all the anodes of the tubes of the bank will drop as the potential of the anode potential supply conductor 439 drops, and this will cause the potential of the anode of a previously conducting tube to drop below the potential of its cathode, which has risen due to conduction in the tube, and will thus cause conduction to cease in the previously conducting tube and enable its control grid to regain control.

The presetting tube "Preset" is fired by a circuit which may be closed by any convenient means prior to the reception of data. For simplicity in the diagram, the circuit is shown close-by a presetting key 442. The circuit starts at terminal 443, upon which a positive potential of 150 volts is impressed, and continues over conductor 444, key 442, conductor 445, resistor 446 of 167,000 ohms, to point 434 in the circuit for the control grid 437. When this circuit is closed by the key 442, it applies positive potential to the grid and causes its potential to become more positive than the cathode, which causes the tube to fire and become conducting.

The operation of the bank is as follows:

The presetting tube "Preset" is fired by momentary closing of the presetting key 442 before reception of data takes place. The firing of this tube extinguishes any previously conducting tube in the bank and primes the marking impulse tube, so that the first impulse of the burst which is relayed to the firing impulse conductor 423 of the bank will cause the marking impulse tube to be fixed and become conducting. The firing of the marking impulse tube will extinguish the preset tube, and conduction in the marking impulse tube will prime the space symbol tube "Space." The succeeding impulses of the burst will fire the tubes "Space," "A," "B," "C," and so on, depending upon the number of impulses in the burst. After the last impulse in the burst has fired a tube, that tube will remain conducting and will thereby store the symbol and provide a visual indication of the symbol which was represented by the burst. The potential of the cathode of this conducting tube will be positive, and this will be the only tube in the bank having its cathode at a positive potential. Conductors, as 450, extending from the cathodes of the symbol-representing tubes, can be sensed by any suitable means for this condition and can control a remote indicating or recording mechanism or can be used to control the direct transfer of the setting of the bank to another storage means.

The other banks for transforming and storing the second, third, fourth, and fifth symbols operate exactly as this bank. These banks are prepared by the presetting keys 451, 452, 453, and 454 (Figs. 2, 3, 4, and 5), which cause the presetting tubes to be fired. The circuits for firing the presetting tubes are shown closed by individual keys for simplicity in the showing of the circuits, but it is obvious that all these circuits could be closed by contacts of a single presetting relay or by some other similar construction.

The anodes of the tubes of each bank are connected together, and over a resistor to a separate source of potential, so that the mutual extinguishing action between the tubes is limited to the tubes of a bank. At the end of a receiving operation, therefore, the last tube to operate in each bank will remain conducting until the banks are preset for another receiving operation.

The firing conductors 455, 456, 457, and 458 for the "II," "III," "IV," and "V" banks (Figs. 2, 3, 4, and 5) are connected to terminals 459, 460, 461, and 462, which terminals are connected to terminals 463, 464, 465, and 466, respectively (Fig. 6), of the relay means for the various banks.

As the relay means for the various banks become operative one after another to relay impulses to the firing conductors, the tubes in the various banks will be fired in sequence, and, at the end of the receiving operation, the bursts of impulses will have been transformed into single representations of the symbols and those tubes in the several banks will be conducting which correspond to the symbols which have been transmitted to the receiving apparatus.

Routing means

Routing means, comprising relay means and a routing control device, are provided in the receiving apparatus to route the successive bursts of impulses into the different banks of transforming and symbol-storing means.

A plurality of relay means, one for each bank of transforming and symbol-storing means, are used to selectively relay the impulses from the common conductor 360 (Fig. 6) to the firing impulse conductors of different banks of transforming and symbol-storing means. The several relay means are normally unresponsive to the impulses on the common impulse conductor 360 but can be successively "primed" or made responsive under control of the routing control device so that different relay means will be responsive to the successive bursts of impulses and can cause the successive bursts of impulses to control the setting of the symbols in the various banks.

The routing control device (Fig. 7) includes a control tube for each relay means, and these control tubes, which are gaseous electron tubes of the same type as those used in the transforming and symbol-storing means, are connected for sequential step-by-step operation each time a marking impulse is received. As each control tube is fired and becomes conducting, it extinguishes any previously conducting control tube of the device; primes its related relay means to render it effective to relay impulses from the impulse conductor 360; and primes the next control tube in the sequence so that it will fire and become conducting when the next marking impulse is received.

Inasmuch as the marking impulses follow the small-amplitude impulses in a burst, it is necessary to fire the control tube for the first bank before the first burst is received. The firing of the first control tube will extinguish any previously conducting control tube which might have remained conducting from a previous operation of the device, and insures that the first burst of impulses will be entered in the first bank of transforming and symbol-storing means.

The routing control device is shown in Fig. 7, in which the control tubes are given the reference numerals "I," "II," "III," "IV," and "V" to indicate with which of the bursts they are operative. As the circuits for the various control tubes of the routing control device are similar, it is believed that the operation of the device will be clear from a description of representative circuits.

Potential is supplied to cathode 470 of the "I" control tube by a circuit which has two branches, one of which is also utilized to supply a negative biasing potential for the relay means related to the "I" control tube, and the other of which is also utilized to supply negative biasing potential to the control grid 471 for the "II" control tube. The one branch extends from a negative potential supply conductor 472, to which a negative potential of 150 volts is applied at terminal 473, and continues over point 474, resistor 475 of 390,000 ohms, point 476, resistor 477 of 150,000 ohms, to points 478, 479, and 480. The other branch extends from the potential supply conductor 472 at point 482 and continues over resistor 483 of 300,000 ohms, point 484, and resistor 485 of 200,000 ohms to the points 479 and 480. From the points 479 and 480, the two branches continue to ground over resistor 486 of 15,000 ohms in parallel with resistor 487 of 2,500 ohms and capacitor 488 of .002 microfarad in series. The cathode 470 is connected at point 479 in this circuit and is given a negative potential of approximately 9 volts whenever the tube is not conducting. When the tube is conducting, the electron discharge enables a positive potential applied to the anode to be applied to the cathode and will cause the potential of the cathode to rise to a positive potential of about 50 volts.

A circuit extends from point 476 in said one branch and continues over conductor 489, point 490, conductor 491, and terminal 492, which is connected to terminal 493 (Fig. 6) and supplies a negative biasing potential of about 50 volts to the relay means for the first bank of transforming and symbol-storing means. This circuit also enables the potential rise of the cathode 470, due to conduction in the control tube, to be used to reduce the negative bias or "prime" the relay means.

A capacitor 494 of 50 micro-microfarads is connected between points 478 and 490 to cause the change in potential to be applied rapidly when the relay means is primed by the potential rise of the cathode.

A circuit extends from said other branch of the cathode potential supply circuit at point 484 and continues over resistor 495 of 500,000 ohms, point 496, and resistor 497 of 50,000 ohms to grid 471 of the "II" control tube to supply this grid with a normal negative potential of about 65 volts. This circuit enables the "II" tube to be primed by having this negative potential reduced to 30 volts by the potential rise of cathode 470 when the "I" tube is conducting.

Grid 471 of the "II" tube is connected over point 496 and capacitor 501 of 10 micro-microfarads to an impulse conductor 502, which is connected to terminal 397, upon which is impressed a positive impulse by the discriminating means each time a marking impulse is received. These positive impulses will not be able to fire any of the tubes unless the tube which is to be fired has been primed.

The "I" tube is the first tube in the sequence, and its grid 503 can not derive its negative bias from the cathode potential supply circuit of a preceding tube. A circuit extending from point 504 on conductor 472, and over resistor 505 of 150,000 ohms, point 506, and resistor 507 of 100,000 ohms to ground, supplies grid 503 with a negative biasing potential of 60 volts over point 506 and resistor 508 of 500,000 ohms.

Since the routing control tubes are fired in response to marking impulses which occur after the small-amplitude impulses of the bursts, the "I" routing control tube must be fired from a different source before the first burst is received, in order that the relay means for the first transforming and symbol-storing bank can be primed and will respond to all the impulses of the first burst. This may be accomplished in any convenient manner; for instance, a presetting key 509 (Fig. 7) can momentarily close a circuit starting from terminal 510, upon which a positive potential of 150 volts is impressed, and continuing over the key 509, resistor 511 of 167,000 ohms to point 506 in the circuit of grid 503. The application of this positive potential to the grid 503 will reduce the negative bias of the grid and cause the tube to fire and become conducting, thereby rendering the relay means for the first bank of transforming and symbol-storing means operative and preparing the "II" routing control tube for firing in response to the marking impulse of the first burst. The circuit closed by key 509 may be closed momentarily by a presetting relay along with the presetting circuits of the transforming and symbol-storing banks, as explained earlier herein.

Potential is applied to the anode 515 of the "I" tube by means of a circuit starting at terminal 516, upon which is impressed a positive potential of 75 volts, and extending over resistor 517 of 250 ohms, point 518, resistor 519 of 2,000 ohms, and conductor 520, to which anode 515 is connected. The anodes of the other tubes are also connected to conductor 520, and, when none of the tubes is conducting, the potential of the anodes will be 75 volts, but, when any tube is conducting, this potential is reduced to 65 volts due to the resistors 517 and 519. Point 518 in this circuit is connected to ground over a capacitor of 8 microfarads to absorb the shock of an abrupt application or change in potential in this circuit. The common resistance in the anode potential supply circuit enables the firing of any tube of the routing control device to extinguish conduction in any previously conducting tube in the device in the manner explained earlier herein.

From the above description, it is clear that the control tubes in the routing control device will be fired one after another as the successive bursts are received, and will prime the relay means for the several banks one after another in succession.

The relay means are shown in Fig. 6 and consist of a pair of vacuum tubes for each transforming and symbol-storing bank, which relay means have been given the reference numerals "I," "II," "III," "IV," and "V" to indicate with which bank of transforming and symbol-storing tubes they are related and also to indicate the order in which they operate. A description of the relay means shown at "I" in Fig. 6 will be given, and, as the relay means for the other banks are similar, it is believed that an understanding of these means and their operation will be clear from this description.

Tubes 525 and 526, which constitute the means for relaying impulses from the common impulse conductor 360 to the first bank of transforming and symbol-storing tubes, are normally inoperative to relay the positive impulses from the common impulse conductor 300, because the control grid 527 of tube 525 is normally given a negative bias which the positive impulses cannot overcome. The tube 525 is "primed" by having the negative bias of its grid 527 reduced, and in this condition the tube can respond to the positive potential impulses on the common impulse conductor 360 and can cause the impulses to be relayed to the firing impulse conductor 423 for the first bank of transforming and symbol-storing tubes.

The cathode 528 of tube 525 is connected to ground over point 529. The anode 530 of tube 525 is given a positive potential of 150 volts over a circuit starting at terminal 531, upon which is impressed a positive potential of 150 volts, and continuing over potential supply conductor 532, point 533, resistor 534 of 500 ohms, point 535, resistor 536 of 5,000 ohms, and point 537 to the anode 530. The screen grid 538 is given a normal positive potential of 150 volts by being connected to point 535 in the above anode circuit.

The control grid 527 is connected over point 539 and resistor 540 of 10,000 ohms to terminal 493, which, as explained before, is given a negative biasing potential of about 50 volts from one branch of the cathode potential supply circuit for the "I" routing control tube (Fig. 7). The control grid 527 is also connected electrostatically to the common impulse conductor 360 (Fig. 6) from point 539 over a capacitor 541 of 100 micromicrofarads. The potential on the grid 527 is normally sufficiently negative that the tube 525 is not responsive to the positive potential impulses on the impulse conductor 360, but, when the "I" control tube of the routing control device is conducting, the potential rise of its cathode 470 will reduce the negative potential of grid 527, or "prime" the tube 525 so that it will be capable of responding to the impulses on conductor 360 and become conducting each time an impulse occurs on that conductor.

Whenever tube 525 becomes conducting, the potential of its anode 530 will drop due to the resistors 534 and 536 in its anode potential supply circuit, and, through an electrostatic connection from point 537 over capacitor 542 of 100 micromicrofarads and point 556, this drop is applied as a negative potential impulse on the control grid of the phase-changing and amplifying tube 526.

Tube 526 is a zero-biased tube and is normally conducting. This tube has its cathode 544 directly connected to ground; its screen grid 545 connected over resistor 546 of 500 ohms, point 547, and conductor 548 to terminal 549, to which is applied a positive potential of 105 volts; and its control grid 555 connected to ground from point 556 over resistor 557 of 10,000 ohms, and also electrostatically connected to the anode 530 of tube 525, as explained above.

The anode 558 of the phase-changing and amplifying tube 526 is connected over resistor 559 of 5,000 ohms to point 560 on the potential supply conductor 532, which is connected to terminal 531, to which is applied a positive potential of 150 volts. As this tube is normally conducting, anode 558 will normally have a potential of 50 volts, but, whenever a negative potential impulse is impressed on the control grid 555, conduction in the tube will be reduced and the potential of the anode will rise. A potential-tapping member 561 cooperates with resistor 559 to enable this rise to be utilized as a positive potential impulse which is impressed on the firing impulse conductor 423 (Fig. 1) of the first bank of transforming and symbol-storing means to cause the firing of the tubes in that bank. The connection

from the potential-tapping member 561 to the firing impulse conductor extends from the potential-tapping member 561 over conductor 562 to terminal 425, which, as explained above, is connected to terminal 424 (Fig. 1), to which the firing impulse conductor 423 is connected.

The other relay means will, when effective, relay impulses from the common impulse conductor 360 to the firing impulse conductors of their respective banks.

Terminals 563, 564, 565, and 566 (Fig. 7), which are connected to terminals 567, 568, 569, and 570, respectively (Fig. 6), supply biasing potential to the various relay means and enable the "II," "III," "IV," and "V" control tubes of the routing control device to prime the relay means one after another.

As explained earlier herein, terminal 463 (Fig. 6) is connected to terminal 459 (Fig. 2), to which the firing impulse conductor 455 for the second bank is connected, and enables the relay means to impress as many firing impulses on this conductor as there are impulses in the second symbol-representing burst of impulses impressed on conductor 360.

Similarly, terminals 464, 465, and 466 (Fig. 6) are connected to terminals 460, 461, and 462 of Figs. 3, 4, and 5, respectively, to enable the third, fourth, and fifth bursts of impulses to be relayed to the firing conductors 456, 457, and 458 of their respective banks of transforming and symbol-storing means.

An alternate form of routing means employing a conventional step by step sequence switch and a conventional operating circuit therefor is shown in Fig. 10.

The switch is of the type in which a rotatable wiper 1400 operates step by step to engage cooperating contacts, one after another, the wiper being given a step of movement through a pawl and ratchet drive each time a switch-operating magnet 1401 changes from its energized to its deenergized condition.

The wiper 1400 is connected to a terminal 1402 which is connected to terminal 358 (Fig. 8). As explained earlier herein a positive impulse will occur at terminal 358 each time a signal impulse of either kind is received.

As shown in Fig. 10, the wiper is in the position which it occupies during the reception of the first burst of signals. Impulses on terminal 358 will be transmitted over the wiper to contact 1403 which is connected over terminal 1404 to terminal 424 (Fig. 1) to cause the first bank of transforming and symbol-storing tubes to be operated. The last or large amplitude impulse of the first burst will cause the switch operating magnet 1401 to be energized momentarily and to be deenergized to allow the wiper to move into engagement with contact 1405 which is connected over terminal 1406 to terminal 459 (Fig. 2) to enable the second burst of impulses on terminal 358 to be transmitted to the second bank of transforming and symbol-storing tubes to cause their operation. As before, the last impulse of the burst will cause the switch operating magnet 1401 to be energized momentarily and to be deenergized to allow the wiper to move into engagement with the contact 1407 which is connected over terminal 1408 to terminal 460 (Fig. 3) of the next bank of transforming and symbol-storing tubes so that the third burst of impulses can be transmitted to the third bank of transforming and symbol-storing tubes to cause their operation. In a similar manner the wiper will engage further contacts 1409 and 1410 which are connected over terminals 1411 and 1412 respectively to terminals 461 (Fig. 4) and 462 (Fig. 5) to transmit the impulses of the fourth and fifth bursts of impulses to their respective banks of transforming and symbol-storing tubes.

Since only five banks of transforming and symbol-storing tubes have been provided, the switch wil move to contact 1413 after the fifth burst has been received. Contact 1413 is connected to contact 1403 so that the switch is again in position to cause a first burst of impulses to be routed to the first bank of transforming and symbol-storing tubes. In a similar manner further step by step operation of the wiper will cause the following bursts to be routed into the proper banks of transforming and symbol-storing tubes.

The operating magnet 1401 is included in the anode circuit of a thyraton 1415 along with an interrupter switch 1416 which is opened by the armature 1417 of the operating magnet 1401 as the armature pivots about its pivot point 1418 and nears its full extent of operation when the magnet is energized.

The grid of the thyraton 1415 is given a negative bias from a resistor network extending between a suitable source of negative potential and ground. The grid is also coupled over capacitor 1419 and terminal 1420 to terminal 396 (Fig. 8) which, as has been explained earlier, has a positive impulse impressed thereon each time a large amplitude signal is received The bias on the grid is such that it will prevent the thyraton from conducting until the positive impulse on terminal 396 is impressed on the grid over capacitor 1419.

The cathode of the thyratron is grounded.

When the thyratron is rendered conducting, it will continue to conduct until the armature 1417 of the switch operating the magnet 1401 opens the interrupter switch 1416.

Each impulse on terminal 396 (Fig. 8) when the last impulse of a burst is received will cause thyratron 1415 to become conducting and energize operating magnet 1401. As the magnet becomes energized it shifts its armature 1417 which opens the anode circuit of the thyratron 1415 at switch 1416, extinguishing the thyratron and deenergizing the magnet. Deenergization of the magnet allows spring 1421 to return the armature 1417 to its unoperated position and causes the pawl to move the wiper 1400 to the next contact.

With this form of routing means, the wiper will be shifted between bursts to direct the impulses of the bursts to the proper banks of transforming and symbol-storing tubes, the shifting being controlled by the last or marking impulse in each burst.

Thus, by the operation of the routing means, the successive bursts of impulses which are received are automatically sent to the proper banks of transforming and symbol-storing means, where the bursts are transformed into single representations of the various symbols and are stored.

Operation

In the operation of applicants' novel receiving apparatus, the apparatus is preset or prepared for the reception of data by firing, in any convenient manner, a "presetting" tube in each of the plurality of banks of transforming and symbol-storing tubes and by firing the first control tube of the routing control device. This presetting operation clears the receiving apparatus of any symbols which remained therein from a previous operation, and conditions the routing control device to prime the relay means for the first bank of transforming and symbol-storing tubes so that the first burst of impulses will be routed to that bank.

As the bursts of impulses are received by the receiving apparatus, the discriminating means passes them to the relay means for the various banks of transforming and symbol-storing tubes. The discriminating means also distinguishes between the small and large-amplitude impulses of a burst and causes the routing control device to operate and prime the relay means for the next bank when the large-amplitude impulse is received, so that the next burst of impulses will be routed to the next bank of transforming and symbol-storing tubes. In this manner, the relay means are primed one after another as the bursts are received, and cause the various bursts to be relayed to the proper banks of transforming and symbol-storing tubes.

The impulses relayed to the various banks of transforming and symbol-storing tubes will cause the step-by-step operation of the tubes of the banks to transform the different numbers of impulses in the bursts into single representations of the symbols, so that, at the end of the receiving operation, those tubes which have been fired and remain conducting in the various banks will correspond to the keys which were set in the sending apparatus and will provide an indication of the symbols making up the data which has been transmitted and received, which symbols are stored until the receiving apparatus is preset for another receiving operation.

Applicants' novel receiving apparatus, therefore, receives data which has been transformed into bursts of different numbers of discrete supersonic signals and has been transmitted thereto, and transforms the supersonic signals back into direct representations of the data and enables the data to be stored.

While the form of the invention herein shown and described is admirably adapted to fulfill the objects primarily stated, it is to be understood that it is not intended to confine the invention to the one form or embodiment herein disclosed, for it is susceptible of embodiment in various forms all coming within the scope of the claims which follow.

What is claimed is:

1. In a receiving apparatus for a communication system in which different numbers of electrical impulses are assigned to represent different symbols which may be transmitted, the last of the impulses representing a symbol being distinctive from the rest, the combination of a plurality of banks of electron devices, the devices in the banks being differentially operable to count the number of impulses in a corresponding plurality of bursts and transform the impulses into direct representations of symbols in response to different number of impulses which represent the symbols and to store the representation of the symbols; common means upon which bursts of impulses are impressed in succession, each burst containing the number of impulses corresponding to that assigned to the symbol which it represents; normally inoperable relay means related to each of said plurality of banks for selectively routing the impulses from

the common means to its related bank to render the devices in the bank responsive to one of the bursts of impulses; and means controlled by the last and distinctive electrical impulse in each burst to render the several relay means operative one after another as the bursts are received, to thereby enable the various bursts of impulses to cause the differential operation of the devices in the plurality of banks of devices to set up direct representations of the symbols represented by the different numbers of impulses in the bursts.

2. In a receiving apparatus for a communication system in which different numbers of signal impulses are assigned to represent different symbols which may be trasmitted and in which a symbol is transmitted as a burst of impulses containing a number of small-amplitude impulses which are followed by a large-amplitude terminal impulse, the combination of a plurality of banks of transforming and storing means, each bank including a plurality of electron devices of which different numbers of devices are operable in response to different numbers of impulses in the bursts to transform the bursts of impulses into direct representations of the symbols represented by the bursts; means to connect the devices of a bank for sequential operation one after another in response to impressed impulses; an impulse conductor for each bank by which impulses are impressed on the devices of the bank; input means upon which the bursts of signal impulses are impressed one after another in succession; routing means for selectively routing the impulses from the input means to the impulses conductors for the plurality of banks of transforming and storing means; and means controlled by the last or large-amplitude impulse in each burst to cause the routing means to route the next burst to the impulse conductor for another one of the plurality of banks of transforming and storing means, whereby the successive bursts of signal impulses will be routed to control the operation of the banks of transforming and storing means one after another in succession.

3. In a receiving apparatus for a communication system in which different numbers of electrical impulses are assigned to represent different symbols which may be transmitted, the last of the impulses representing a symbol being distinctive from the rest, the combination of a plurality of banks and gaseous electron tubes; means connecting the tubes in each bank for step-by-step operation in sequence in response to the electrical impulses, the different numbers of electrical impulses forming bursts and causing different numbers of tubes to be operated to transform the bursts into direct representations of the symbols; means common to all the banks of tubes and upon which the bursts of electrical impulses are impressed in succession, each burst containing a number of electrical impulses corresponding to that assigned to the symbol which it represents; a thermionic valve related to each of said plurality of banks of tubes for selectively relaying electrical impulses from the common means to its related bank of tubes to cause a number of tubes therein to be operated according to one of the bursts of signals; means normally giving the thermionic valves a sufficient bias so that they will not respond to the electrical impulses; and means operable by the distinctive electrical impulses of the several bursts to reduce the bias on the thermionic valves one after another in sequence to enable the valve to successively respond to the electrical impulses and relay the successive bursts to the several banks of tubes in succession.

4. In a receiving apparatus for a communication system in which different numbers of electrical impulses are assigned to represent different symbols which may be transmitted, the last of the impulses representing a symbol being distinctive from the rest, the combination of a plurality of banks of gaseous electron tubes; means connecting the tubes in each bank for step-by-step operation in sequence in response to the electrical impulses, the different numbers of electrical impulses forming bursts and causing different numbers of tubes to be operated to transform the impulses into direct representations of the symbols; means common to all the banks of tubes and upon which the bursts of electrical impulses are impressed in succession, each burst containing the number of electrical impulses corresponding to that assigned to the symbol which is represents; a thermionic valve related to each of said plurality of banks for selectively relaying electrical impulses from the common means to its related bank of tubes to cause a number of tubes therein to be operated according to one of the bursts of impulses; means normally giving the thermionic valves a sufficient bias so that they will not respond to the electrical impulses; and electron devices operable one at a time in sequence in response to the distinctive electrical impulse in each burst for reducing the bias on the thermionic valves one after another to enable the valves to respond to the electrical impulses and route the successive bursts into different banks of tubes.

5. In a receiving apparatus for a communication system in which different symbols which may be transmitted are represented by bursts of electrical impulses, the burst containing different numbers of impulses according to the symbols and the last impulse in each burst being distinctive from the others in a burst, the combination of a plurality of banks of gaseous electron tubes; means connecting the tubes in each bank for operation one at a time in step-by-step sequence in response to the electrical impulses, the different numbers of impulses in the bursts being effective to cause different numbers of tubes to be operated in the banks and enable the last tube to be operated in each bank to provide a direct representation of the symbols; common means upon which the bursts of electrical impulses are impressed in succession; a relay device related to each of said plurality of banks for selectively relaying the electrical impulses from the common means to its related bank of tubes to cause a number of tubes therein to be operated according to the number of impulses in one of the bursts; a gaseous electron routing control tube for each relay device; means connecting the routing control tubes for operation one at a time in sequence, the connections enabling conduction in one tube to prime the next tube in the sequence to be operated in response to routing control impulses; means controlled by the last electrical impulse in each burst to send a routing control impulse to the routing control tubes to cause the primed tube to operate; and means enabling routing control tubes to render their related relay devices operable when the control tubes are operating, thereby to enable the relay devices to relay the electrical impulses in the various bursts to the proper banks of tubes.

6. In a receiving apparatus for a communication system in which different numbers of electrical impulses are assigned to represent different symbols which may be transmitted and in which a distinctive electrical impulse follows a number of similar electrical impulses for each symbol, the combination of a plurality of banks of gaseous electron tubes; means connecting the tubes in each bank for step-by-step operation in sequence in response to the impulses, the different numbers of similar impulses together with a distinctive impulse forming bursts and causing different numbers of tubes to be operated to provide direct representations of the symbols; discriminating means upon which bursts of impulses are impressed in succession, each burst containing a distinctive impulse and a number of similar impulses according to the symbol which it represents, said discriminating means including a first means operated by each impulse and a further means operated only by the distinctive impulse; a common impulse conductor having an impulse impressed thereon by the first means of the discriminating means for each impulse in each burst that is received; a thermionic valve related to each of said plurality of banks for selectively relaying impulses from the common conductor to its related bank of tubes to cause a number of tubes therein to be operated according to one of the bursts of signals; means normally giving the thermionic valves a sufficient bias so that they will not respond to the impulses; control electron devices; circuits connecting the devices for operation one at a time in sequence, conduction in one device being effective to prime the next device of the sequence for operation under the control of the further means of the discriminating means each time a distinctive impulse is received; and means coupling the control electron devices to the thermionic valves so that conduction in a device reduces the bias on a related valve thereby to enable the valves to respond to the impulses and route the successive bursts into different banks of tubes.

7. In a receiving apparatus for a communication system in which different numbers of signal impulses are assigned to represent different symbols which may be transmitted and in which a symbol is transmitted as a burst of impulses containing a number of small-amplitude impulses followed by a large-amplitude impulse, the combination of a plurality of transforming and symbol-storing means differentially operable in response to the different numbers of impulses representing the symbols, to transform the bursts into direct representations of these symbols and to store the symbols; discriminating means upon which the bursts of signal impulses representing the various symbols being received are impressed one after another, said discriminating means having a first part which is responsive to all the signal impulses of the bursts and a second part which is responsive to only the large-amplitude signal impulses; an impulse conductor common to said plurality of differentially operable means and upon which an impulse is impressed by the first part of the discriminating means when each signal impulse is impressed on the discriminating means; routing means selectively operable to route impulses from the impulse conductor to the several differentially operable means one after another in succession; and means controlled by the second part of the discriminating means, each time a large-amplitude impulse is received, to control the selective operation of the routing means to enable the impulses of the successive bursts to be routed to different ones of said plurality of differentially operable means to cause direct representations of the symbols represented by the bursts of impulses to be set up.

8. In a receiving apparatus for a communication system in which different numbers of signal impulses are assigned to represent different symbols which may be transmitted and in which a symbol is transmitted as a burst of impulses containing a number of small-amplitude impulses followed by a large-amplitude impulse, the combination of a plurality of means differentially operable in response to the different numbers of impulses representing the symbols, to provide direct representations of these symbols; discriminating means upon which the bursts of signal impulses representing the various symbols being received are impressed one after another, said discriminating means having a first part which is responsive to all the signal impulses of the bursts and a second part which is responsive to only the large-amplitude signal impulses; an impulse conductor common to said plurality of differentially operable means and upon which an impulse is impressed by the first part of the discriminating means when each signal impulse is impressed on the discriminating means; a relay device related to each of said plurality of differentially operable means for selectively relaying impulses from the impulse conductor to its related bank of tubes; a plurality of gaseous electron control tubes, one for each relay device, to cause the relay devices to be operative whenever their related tubes are conducting; means connecting the control tubes so that they may be fired and rendered conducting one at a time in sequence in response to control impulses; and means controlled by the second part of the discriminating means, each time a large-amplitude impulse is received, to send a control impulse to the control tubes to cause the tubes to become conducting one after another and render the relay means operable in succession to enable the impulses of the successive bursts to be relayed to different ones of said plurality of differentially operable means to cause direct representations of the symbols represented by the bursts of impulses to be set up.

9. In a receiving apparatus for a communication system in which different numbers of signal impulses are assigned to represent different symbols which might be transmitted and in which a symbol is transmitted as a burst of small-amplitude impulses followed by a large-amplitude impulse, the combination of a plurality of banks of electron devices; means for causing the devices in a bank to be operated step by step and one at a time in sequence in response to the impulses of one of the bursts, the last device to be operated in each bank providing a direct representation of the symbol represented by the burst which caused the operation in that bank; discriminating means upon which the bursts of signal impulses are impressed one after another; a conductor common to the banks of devices, said conductor having an impulse impressed thereon by the discriminating means each time a signal is impressed on the dicriminating means; routing means for routing the impulses selectively from the common conductor to the various banks of devices to cause the devices to be operated according to the number of impulses in a burst; and means controlled by the discriminating means and operable each time a large-amplitude im-

pulse is impressed on the discriminating means to control the operation of the routing means to thereby route the successive bursts of impulses to different banks of electron devices to set up direct representations of symbols therein.

10. In a receiving apparatus for a communication system in which different numbers of signal impulses are assigned to represent different symbols which might be transmitted and in which a symbol is transmitted as a burst of small-amplitude impulses followed by a large-amplitude impulse, the combination of a plurality of banks of electron devices; means for causing the devices in a bank to be operated step by step and one at a time in sequence in response to the impulses of one of the bursts, the last device to be operated in each bank providing a direct representation of the symbol represented by the burst which caused the operation in that bank; discriminating means upon which the bursts of signal impulses are impressed one after another, said discriminating means having one part responsive to all the signal impulses and a second part responsive to only the large-amplitude impulses; a conductor common to the banks of devices, said conductor having an impulse impressed thereon by said one part of the discriminating means each time a signal is impressed on the discriminating means; a relay device related to each of said plurality of banks of electron devices for selectively relaying impulses from the common conductor to its related bank of devices to cause the devices to be operated according to the number of impulses in a burst; and means controlled by the second part of the discriminating means and operable each time a large-amplitude impulse is impressed on the discriminating means to control the operation of the relay devices in sequence to route the successive bursts of impulses to different banks of electron devices to set up direct representations of symbols therein.

11. In a receiving apparatus for a communication system in which different numbers of signal impulses are assigned to represent different symbols which might be transmitted and in which a symbol is transmitted as a burst of small-amplitude impulses followed by a large-amplitude impulse, the combination of a plurality of transforming and symbol-storing means differentially operable to provide direct representations of symbols in response to different numbers of signal impulses which represent the symbols; discriminating means upon which the bursts of signal impulses are impressed one after another, said discriminating means including a vacuum tube biased to respond to all the signal impulses and a second vacuum tube biased to respond to only the large-amplitude impulses; a conductor common to the plurality of transforming and storing means, said conductor having an impulse impressed thereon under control of said one tube in the discriminating means each time a signal is impressed on the discriminating means; routing means for routing the impulses from the common conductor to the various ones of the plurality of transforming and symbol-storing means; and means controlled by the second tube in the discriminating means and operable, each time a large-amplitude impulse is impressed on the discriminating means, to cause the routing means to route the impulses from the common conductor to the various ones of the plurality of transforming and symbol-storing means whereby successive bursts of impulses can control the different transforming and storing means to set up direct representations of symbols therein.

12. In a receiving apparatus for a communication system in which different numbers of signal impulses are assigned to represent different symbols which might be transmitted and in which a symbol is transmitted as a burst of small-amplitude impulses followed by a large-amplitude impulse, the combination of a plurality of banks of gaseous electron tubes; means connecting the tubes in a bank to be fired and rendered conducting step by step and one at a time in sequence in response to the impulses of one of the bursts to transform the burst of signals into a direct representation of the symbol represented by the burst, the last tube to be operated and which is conducting in each bank providing a direct representation of the symbol represented by the burst which caused the operation in that bank and serving to store that symbol; discriminating means upon which the bursts of signal impulses are impressed one after another, said discriminating means including a vacuum tube biased to respond to all the signal impulses and a second vacuum tube biased to respond to only the large-amplitude impulses; a conductor common to the banks of tubes, said conductor having an impulse impressed thereon under control of said one tube in the discriminating means each time a signal is impressed on the discriminating means; a thermionic valve relay device related to each of said plurality of banks of gaseous electron tubes for selectively relaying impulses from the common conductor to its related bank of tubes to cause these tubes to be operated according to the number of impulses in a burst; means normally giving the thermionic valve relay devices a sufficient bias so that they will not respond to the impulses on the common conductor; and means controlled by the second tube in the discriminating means and operable each time a large-amplitude impulse is impressed on the discriminating means to reduce the bias on the relay devices one after another in sequence to enable the relay devices to successively respond to the impulse on the common conductor and route the successive bursts of impulses to different banks of tubes to set up and store therein direct representations of symbols represented by the bursts of signal impulses.

13. In a receiving apparatus for a communication system in which different numbers of signal impulses are assigned to represent different symbols which might be transmitted and in which a symbol is transmitted as a burst of small-amplitude impulses followed by a large-amplitude impulse, the combination of a plurality of banks of gaseous electron tubes; means connecting the tubes in a bank to be fired and rendered conducting step by step and one at a time in sequence in response to the impulses of one of the bursts to transform the burst of signals into a direct representation of the symbol represented by the burst, the last tube to be operated and which is conducting in each bank providing a direct representation of the symbol represented by the burst which causes the operation in that bank and serving to store that symbol; discriminating means upon which the bursts of signal impulses are impressed one after another, said discriminating means including a vacuum tube biased to respond to all the signal impulses and a second vacuum tube biased to respond to only the large-amplitude impulses; a conductor common to the banks of tubes, said conductor having an impulse impressed thereon under control of said one tube in the

discriminating means each time a signal is impressed on the discriminating means; a thermionic valve relay device related to each of said plurality of banks of gaseous electron tubes for selectively relaying impulses from the common conductor to its related bank of tubes to cause the devices to be operated according to the number of impulses in a burst; means normally giving the thermionic valve relay devices a sufficient bias so that they will not respond to the impulses on the common conductor; a plurality of gaseous electron control tubes, one related to each relay device; means connecting the tubes for operation one at a time in step-by-step sequence in response to control impulses; means controlled by the second vacuum tube in the discriminating means to send a control impulse to the control tubes each time a large-amplitude impulse is impressed on the discriminating means; and means enabling the control tubes, as they are operated, to reduce the bias on their related relay devices one after another to enable these devices to respond to impulses on the common conductor and relay these impulses to the proper banks of tubes to set up therein direct representations of the symbols.

14. In a device of the class described, the combination of means upon which is impressed a signal train made up of a succession of bursts of impulses, each burst containing small-amplitude impulses followed by a large-amplitude impulse; a plurality of conductors; a normally unoperated relay device for each of said plurality of conductors; and means controlled by the means upon which the signal train is impressed and operable under control of the large-amplitude impulses to render the relay devices operable one after another in succession to relay the impulses of the various bursts from the means upon which the signal train is impressed to different ones of the plurality of conductors.

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