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PROGRAMMING AND TELEMETERING SYSTEM AND APPARATUS

Filed Oct. 12, 1962

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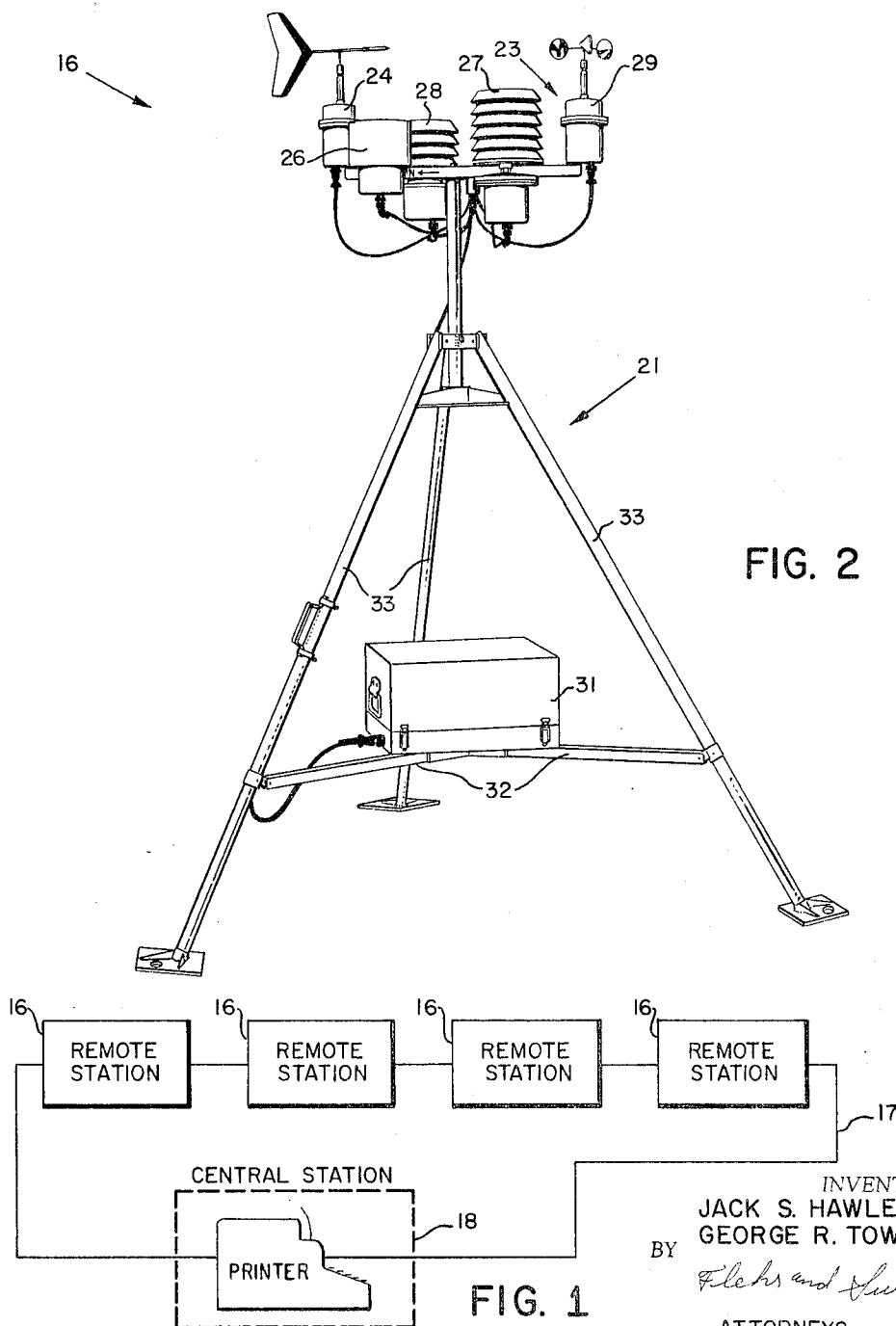


FIG. 2

FIG. 1

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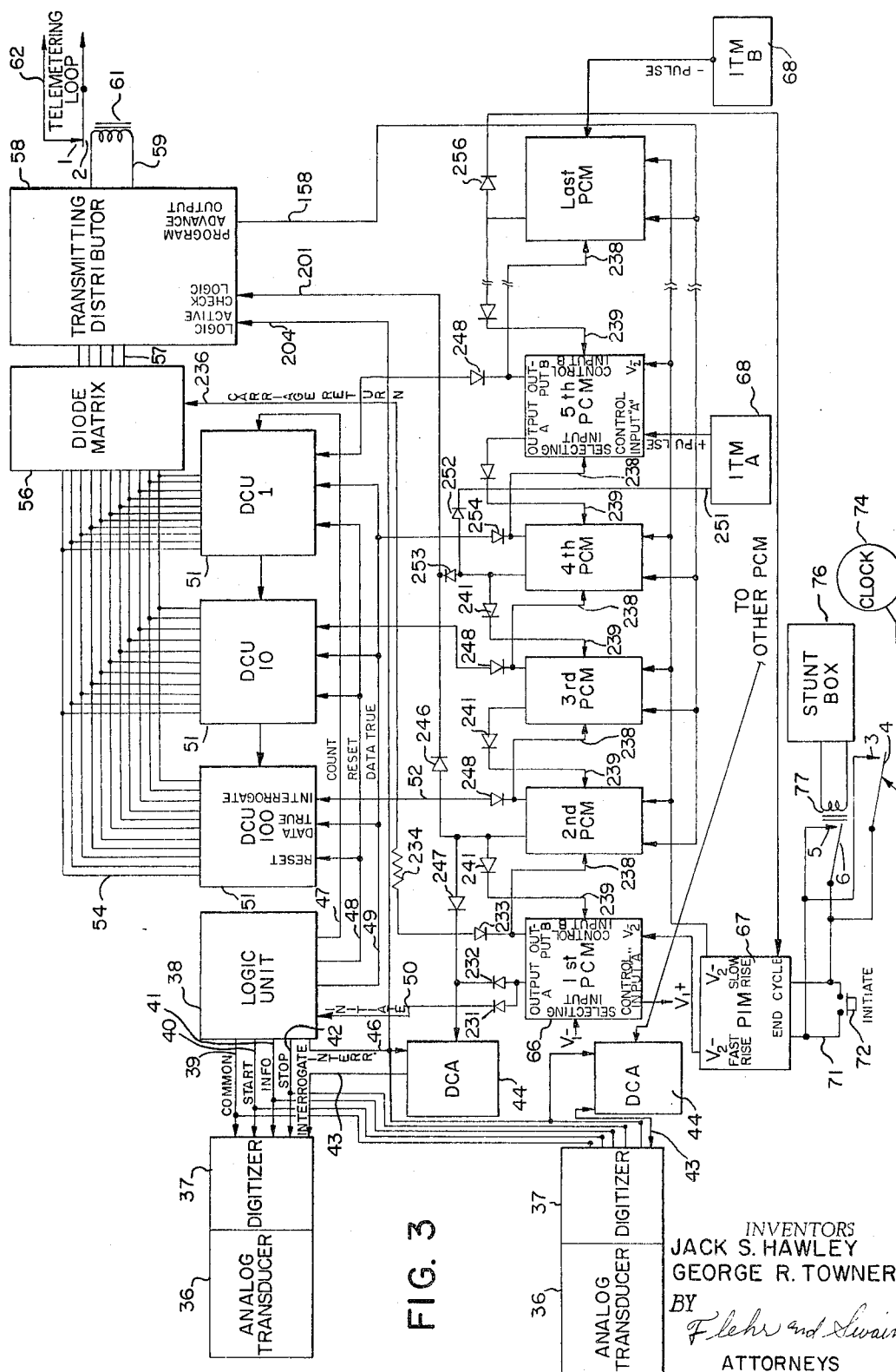
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PROGRAMMING AND TELEMETERING SYSTEM AND APPARATUS

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6 Sheets-Sheet 3

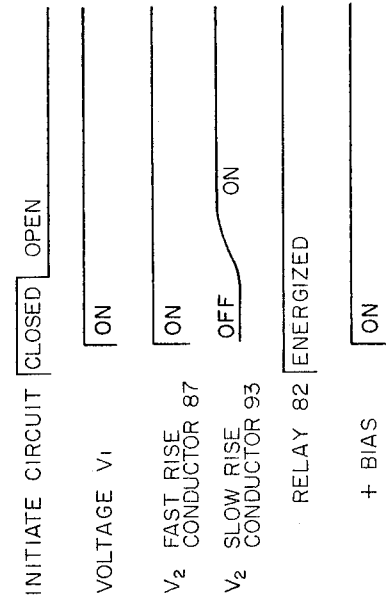


FIG. 5

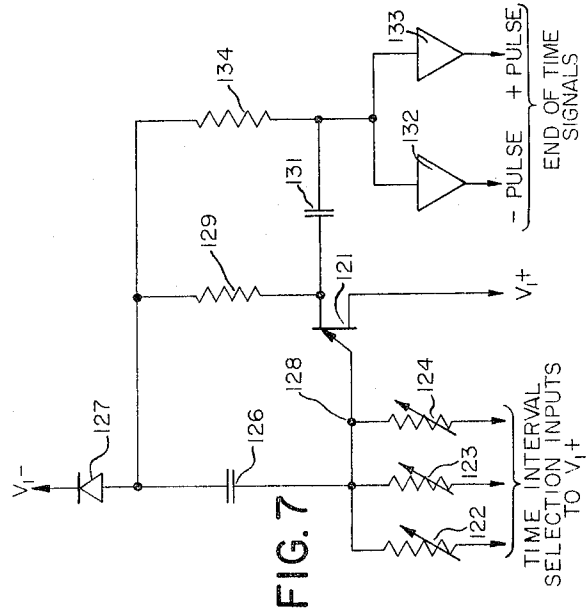


FIG. 7

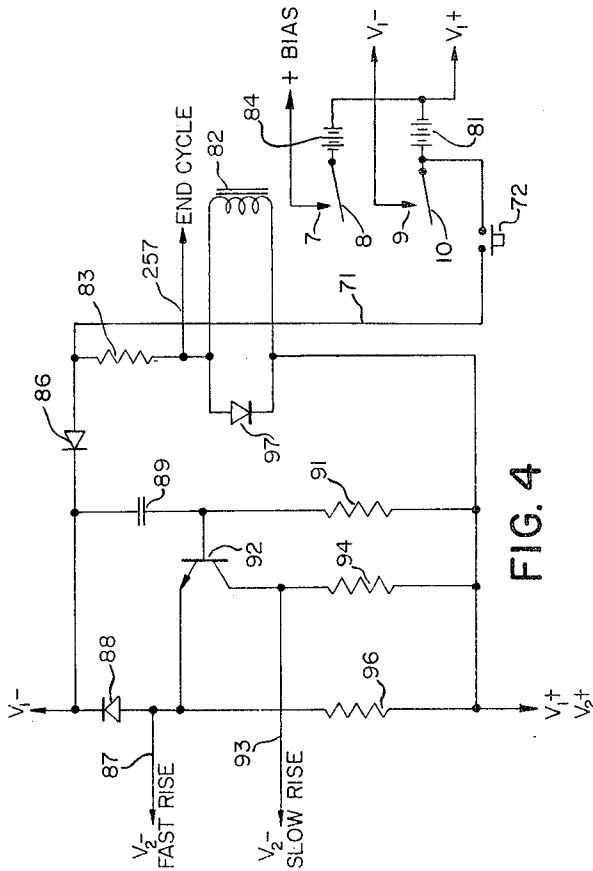


FIG. 4

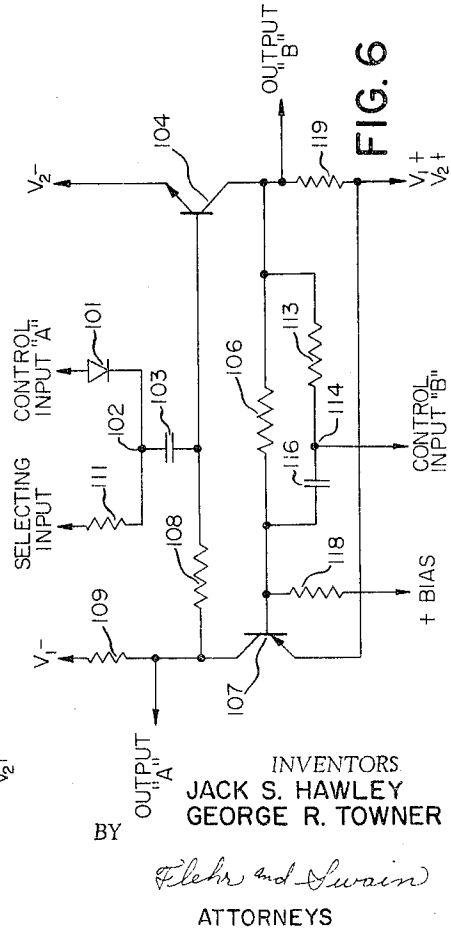


FIG. 6

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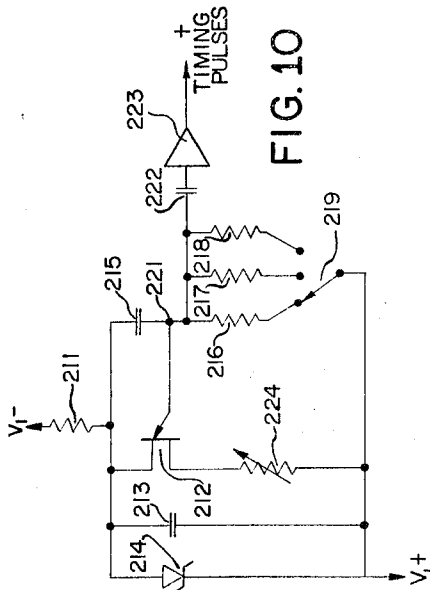


FIG. 10

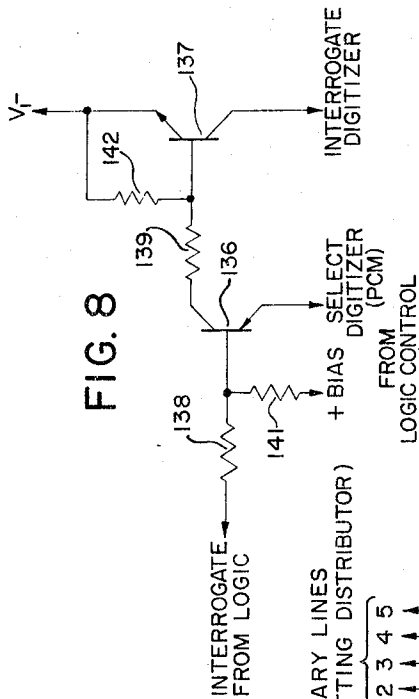


FIG. 8

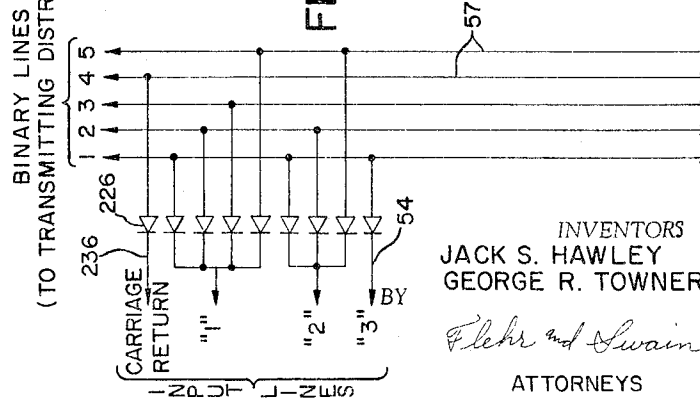


FIG. 11

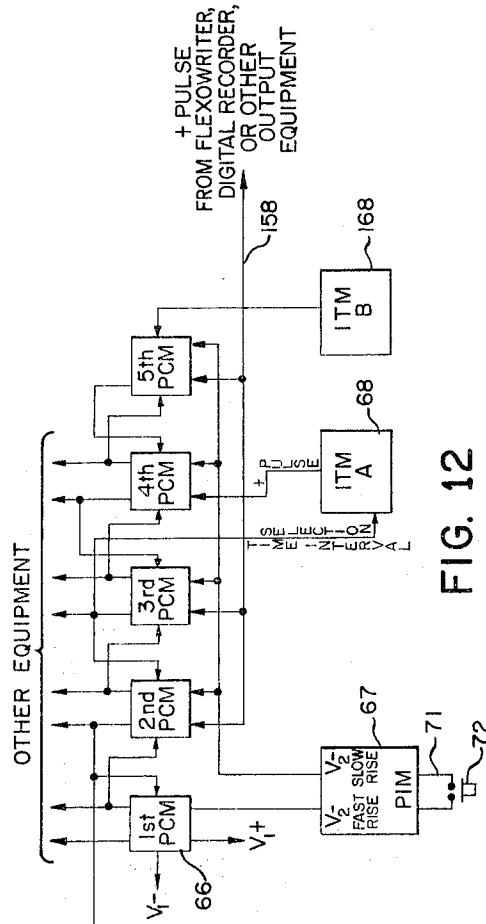
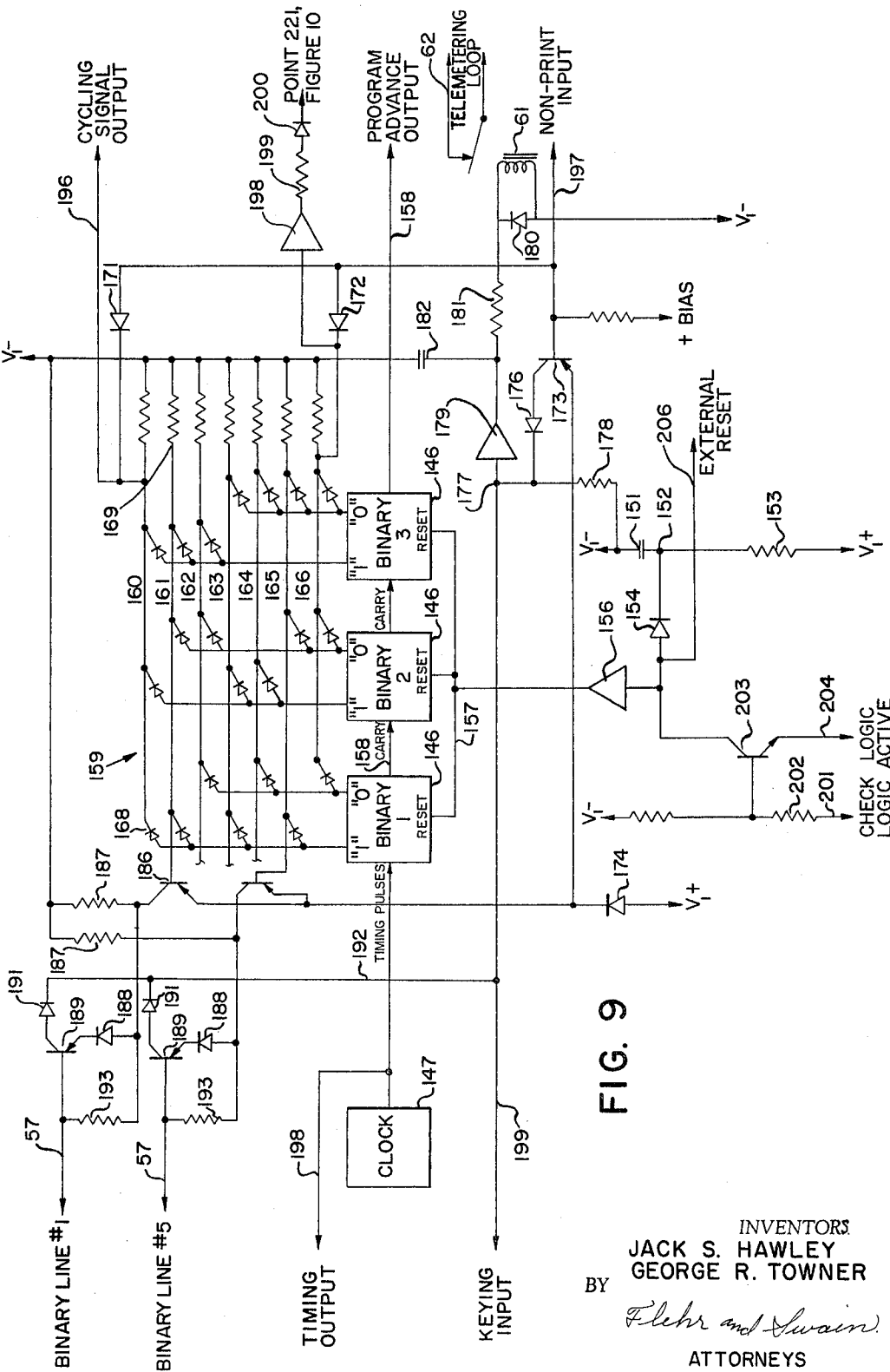


FIG. 12

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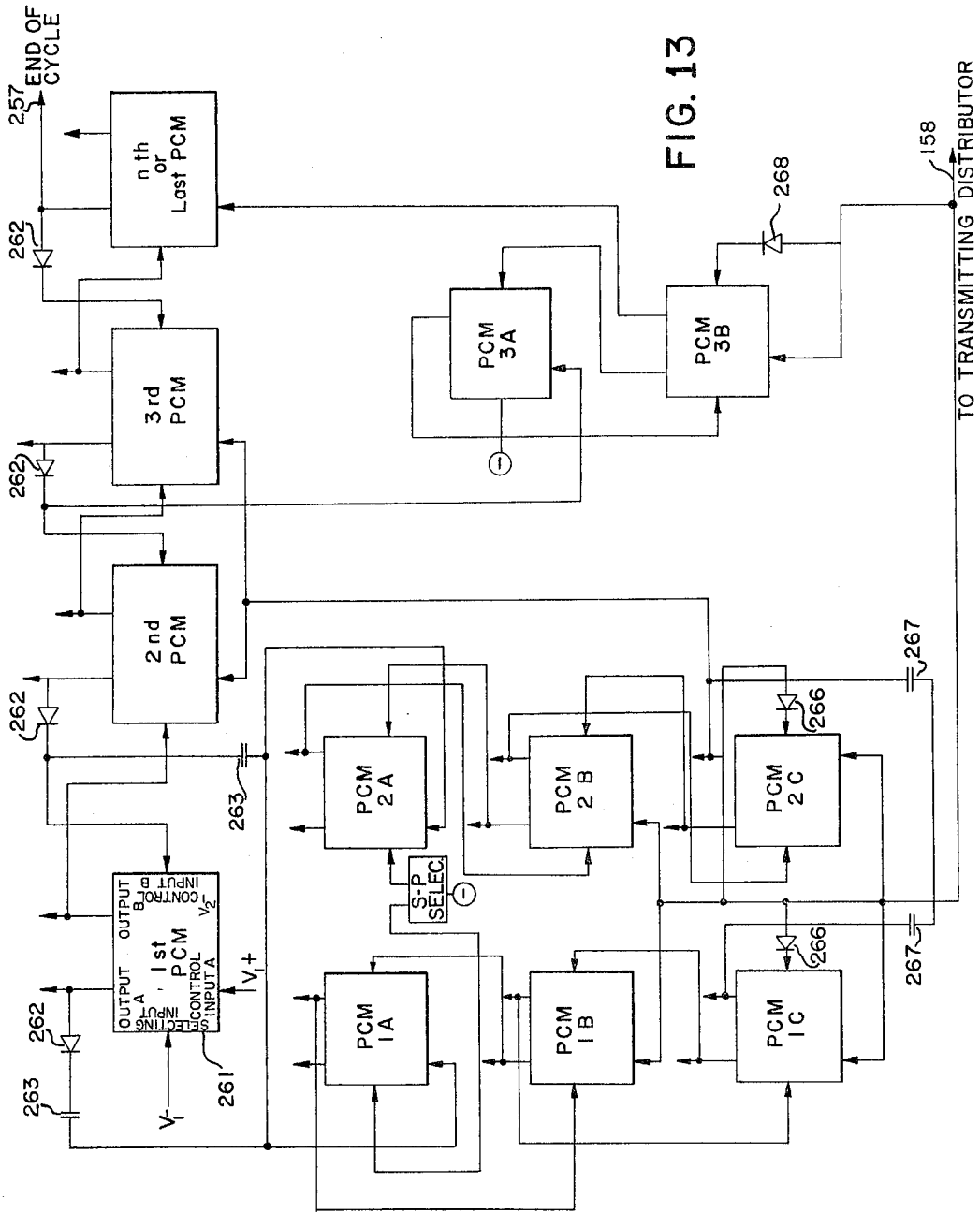
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PROGRAMMING AND TELEMETERING SYSTEM AND APPARATUS

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6 Sheets-Sheet 6



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3,289,165

PROGRAMMING AND TELEMETERING SYSTEM AND APPARATUS

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14 Claims. (Cl. 340-151)

This invention relates to a programming and telemetering system and apparatus and more particularly to a programming and telemetering system and apparatus which is particularly adapted for use with teleprinter equipment.

In copending application Serial No. 135,295, filed August 31, 1961, entitled, "Digital Data System and Apparatus," there is disclosed a system and apparatus for gathering various types of information, e.g., the collection of data from various analog transducers and digitizing of the same, or in other words, transforming the analog information into digital information at a central location. There is a need for a system and apparatus for use with such a digital data system and apparatus to permit telemetering of the information gathered at a remote location to a central station. There is also a need for translating this digital information into usable serial synchronous binary signals particularly those of a type which can be received and interpreted by standard teleprinter or other synchronous bit-serial receiving apparatus.

In general, it is an object of the present invention to provide a programming and telemetering system and apparatus which can be utilized for gathering information at remote locations and telemetering the information to a central station.

Another object of the invention is to provide a system and apparatus of the above character in which the information is telemetered in synchronous bit-serial form.

Another object of the invention is to provide a system and apparatus of the above character which can be utilized for translating parallel ten line information into synchronous serial pulses.

Another object of the invention is to provide a system and apparatus of the above character in which the order of the information telemetered can be readily programmed.

Another object of the invention is to provide a system and apparatus of the above character which can be controlled from the central station or from the remote station.

Another object of the invention is to provide a system and apparatus of the above character in which the telemetered information will provide a complete and intelligible message arranged in a predetermined format on a conventional teleprinter.

Another object of the invention is to provide a system and apparatus of the above character which can be utilized for linking a large number of remote stations in which the information can be automatically received.

Another object of the invention is to provide a system and apparatus of the above character in which the apparatus will operate over long periods of time at unattended installations in remote areas.

Another object of the invention is to provide a system and apparatus of the above character which is rugged, small and light in weight.

Another object of the invention is to provide a system and apparatus of the above character which has high reliability and is packaged to facilitate rapid field servicing by nontechnical personnel.

Another object of the invention is to provide a system and apparatus of the above character which will operate under extreme environmental conditions.

Another object of the invention is to provide a system and apparatus of the above character which is positive in its operation.

Another object of the invention is to provide a system and apparatus of the above character in which aging of the components will not affect the positive operation.

Another object of the invention is to provide a system and apparatus of the above character in which voltages of both polarities are provided for energizing equipment having differing polarity requirements.

Another object of the invention is to provide a system and apparatus of the above character in which modularity is used as much as possible.

Another object of the invention is to provide a system and apparatus of the above character in which printed circuit boards can be utilized for the modules and in which the printed circuit boards can be mounted in stacked connectors.

Another object of the invention is to provide a system and apparatus of the above character in which the number of characters in a message can be changed by increasing or decreasing the number of modules.

Another object of the invention is to provide a system and apparatus of the above character which utilizes a particularly novel transmitting distributor.

Another object of the invention is to provide a system and apparatus of the above character which requires small amounts of power.

Another object of the invention is to provide a system and apparatus of the above character which, in addition to being useful for telemetering, can be used for many other purposes such as programming solenoid-operated printers, and the like.

Additional objects and features of the invention will appear from the following description in which the preferred embodiments are set forth in detail in conjunction with the accompanying drawings.

Referring to the drawings:

FIGURE 1 is a block diagram of a programming and telemetering system and apparatus incorporating my invention.

FIG. 2 is a perspective view of a typical programming and telemetering apparatus located at a remote station.

FIGURE 3 is a block diagram of a typical programming and telemetering apparatus.

FIGURE 4 is a schematic diagram of a typical power initiate module utilized in FIGURE 3.

FIGURE 5 is a diagram showing the time relationships which arise upon application of power in the power initiate module shown in FIGURE 4.

FIGURE 6 is a circuit diagram of a typical program control module shown in FIGURE 4.

FIGURE 7 is a circuit diagram of a typical interval timing module shown in FIGURE 4.

FIGURE 8 is a circuit diagram of a typical digitizer control amplifier shown in FIGURE 4.

FIGURE 9 is a circuit diagram of a typical transmitting distributor shown in FIGURE 4.

FIGURE 10 is a circuit diagram of a typical transmitting distributor clock shown in FIGURE 9.

FIGURE 11 is a circuit diagram of a typical diode encoding matrix shown in FIGURE 4.

FIGURE 12 is a block diagram of a typical arrangement of modules to form a programming system.

FIGURE 13 is a block diagram of a more complicated arrangement of program control modules.

General description

In FIGURE 1, we have shown a block diagram of our programming and telemetering system and apparatus which represents a typical, rather simple installation. As shown in FIGURE 1, it consists of a plurality of remote telemetering stations 16 which are all connected in series into a single teleprinter loop 17. At the central station 18, the teleprinter loop is connected to suitable receiving and recording apparatus such as Model No. 28 Teletype Page Printed shown in FIGURE 1. In such a simple installation, the remote stations can be interrogated either by a special signal coming over the teleprinter line which operates a teleprinter "stunt box" which causes the station to respond and transmit the information it has gathered to the teleprinter. Alternatively, if desired, the remote stations can be actuated by a clock or other device which causes the remote stations to report into the central station predetermined spaced time intervals. The remote stations can also report only when an alarm condition occurs at the remote station.

In more sophisticated installations, it is readily apparent that additional loops can be connected into the same central station 18 and that by proper timing, the information can be fed into the same teletyped page printer. If desired, additional page printed can be provided. If it is desired for individual remote stations to report to separate page printers, each remote station may send a special sequence of characters before its report, which sequence of characters will operate one or more teleprinter "stunt boxes" associated with the printer or printers that are to print the report, turning them on to receive the transmission. It is also readily apparent that, if desired, instead of land line, radio or other electrical means can be used for transmitting the information. For example, if desired, each of the remote stations can be provided with a transceiver. Similarly, the central station is provided with a transceiver. In such a case, the remote station 16 is connected by a local loop into the transceiver. Selective calling equipment readily available on the market, such as Motorola "Quick-Call," can be utilized with the transceivers so that the remote station will transmit its information to the central station when called. Similarly, if desired, the remote stations can be controlled by clocks to transmit the desired information at predetermined spaced intervals of time. With such an arrangement, it is readily apparent that a great many remote stations can report to a single central station with the transceiver at the central station being connected directly to the page printer. For communications over long distances, microwave relay links can be utilized. In general, the compatibility of signal output and reception of the equipment herein described allows a wide variety of particular arrangements of system elements.

Telemetering station

In FIGURE 2, we have shown an example of a remote telemetering station 16 which takes the form of an automatic weather reporting station. It consists of a collapsible tripod assembly 21 upon which are mounted a plurality of sensing and digitizing assemblies 23. Sensing and digitizing assemblies of this type are disclosed in detail in copending application Serial No. 135,295, filed August 31, 1961. These sensing and digitizing assemblies consist of a wind direction digitizer 24, a barometric pressure digitizer 26, a temperature digitizer 27, a humidity digitizer 28, and a wind velocity digitizer 29.

As explained in copending application Serial No. 135,295, filed August 31, 1961, such digitizers include transducers giving output information in analog form. The information in analog form is digitized by digitizers disclosed in the above identified copending application to convert the analog information into digital form.

The information in digital form is supplied to a cabinet 31 which is mounted upon cross-braces 32 interconnecting the legs 33 of the tripod 21. The electronic circuitry in

this cabinet 31, as hereinafter explained, contains means for sequentially interrogating the digitizers, receiving information from the interrogated digitizers, storing this information on registers and then subsequently supplying all of the gathered information in a teleprinter program which includes such auxiliary information as the station identification, proper carriage returns and spaces so that the information will be properly printed by a Teletype printer.

In FIGURE 3, we have shown a block diagram of a typical telemetering station in which the blocks 36 represent any suitable analog transducer and the digitizers 37 represent any suitable digitizer as, for example, the analog transducers and digitizers disclosed in copending application Serial No. 135,295, filed August 31, 1961. The only requirement is that the digitizers supply information in digital form.

Each of the digitizers 37 is connected to a common logic unit 38 by four conductors 39, 40, 41 and 42 which can be identified as the "common," "start," "information" and "stop" lines, respectively. An interrogate line 43 is also connected to each of the digitizers. The other end of each of these lines 43 is connected to a digitizer control amplifier 44 which is provided for each of the digitizers 37. The digitizer control amplifiers are connected to the logic unit by an interrogate line 46.

The logic unit 38 is connected to four additional lines 47, 48, 49 and 50 which can be designated as a count, reset, data-true, and initiate lines, respectively. As shown in FIGURE 3 of the drawings, these lines 47, 48 and 49 are connected in parallel to a plurality of decimal counting units 51. For example, as shown in the drawings, it may be desirable to provide three of such units in which the first unit from the right as viewed in FIGURE 3 would count the units up to nine with the carry pulse being applied on the carry line to a tens counting decimal counting unit which, after receipt of the ninety-ninth pulse, would supply a carry pulse to the hundreds decimal counting unit to make possible a maximum count of 999 with three of the decimal counting units. The count line 47 is only connected to the first DCU. The reset and data-true lines 48 and 49 are connected to each of the decimal counting units. Each of the decimal counting units is connected to the program control modules as hereinafter described.

Each of the decimal counting units 51 is provided with eleven output lines 54, ten of which represent the digits from zero to nine and the eleventh which represents an error or E line. These output lines 54 of the decimal counting units are connected in parallel to a diode matrix 56 which is described in copending application Serial No. 135,295, filed August 31, 1961, and which serves to encode the ten line output from the decimal counting units into a desired binary code as, for example, a two-out-of-five code.

The output of the diode matrix is supplied on a plurality of conductors 57 in bit-parallel binary form to a transmitting distributor 58 which, as hereinafter described, transforms the bit-parallel binary input into bit serial synchronous signals which are supplied to a loop 59 which includes a suitable keying relay such as a Clare mercury wetted relay type #HGS 1009. The loop relay translates the signals on the loop 59 into contact closures by means of the normally closed contacts 1 and 2 onto a telemetering loop 62. As hereinbefore explained, this telemetering loop 62 can be connected by land line or radio to a teleprinter at the central station.

The analog transducers 36, the digitizers 37, the logic unit 38, the decimal counting units 51 and the diode matrix 56 are of the type described in copending application Serial No. 135,295, filed August 31, 1961, and for that reason will not be explained in detail.

The telemetering station shown in FIGURE 3, in addition includes a plurality of program control modules,

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a power initiate module 67 and a plurality of interval timing modules 68. It also includes additional apparatus as hereinafter described.

Power initiate module

In FIGURE 4, we have shown a typical power initiate module. The power initiate module consists of an initiate circuit 71 which is adapted to be closed by a push-button 72. Alternatively, as shown in FIGURE 3, this initiate circuit 71 can be closed by a clock 74 which operates contacts 3 and 4 at a predetermined time. Also, it can be operated, if desired, by remote calling equipment by the use of a teleprinter "stunt box" 76 which operates a relay 77 to close its contacts 5 and 6 to close the initiate circuit 71.

As soon as contacts 9 and 10 of relay 82 close, a voltage is supplied from the battery 81 through current limiting resistor 83 to the winding of the relay 82 causing energization of the relay 82 and closing of its contacts 7 and 8, and 9 and 10. Closing of contacts 7 and 8 supplies a plus bias voltage to the indicated circuits in the system from a battery 84. Closing contacts 9 and 10 of relay 82 supplies voltage V_1- from battery 81 to the indicated circuits in the system. Voltage V_1- flows through isolating diode 86 and current limiting resistor 83 to continue the energization of relay 82 after the push-button 72 has been released. The diode 86 prevents contact bounce in the pushbutton 72 from affecting other parts of the system. A shunting diode 97 serves to prevent inductive surges from the relay 82 from affecting other components of the system.

As soon as contacts 9 and 10 of relay 82 close, a voltage V_2- is supplied to the conductor 87 through the diode 88. The diode 88 merely serves as a voltage dropping diode and, therefore, the negative voltage appears immediately on the conductor 87. As soon as the V_1- voltage is applied to the power initiate module, the capacitor 89 begins charging through the resistor 91 and as soon as the voltage on the base of the NPN transistor 92 reaches a certain value, the NPN transistor 92 will turn on. As soon as it turns on, it supplies a gradually increasing negative voltage V_2- on conductor 93. The resistor 94 serves as a load resistor for the transistor 92. The resistor 96 serves as a voltage dropping resistor. Because of the voltage drop across the diode 88, a voltage V_1- constitutes a minus bias with respect to voltage V_2- for biasing of NPN transistors and other parts of the system.

Thus, it can be seen that when the relay 82 operates, the power initiate module will immediately produce a negative voltage V_2- on the conductor 87 which, therefore, can be termed a "fast rise" voltage, and thereafter produce a gradually increasing negative voltage after a predetermined time delay on the conductor 93 to provide a voltage which can be called a "slow rise" voltage. Typical time relationships between the operation of the initiate circuit, the voltage V_1 the voltages V_2- (fast rise) and V_2- (slow rise), operation of the relay 82 and the plus bias are shown in FIGURE 5.

The power initiate module is provided with an end of cycle conductor 257 which, when the positive voltage is applied to it, as hereinafter described, reduces the current flow through the relay 82 so that it drops out to open its contacts 1 and 2, and 3 and 4 to remove the voltage V_1- and the plus bias from the various parts of the system.

Program control module

A typical program control module is shown in FIGURE 6. When the program control module is energized from the power initiate module as hereinafter described, it receives power on the terminal labelled V_1- , V_2- , +BIAS and V_1+ and V_2+ . The V_1+ and V_2+ voltages are always common. When a fast rising positive pulse is applied to the control Input A, as hereinafter described, it passes through the isolating diode 101 to rapidly change

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the polarity at point 102. (Point 102 is negative prior to this time because of the voltage applied to the Selecting Input as hereinafter described.) So that this pulse is coupled through the capacitor 103 to raise the voltage on the base of NPN transistor 104 to cause it to conduct momentarily. This conduction of the transistor 104 causes the production of a negative current at Output B. This negative current travels through the resistor 106 to the base of PNP transistor 107. The transistor 107 is, therefore, turned on and sends positive current through the resistor 108 back to the base of the transistor 104.

Thus, it can be seen that both the transistors 104 and 107 of the program control module attain a stable condition of conduction or nonconduction when the system's power is first supplied by the power initiate module. The resistors 106 and 108 serve as coupling resistors. The transistors 104 and 107, in effect, form a bistable circuit, that is, a circuit with two states in which the two transistors 104 and 107 are either both on or both off. The +BIAS terminal is supplied with a positive bias and its connected to the base of the transistor 107 through a resistor 118 to bias the transistor 107 in a normally off condition. The V_1+ , V_2+ voltages are applied to the collector of the transistor 104 through a dropping resistor 119.

When both of the transistors 104 and 107 are on, a V_2- current is supplied at the Output B. A V_1+ current is generated at Output A. Both of these currents generated are sufficiently strong to operate relays and to perform other functions as hereinafter described.

If the V_2- voltage which is applied to the emitter of the transistor 104 is a slow rising voltage rather than a fast rising voltage, the V_1- voltage will be applied to the base of the transistor 104 through the resistors 109 and 108 to place a temporary strong bias current on the transistor 104 to prevent its conduction which normally otherwise would occur if a strong voltage V_2- is supplied to assist when a positive pulse is applied to the control Input A.

The program control module is primed by placing a negative voltage as hereinafter described on the Selecting Input through the resistor 111 to apply a negative voltage to the point 102 and to the capacitor 103.

The program control module is turned off by utilizing the Control Input B. Now assuming that the program control module has assumed a stable "on" state, i.e., one in which both of the transistors 104 and 107 are conducting, if the program control module is on, negative current will be conducted through the resistor 113 to the point 114 and the Control Input B will be negative. Now if a positive pulse is applied to the Control Input B to turn the program control module off, this positive pulse will change the polarity at point 114 to couple it through the capacitor 116 to the base of the transistor 107. Since the transistor 107 is a PNP transistor, this positive pulse will turn it off. When it is turned off, it no longer supplies positive current through the resistor 108 to the base of the transistor 104 and, therefore, transistor 104 also is turned off. Thus, the program control module attains its "off" stable state; that is, with both of the transistors 104 and 107 off or not conducting.

From the foregoing, it can be seen that Control Input B presents a load to a positive pulse only if the program control module is already on, in which case there is a negative voltage on the base of transistor 107 and the positive pulse couples through capacitor 116. Thus, if two positive pulses are presented successively to both Control Input A and Control Input B, as hereinafter described, and if the selecting input is supplied with negative voltage before and during the first pulse but not the second, the first pulse will turn the program control module on by means of Control Input A as described above and the second pulse will turn the program control module off by means of Control Input B as described above without any conflict of operation.

Interval timing module

A typical interval timing module is shown in FIGURE 7. It consists of a uni-junction transistor 121 in which the second base is always connected to V_1+ . When a voltage V_1+ is supplied to one of the time interval selection inputs connected to the variable resistors 122, 123 and 124, charging of the capacitor 126 is commenced through a circuit formed by an isolating diode 127 and the variable resistor. When a critical voltage level is reached at the point 128 as the voltage is rising from negative towards positive to charge the capacitor 126, the uni-junction transistor 121 turns on and discharges the capacitor 126 through a resistor 129. This discharge takes place very rapidly so that there is, in effect, a positive pulse coupled through the capacitor 131. This pulse is supplied to an amplifier inverter 132 which amplifies and inverts the pulse so that an amplified negative pulse is produced. Similarly, the same pulse is supplied through an amplifier 133 to provide an amplified positive pulse. These negative and positive pulses are utilized as end-of-time signals as hereinafter described. The diode 127 is used to isolate the strong pulse which is produced when the capacitor 126 is discharged from the supply line so that this strong pulse will not interfere with the other apparatus. The resistor 134 serves as a bleeder resistor for the capacitor 131.

Digitizer control amplifier

A typical digitizer control amplifier is shown in FIGURE 8. It consists of transistors 136 and 137. When positive current is received from a program control module which is on as hereinafter described and supplied to the emitter of the PNP transistor 136 and a negative current is supplied to the base of the transistor 136 from the logic unit as hereinafter described through the current limiting resistor 138, the PNP transistor 136 will conduct and supply positive current through the resistor 139 to supply positive current to the base of the NPN transistor 137. This causes the transistor 137 to conduct and to supply a negative current on the interrogate digitizer line which is utilized for interrogating a selected digitizer as hereinafter described. Resistors 141 and 142 serve as biasing resistors.

Transmitting distributor

A block diagram of the transmitting distributor is shown in FIGURE 9. It consists of a plurality of binaries 146 namely, three binaries which are identified as binary 1, binary 2 and binary 3, respectively. It also includes a clock 147 and other associated apparatus and components hereinafter described. When the voltages V_1+ , V_1- and $+BIAS$ are supplied to the circuitry shown in FIGURE 9 in a manner hereinafter described, there is a voltage change across the capacitor 151 to cause the point 152 to assume a negative value until the capacitor 151 has been charged by a current flowing through the resistor 153. The negative current at point 152 drops off rapidly as the capacitor 151 charges and is transmitted through the isolating diode 154 to an amplifier inverter 156 to produce a positive current on the line 157. This line 157 is a reset line for the binaries 146 and resets all of the binaries to zero.

At the same time the power is applied, the clock 147 emits timing pulses which are at the bit rate of the receiving apparatus to be utilized such as a teleprinter page printer. For example, in a conventional 60 words per minute teleprinter system, a timing bit occurs in every 22 milliseconds. As is well known to those skilled in the art, this establishes the length of time for the marks and spaces as they are sent over the teleprinter loop. These clock pulses are scaled by the binaries 146.

The binary circuits 146 are of a type well known to those skilled in the art and have two stable states and produce a positive current on one or the other of their

output lines depending upon which stable state they are in. The binaries are provided with interconnecting carry conductors 158 which are utilized for carrying the count to the next binary. Since there are three binaries, the three binaries can count through eight before returning to their original conditions in which they are all zero, zero, zero. As soon as this has been accomplished, a carry pulse is supplied on the conductor 158 to the program control modules 66 to advance the program one step as hereinafter described.

The timing pulses which are generated by the clock 147 are scaled by the binaries 146. Each binary circuit produces a positive current on one or the other of its output lines identified as 1 and 0, respectively, and which are connected by a diode matrix 159 to lines 160-166 as shown in the drawing. The diode matrix 159 consists of a plurality of diodes 168 which are connected between the outputs of the binaries and the lines 160-166 as shown in the drawings. The matrix diodes 168 are so arranged that for every binary count except the second, which may be represented by the binary number 001, all of the lines 160-166 except one are fed with positive current through one or more of the matrix diodes 168. The one line not so fed is different for each possible binary count and is fed with a negative current through the resistor 169 associated with the conductor. The lines which are fed with negative current for the respective counts are given below.

Count	Binary State	Line
1	000	160
2	001	161
3	010	162
4	011	163
5	100	164
6	101	165
7	110	166
8	111	

When negative current is present on conductors 160 or 166, the negative current passes through diodes 171 or 172 to the base of the PNP transistor 173 to cause it to conduct V_1+ voltage through the biasing diode 174 and the isolating diode 176 to point 177. This changes the polarity at point 177 from the negative voltages supplied through the resistor 178 from the V_1- terminal to produce a negative output from the amplifier-inverter 179. Normally, the point 177 is negative because of the negative voltage supplied from V_1- through the current limiting resistor 178. This negative condition at point 177 is overridden or overcome when either line 160 or 166 is negative in the manner explained above.

When the output of the amplifier-inverter 179 is negative, no current flows through the loop relay winding 61. The contacts 1 and 2 of the relay remain closed causing a mark to be transmitted over the telemetering loop 62.

From the above, it can be seen that the first and last counts of the binaries will cause a mark to be transmitted over the telemetering loop 62. When the binaries 146 make their second count, there is no line of the lines 160-166 which is selected for a negative current, and for that reason there is no positive voltage supplied to the point 177 to override the normally negative condition of this point. This negative voltage is inverted and amplified by the amplifier-inverter 179 to energize the winding of relay 61 to open its contacts 1 and 2 to provide a space on the telemetering loop 62. This space serves as a synchronizing space on the telemetering loop 62.

The network consisting of the resistor 181 and the capacitor 182 are chosen so that the time constant for the network compensates for the mechanical characteristics of the particular loop relay urged to thereby produce a minimum of mark-space bias distortion during transmission. The diode 180 connected across the winding of the relay 61 is used to limit any back e.m.f. which is generated within the winding.

On the next five counts of the binaries 146, the conductors 161-165 are supplied sequentially with negative current in a manner hereinbefore described. Each of these conductors 161-165 is connected to the base of PNP transistor 186. The collectors of the transistors 186 are connected through load resistors 187 to the voltage V_1 —as shown in the drawing. The emitters are connected to the V_1 + supply through the diode 174. Thus, it can be seen that when a negative voltage is applied to the base of one of the transistors 186, V_1 + voltage is supplied through a biasing diode 188 to the emitter of a PNP transistor 189. The biasing diodes 188 make the emitters of the transistors 189 a little more negative than the bases of the transistors so that when they are off, they will be turned completely off. The bases of the transistors 189 are connected to the binary lines 57 from the diode matrix 56. When positive voltage is supplied to the emitter of one of the transistors 189 and its base is connected to a binary line which is negative, the transistor 189 will conduct positive current through the isolating diode 191 to the conductor 192 which, as shown in the drawing, is connected to point 177. As hereinbefore explained, when a positive current is applied at point 177, the relay 61 is released so that its contacts are closed to produce a mark on the telemetering loop 62.

Thus, it can be seen that as the binaries 146 progress through the third to the seventh counts, the transistors 189 sequentially sample the binary lines 1-5 to determine if there is negative current on these binary lines. If there is a negative current, the transistor conducts a positive current to exceed the negative bias supplied by the resistor 178 to the amplifier-inverter 179 to cause a mark to be sent over the telemetering loop 62. If there is no negative current on the binary line being sampled, no positive current is supplied to the conductor 192 and the negative current supplied by the resistor 178 causes the amplifier-inverter 179 to energize the loop relay 61 and to open its contacts to cause a space to be transmitted on the telemetering loop 62. Thus, it can be seen that, depending upon the conditions of the binary lines 1-5, a series of marks and spaces are transmitted over the telemetering loop representing the information on the binary lines. A negative current on the binary line produces a mark and no current on the binary line produces a space.

The diodes 191 are isolating diodes and permit all the transistors 189 to supply positive current to the single conductor 192. The resistors 193 are biasing resistors and serve to turn the transistors 189 off if the binary line does not have a negative voltage on it.

As pointed out previously, the binary lines 1-5 come from the diode matrix 56 and for that reason, the lines do not go from a negative voltage to a positive voltage. Rather, they go from a negative condition to a not negative condition. The resistor 193 converts the not negative condition into a positive condition by feeding positive current into the binary line.

A conductor 196 which is identified as the cycling signal output is connected to the conductor 160 and supplies a positive current on every count of the binary scalars 146 except the reset condition in which the binaries are in states 000 thereby providing a signal to other equipment such as an auxiliary programmer that the transmitting distributor is engaged in a transmitting cycle.

A conductor 197 is connected to the base of the transistor 173 and is labelled "non-print input." When a negative current is applied to the conductor 197, it produces the same condition as when the lines 160 and 166 are supplied with negative current, that is, a constant mark transmission. This non-print input, therefore, may be used to override other transmissions or when selected by the programmer to produce a delay in transmission of exactly one character time, e.g., eight clock times or pulses for the transmitting distributor.

From the following sequence, it can be seen that for each cycle of operation of the binaries 146, that is, as they pass through eight counts, a character is transmitted.

Starting from a rest position first, a mark and then a space is transmitted, followed by five information bits (marks and spaces), followed by a mark as negative currents are applied to the conductors 166 and 160 in sequence. The two marks which begin and end the count are used to give the receiver time to finish a cycle and stop. The use of two marks differs from the 1.4 marks in the conventional teleprinter format. The use of the two marks in place of the 1.4 marks is not objectionable because the increased time for transmission is relatively small.

However, if it is desired to conform exactly to conventional teleprinter format, an amplifier-inverter 198, current limiting resistor 199 and isolating diode 200 may be provided as shown in FIGURE 9. In such a case, when line 166 is supplied with voltage V_1 — through resistor 169, which happens only on the eighth count of the binaries 146, the amplifier-inverter 198 would provide positive current through current limiting resistor 199 and isolating diode 200 to point 221 of the electronic clock shown in FIGURE 10. The value resistor 199 would be chosen so that the additional current so supplied would cause capacitor 215 to charge at a rate that would produce a bit time of $\frac{1}{40}$ the normal duration, thereby marking the total time during which mark is transmitted on the telemetering loop 1.4 bit times instead of 2 bit times.

With the arrangement described, the transition from one mark to the other mark represents the at-home or rest position for the transmitting distributor. In this way, the transmitting distributor is returning to its home position at a time when no information is being sent out over the loop. For this reason, the presentation of information to the transmitting distributor is not a problem because there is a bit time before the home position and a bit time after the home position during which no information is being transmitted. In summary, the transmitting distributor uses five bits of information plus one synchronizing bit plus two mark bits, or alternatively 1.4 mark bits.

A timing output 198 is provided which is connected to the output of the clock to make it possible to monitor the timing signals from the clock and also for the purpose of checking and adjusting the transmitting distributor. A keying input 199 is provided which is connected to the point 177 and to the amplifier inverter 179. This input connection is provided for the purpose of transmitting signals generated and synchronized by other equipment over the telemetering loop 162 through the amplifier-inverter 179. This keying input 199 also makes it possible to monitor and check out the transmitting distributor.

When it is desired to interrupt or hold up the cycle of the transmitting distributor for reasons hereinafter described, a positive voltage is applied to the "check logic" line 201 which passes through a current limiting resistor 202 to the base of NPN transistor 203. If, in addition, there is a negative current on the "logic active" conductor 204 as, for example, if the data gathering apparatus such as the digitizer 37 is still completing its cycle as hereinafter described, the negative current will be conducted through NPN transistor 203 to the amplifier-inverter 156 which applies a positive current to the line 157 to reset the binaries 146 to the 000 count and thereby stop the action of the transmitting distributor.

In addition, there is provided an external reset conductor 206 which is connected to the amplifier-inverter 156. By applying a negative pulse to this external reset line 206, the binaries 146 can be reset.

Additional circuits of the same form as that composed of resistor 202 and transistor 203 may be added to check other logic units or other equipment and stop the program at predetermined points until their operating cycle is completed, all such circuits being connected to conductor 206.

It is evident that the transmitting distributor herein described may be expanded to create teleprinter signals of

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more levels than 5 by adding one or more binaries 146 and appropriately increasing the number of resistors 169, lines 160-166, diodes 168, transistors 186, resistors 187, diodes 188, transistors 189, diodes 191, resistors 193 and binary lines 57. In such a case the diode matrix 56 would be expanded to the desired code.

Clock

A clock suitable for use as the clock 147 in the transmitting distributor is shown in FIGURE 10. Although, as can be seen, this clock is an electronic clock, if desired, other types of clocks can be used as, for example, a mechanical device which opens and closes contacts, etc. The clock preferably should produce positive timing pulses at the bit rate desired by the receiving read-out or print-out equipment connected to the telemetering loop 62 which is connected to the output of the transmitting distributor. In the case of a synchronous receiving device, such as teleprinter punch or page printer, the clock may either have its contacts activated by a cam on a local synchronous machine if such is available, or it can be an independent stable time base. If the clock is independent of other equipment, the clock should generate periodic timing signals whose frequency is relatively independent of environmental conditions such as temperature and of changes in voltage supply. It should be readily capable of change of frequency so that it may transmit to receivers having different bit frequencies. Such a clock is shown in FIGURE 10.

In the clock shown in FIGURE 10, the voltage V_1 — flows through a current limiting resistor 211 to a uni-junction transistor 212. The voltage which is supplied to the uni-junction transistor 212 is stabilized or regulated by the filtering capacitor 213 and the Zener diode 214. Current flows into a capacitor 215 through one of the resistors 216, 217 or 218 selected by selector switch 219 to raise the voltage at point 221. When a certain voltage level is reached at point 221, the uni-junction transistor 212 conducts, discharging the capacitor 215 to a low level and sending a negative pulse through the coupling capacitor 222 and through the amplifier-inverter 223 to produce a positive output pulse which is supplied to the binaries 146 as shown in FIGURE 9.

Variable resistor 224 has the function of a temperature compensation adjustment, for changing its resistance changes the thermal characteristics of the uni-junction transistor 212 so as to compensate for the thermal characteristics of the capacitor 215 and whichever of the resistors 216, 217 or 218 is selected by the switch 219. Assuming that resistors 216, 217, 218 and 224, capacitor 215, and uni-junction transistor 212 are all physically adjacent and assuming that the resistance of 224 is properly adjusted, the effects of temperature on the components of the circuit will cancel each other out to thereby provide a temperature compensated clock which will produce a fixed frequency over a wide temperature range.

The three different resistors 216, 217 and 218 have been provided because ordinary teleprinter machines have three different speeds, 60, 75 and 100 words per minute. Merely by selecting the appropriate resistor, the transmitting distributor will operate at the desired speed of these three speeds.

Diode matrix

In FIGURE 11, there is shown a schematic diagram of the portion of the diode matrix 56. This diode matrix is substantially identical to that disclosed in copending application Serial No. 135,295, filed August 31, 1961, and converts 10-line information into binary information. In addition, diode matrices of this type are well known to those skilled in the art. Thus, if a negative current is applied to the carriage return line, a negative current is applied on the binary line 4 which corresponds to the teleprinter code of *space space space mark space* which represents a carriage return. If a negative cur-

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rent is applied to the number 1-line, negative currents are applied to binary lines 1, 2, 3 and 5 to produce the teleprinter code of *mark mark mark space mark* which represents the number 1.

The diode matrix 56 consists of a network which includes a plurality of isolating diodes 226 which connect the 10-line information to certain of the binary lines to form the desired teleprinter codes.

For parity checking purposes, a parity checking code can be used in making up the diode matrix. For example, the diode matrix can be arranged to produce a two-out-of-five code. Then, it would be merely necessary to change the strikers on the teleprinter to print the letters or numbers desired and thereby, in addition, provide a parity checking code which requires a very small modification of the conventional teleprinter equipment.

It should be apparent from the foregoing that the relationship between the input lines and the output lines of the diode matrix is purely arbitrary. An additional feature of utilizing a parity check code is that if error symbols are placed on all other strikers which are not used and then when a code is received which is not one of the two-out-of-five codes, the page printer will strike the error symbol thereby giving a visual indication that an error has occurred.

Detailed description of operation of complete system

Let it be assumed that it is desired to operate the telemetering station which is shown in FIGURE 3. The power initiate module 67 is energized by operating the initiating circuit 71 as hereinbefore described to operate the relay 82 and supply the various voltages to the system. The first program control module turns on in the "on" condition because it receives a voltage V_2 — (fast rise) from the power initiate module and because its selecting input is connected to V_1 — and its control input A is connected to V_1 +. The other program control modules will be turned on in the "off" condition because they receive the voltage V_2 — (slow rise) from the power initiate module.

As hereinbefore explained, it is because the selecting input of this first program control module is connected to V_1 — and the control input A is connected to V_1 +, and V_2 — (fast rise) is applied to the transistor 104 (see FIGURE 6) that first causes the transistor 104 to conduct momentarily and causes transistor 107 to conduct to sustain the conduction of transistor 104. This causes both transistors 104 and 107 of the first program control module to attain a stable condition of conduction when power is first supplied to the first program control module by the power initiate module.

In all of the other program control modules, the voltage V_2 — is supplied to the transistor 104 only after a discrete interval of time so that the voltage V_1 — has the opportunity to temporarily strongly bias the transistor 104 to prevent its conduction. Both transistors 104 and 107, therefore, remain in a stable state of non-conduction or off.

Referring again to the first program control module, conduction of the transistor 107 applies V_1 — voltage to the output A which is supplied through isolating diode 231 to the initiate line 50 which is connected to the logic unit 38 and through isolating diode 232 to a digitizer control amplifier 44. Thus, it can be seen that the program control module can be utilized for initiating or performing certain functions. For example, initiating the operation of the central logic unit 38 and the digitizer control amplifier 44.

Conduction of the transistor 104 of the first control module supplies V_2 — voltage through the isolating diode 233 and the current limiting resistor 234 to a carriage return line 236 which is connected to the diode matrix 56 and which, as hereinbefore explained, produces the binary code designated to represent a carriage return character for a receiving page printer.

At the same time that this occurring, the transmitting distributor 58 is started by the application of voltage to it. The clock 147 produces timing pulses and causes the binaries 146 to scale the clock pulses to cause scanning of the binary lines 57. As pointed out previously, the transmitting distributor starts its cycle by first sending out a mark and then a space. The space starts the page printer at the other end of the teleprinter loop 62 so that it is operating at a synchronous rate and ready to receive a character when it is sent over the teleprinter loop. The transmitting distributor then samples the five binary lines and in this case finds that the lines 1-5 are negative, negative, negative, not negative and negative, respectively, so that a space space space mark space are sent over the teleprinter loop as the information bits in serial form which causes the teleprinter page printer at the other end to return its carriage to the initial position for typing.

After the five information bits, the transmitting distributor sends another mark which indicates the end of the transmitting distributor cycle and sends a positive current through the program advance output over the conductor 158 to the control input A of each of the program control modules 66 except the first program control module and any program control modules that are associated with an interval timing module. This positive pulse which is applied on the conductor 158 can be termed a shift pulse because it causes the programming to be shifted from the first program control module to the second program control module.

It will be noted that the output B of each program control module except the last is connected to the selecting input of the succeeding program control module. Also, it will be noted that the output A of each of the program control modules except the first program control module is connected to the control input B of the preceding program control module by conductor 239 through an isolating diode 241. Since the first program control module is "on," it will supply a negative voltage at its output B onto the conductor 238 to the selecting input of the second program control module to sensitize or prime that control module for the receipt of the shift pulse on the line 158. Thus, although the first shift pulse is supplied to all the program control modules except the first program control module, it is only the second program control module which will be switched or turned "on."

The purpose of the selecting input is to ensure that the program control modules will be turned on in a predetermined sequence. The selecting input of the program control module is connected to a negative supply from the preceding program control module and the control input A is connected to the shift pulse line 158 so that as positive pulses occur on the shift pulse line, the program control modules will be turned on successively because the selecting input of each one will be selected by the preceding program control module. In addition, when the control input B is connected to the succeeding module and thus when it turns on, it sends back a positive pulse and turns the preceding program control module off. This is a fail-safe mode of operation because there is no race between on-turning and off-turning of the program control modules. First, the preceding program control module turns the succeeding program control module on and the succeeding program control module turns the preceding program control module off.

When the second program control module turns on, it supplies a current on its output A through the isolating diode 241 to the control input B of the first program control module to turn it off. The isolating diode 241 serves to prevent the turning off of the preceding program control module from affecting the succeeding program control module.

During the time that the transmitting distributor 58 is supplying the carriage return information on the telemetering loop 62, the logic unit 38 is progressing through its sequence of operations. The detailed operation of the logic unit is described in copending application Serial No. 135,295, filed August 31, 1961.

At substantially the same time that the initiate signal is supplied to the logic unit 38, the logic unit generates a negative voltage which is supplied to the interrogate line 46 that is connected to the digitizer control amplifier 44. As hereinbefore explained, the application of a negative current to the digitizer control amplifier causes the application of this negative current to the base of a PNP transistor 136 to cause the transistor to supply a positive current to the base of an NPN transistor 137 to cause it to conduct and supply negative voltage on the interrogate line 43 to the digitizer 37 to thereby select a predetermined digitizer for supplying information to the logic unit 38.

As described in copending application Serial No. 135,295, filed August 31, 1961, the application of a negative current on the interrogate line 43 to the digitizer 37 causes operation of the digitizer to cause a motor to rotate a wiper which engages commutator stripes and supplies information signals over an information line 41. This will continue as long as the digitizer 37 received a negative current on the interrogate line 43. However, as explained above, the logic unit 38 will not accept the information pulses until a start pulse has been sent by the digitizer.

Now let it be assumed that the time delay represented by a first time delay device (which is included in logic unit 38, as disclosed in the above copending application, to allow the wiper to reach full speed) has elapsed and that a start pulse is supplied by the digitizer 37. At the same time that the start pulse is applied, the logic unit generates a reset pulse which is applied to the reset line 48 and to the decimal counting units 51 so that all the decimal counting units will be cleared and will be ready to receive information after the digitizer sends the start pulse.

After receipt of the start pulse by the logic unit 38 it will begin accepting the information pulses on the line 41 and will supply them to the decimal counting units 51 which will count these information pulses in a conventional manner.

Now let it be assumed that the number of information pulses supplied over the information line 41 indicates the position of the shaft of the analog transducer 36. A stop pulse is then supplied by the digitizer 37 over the stop line 42.

At the time that the logic unit 38 receives a stop pulse which is supplied by the digitizer 37, a signal is supplied to the data true line 49. The logic unit 38 includes a second time delay device which at the end of its time interval supplies a signal to a flip-flop which will remove the signal from the data true line 49 if a stop pulse has not been received from the digitizer 37. This will indicate that an error has occurred.

At this same time, the signal from the second time delay device will open the circuit to prevent the transmission of any additional information pulses to the decimal counting units. Also, at the same time, the interrogate signal is removed from the interrogate line 46 to the digitizer control amplifier which removes the interrogate signal from the digitizer 37 to permit it to stop. The digitizer is now in condition so that it can be initiated again if it is selected. The logic unit 38 is also in a condition so that it can be initiated to interrogate another digitizer.

During the time that the logic unit 38 is operating and receiving information from the digitizer 37, the first character may have been transmitted by the transmitting distributor 58 before all of the information has been received by the decimal counting units 51 from the logic unit 38.

Therefore, it is desirable to interrupt the program of the telemetering station until all the information pulses have been received from the digitizer and counted by the decimal counting units 51. For this purpose, the second program control module supplies V_1+ voltage through an isolating diode 246 to the check logic conductor 201 connected to the transmitting distributor 58. This V_1+ voltage, as hereinbefore described, supplies a positive voltage to the base of the transistor 203. If the logic unit 38 is still gathering information from the digitizer 37, there will be a negative voltage present on the interrogate line 46 which is connected to the logic active input of the transmitting distributor 58 and, therefore, a negative voltage is supplied to the emitter of the transistor 203. Thus, when the V_1+ voltage is applied to the check logic line 201 and the digitizer 37 has not completed sending its information pulses, the transistor 203 will transmit a negative voltage to the amplifier-inverter 156 which resets the binaries 146. As soon as the logic unit 38 has completed receiving all the information, the negative signal on the interrogate line 46 is removed to remove the negative voltage from the logic active line 204 which will remove the positive voltage from the reset line 157 for the binaries 146 to thereby permit the binaries 146 free to count through their cycle in response to the timing signals from the timing clock 147.

The output A of the second program control module is also connected to the digitizer control amplifier 44 through an isolating diode 247 to maintain the positive voltage on the emitter of the transistor 136 to continue operation of the digitizer control amplifier during the time that the digitizer 37 is supplying information to the logic unit 38.

As hereinbefore explained, the transmitting distributor 58 has a signal on the check logic line 201 which is supplied from the output A of the second program control module. As long as the transmitting distributor 58 has a signal on the check logic line 201, it stops until it has no signal from the logic active line 204 which is connected to the interrogate line. As also hereinbefore explained, the interrogate line does not turn from negative to positive until the logic unit has completed its function. The transmitting distributor, therefore, waits for the data true line to change its polarity and when it does, it completes its cycle and by this time the information pulses from the digitizer 37 will be in the decimal counting units 51.

While the second program control module is in a state of conduction, it supplies V_2- from its output B through the isolating diode 248 to the interrogate input of the first decimal counting unit 51. The decimal counting unit supplies negative current on one of its ten output lines to the diode matrix 56 to make it possible to read out the data stored in the decimal counting unit. As hereinbefore explained, these lines plus one error line are all common to the decimal counting units and are connected to the appropriate inputs of the diode encoding matrix 56.

As pointed out above, as soon as the digitizing cycle (the cycle in which the digitizer supplies the information pulses to the logic unit and to the decimal counting units) has been completed, the binary scalars 146 of the transmitting distributor 58 are free to count through their cycle in response to timing signals from the clock 147 to sample and serialize the output of the diode encoding matrix 56 in a manner hereinbefore described to thereby supply over the telemetering loop 62 a code representing the number in the 100's decimal counting unit 51.

As soon as the transmitting distributor 58 has completed its cycle, it sends a shift pulse over the line 158 to turn on the third program control module. The third program control module has been primed or sensitized because its selecting input is connected to the output B of the second or preceding program control module. Turning on the third program control module also turns off the preceding or second program control module because of

the output from output A which is supplied to the control input B of the second program control module. The third program control module causes the 10's decimal counting unit to be read out and a suitable character transmitted over the telemetering loop 62.

From the foregoing, it can be seen that each program control module sends one character or performs one set of functions in the program. The shift from one program control module to the next occurs when the transmitting distributor 58 has finished its function. The program control module determines what character the transmitting distributor will transmit.

After the character for the 10's decimal counting unit has been sent out, the transmitting distributor 58 applies another shift pulse to the line 158 to turn on the fourth program control module. In the drawing of the telemetering station shown in FIGURE 3, an interval timing module 68 (identified as ITM "A") has been provided between the fourth and fifth program control modules. The interval timing module is placed between these two program control modules on the assumption that for some reason it is desired to delay the program between the fourth and fifth program control modules.

With the interval timing module 68 connected in the manner shown, at the time the fourth program control module is turned on, it supplies V_1+ voltage to the conductor 251 through the isolating diode 252 which charges the capacitor 126 of the interval timing module as hereinbefore described. The fourth program control module may also perform other functions, such as operating the pilot relay for vacuum tube equipment which is to warm up during the time interval. The fourth program control module also interrupts the program by supplying both V_1+ to the check logic line 201 through the isolation diode 253, and V_2- voltage to the logic active line 204 through the isolating diode 254.

At the end of the predetermined period for which interval timing module 68 has been set, the module 68 sends a positive pulse from the amplifier 133 to the control input A of the fifth program control module. The program then continues in its normal manner after the time delay. The fifth program control module turns off the fourth program control module and applies a voltage to the interrogate line of the 1's decimal counting unit so that a character is sent over the telemetering loop representing the number of the 1's decimal counting unit.

From the foregoing, it can be seen that the fifth program control module is turned on in response to the interval timing module 68 and not in response to the transmitting distributor 58. It is, therefore, apparent that it is possible to have a delay of any duration in the program and in any stage in the program. Also, it is possible to have a multiplicity of inputs 231 to the interval timing module 68 and to have its output connected to any desired program control modules. Each of these inputs can be connected so that each input can select a different time interval. Thus, it is apparent that one interval timing module can provide a number of time delays in a telemetering station.

After the fifth program control module has been turned on, additional program control modules (not shown) can also be turned on in sequence to supply additional programming for the telemetering station, particularly for supplying additional information concerning the analog transducers at the telemetering station over the telemetering loop 62. Thus, for example, the sixth program control module could be connected to a digitizer control amplifier to start the operation of another digitizer and also to start the logic unit 38 through its sequence of operation to determine the position or condition of the analog transducer and to transmit this information over the telemetering loop 62 to the printer at the central station. Thus, the seventh, eighth and ninth program control modules could be provided for reading out the decimal counting units 51 to supply this information to the telemetering loop.

It, therefore, can be seen that any number of program control modules can be provided, and that any number of digitizers can be read out without any difficulty.

The last program control module of the telemetering station has the function of turning off the system after the programming has been completed. It is turned on by the last shift pulse from the transmitting distributor 58. As soon as it is turned on, it sends a V_1+ current through the isolating diode 256 through the conductor 257 to the "end cycle" terminal of the power initiate module 67. This negative current overcomes the positive current and causes the relay 82 to drop out and to open its contacts to turn the power initiate module completely off. As soon as the power initiate module is turned off, all power is removed from the system and the entire system is reset.

Means is provided for preventing the telemetering station from being hung up. It is apparent that failure of certain portions of the system could prevent operation of the remainder of the system and, therefore, some means must be provided to return the apparatus to its normal resting position in the event it is not returned to this condition within the normal period of time. Such means consists of an additional interval timing module 68 which is identified as ITM "B." At the end of a predetermined period of time, the interval timing module "B" sends a negative pulse to the control input B of the last program control module to turn it on and, therefore, causes the last program control module to perform its function of ending the cycle of the system if it has not already been ended by the normal sequence of operation of the system. Thus, it can be seen that the last or additional interval timing module 68 serves as a fail-safe timer.

Two different interval timing modules must be provided to perform both the overall fail-safe timing function and time delays within the program. The overall timing which is accomplished by the last or additional interval timing module is going on during the time that the telemetering station is functioning and, therefore, in order to obtain time delays within the program, it is necessary to provide at least one additional interval timing module.

From the foregoing, it can be seen that a program control module is required for each digit or character of data; every space, every mark, every carriage shift or carriage return or space, etc. In addition, if there is to be a time delay in the program, there must be a program control module which is on during the time delay.

If it is assumed that the telemetering station is the weather station such as shown in FIGURE 2, there would be five analog transducers 36, five digitizers 37 and five digitizer control amplifiers 44. In addition, there would be a large number of program control modules, the exact number to be determined by the number of fixed characters to be transmitted in the desired program.

In packaging the telemetering station, the various modules can be readily mounted on printed circuit boards. In particular, the program control modules can be standardized by placing a number of the isolating diodes on the printed circuit board and then only utilizing the particular diodes which are required in the various arrangements shown in FIGURE 3. This can be accomplished merely by the external connections to the printed circuit board.

If desired, two sets of decimal counting units can be provided. This would make it possible to place the information in one set of decimal counting units while the other decimal counting units are being read out to prevent delays in transmission for the digitizer cycle.

In FIGURE 12, we have shown a more general arrangement of a data gathering station which utilizes many of the same modules but which is adapted to operate, for example, data logging equipment, a digital recorder or any other equipment which it is desired to program. Certain of the components have been omitted as, for example, the isolating diodes.

Operation of the pushbutton 72 causes operation of the power initiate module which turns on the first program control module 66 and turns all the other program control modules off. The positive pulses for advancing the program are received on the shift pulse line 158 from the equipment with which the data gathering station is working. As in the previous embodiment hereinbefore described, each time a shift pulse is received, the next succeeding program control module is turned on and the preceding program control module is turned off.

All of the outputs of the program control modules can be utilized for energizing other equipment. The interval timing module 68 has been provided to show that the program can be interrupted and a predetermined time delay inserted any place in the program. The interval timing module B is used to turn off the entire system if the system should become hung up for any reason.

From the embodiment shown in FIGURE 12, it can be seen that it is not absolutely necessary to drive a teleprinted transmitting distributor but that a local parallel-entry printer can be used for local data logging. It also can be utilized for programming digital recorders.

In FIGURE 13, there is shown a sub-programming arrangement which permits certain portions or sequences of a program to be repeated again and again in different parts of the program and at the same time utilizing the same program control modules. This program arrangement which is shown in FIGURE 13 consists of a plurality of program control modules 261 of a type which are identical to those hereinbefore described. A plurality of the program control modules are arranged in a horizontal row across FIGURE 13 of the drawings and can be termed the master program control modules and which are identified as first, second, third, etc., program control modules. Disposed in vertical rows beneath the master program control modules are a plurality of sub-program control modules.

The first program control module is turned on at the same time as the system with which it is associated is energized. When the first program control module is turned on, it supplies a positive pulse from the output A through the isolating diode 262 and through the coupling capacitor 263 to the control input A of the program control modules 1A and 2A as shown in the drawing which are parts of strings of two sub-program control modules. Either of these two strings can be activated depending upon the position of a switch identified as S-P selector switch. This selector switch places a negative current into the selection input of either the program control module 1A or program control module 2A and, therefore, selects which will be turned on when the positive pulse is received from the first program control module. For example, if longer strings were provided, the string on the left-hand side could be utilized for transmitting the word "open," whereas the other string could be utilized for transmitting the word "closed," and thus these two strings could be utilized to indicate the position of a valve. In such a case, the S-P selector switch could be operated by the valve.

After the program control module 1A or 2A is turned on, the remainder of the program control modules in the string will be turned on in sequence by shift pulses from the line 158 supplied by the transmitting distributor. This continues until the last program control module in the string is turned on. In the last program control module 1C or 2C, the next to the last shift pulse on the conductor 158 for the string turns the last program control module on. It will be noted that these shift pulses are applied to both the control input A and also to the control input B. However, the isolating diode 266 prevents directly coupling these inputs together. When the next pulse is received on the line 158, it will turn the program control module off. A pulse applied to the control input B of a program control module turns the module off only if it is already on. It can have no effect if the program

control module is not on as, for example, when the shift pulse is first applied to the control input A to turn the program control module on.

When the last program control module in the string is turned off, the output from the output B will be changed from negative to positive. This positive pulse is coupled through the capacitors 267 to the next program control module in the master row as, for example, the second program control module as shown in the drawings. This will turn the second program control module on and will cause the first program control module to be turned off in the manner hereinbefore described. However, it can be seen that the first program control module in this case has been provided with a complete sub-program which can be sent through the transmitting distributor before the next program control module is turned on. The same sub-program can be gone through again as shown in FIGURE 13 of the drawings because when the second program control module is turned on, it supplies a positive pulse through the isolating diode 262 and the capacitor 263 to the control input A of the program control modules 1A and 2A so that the same sub-program can be supplied to the transmitting distributor 58. Thus, for example, the sub-program could be utilized for indicating the position of two separate valves. A separate S-P selector is operated by each valve and the negative supply to the S-P selector desired is provided by the output "B" of the master program control module.

When the last program control module in the string has been turned on, it sends a positive pulse through the capacitor 267 to the control input A of the third program control module which turns the third program control module on and turns the second program control module off. By utilizing additional program control modules, it is readily apparent that a sub-program can be repeated as many times as desired. When the third program control module is turned on and supplies a positive pulse to the control input A of another sub-program string identified as PCM "3A." In the case of this program control module, a selecting input is connected permanently to a V_1 — voltage because there is only one possible sub-program. When the next shift pulse is received, it turns on the program control module 3B. The next succeeding shift pulse turns the program control module 3B off because the shift pulse is applied to the control input B. This causes a signal to be supplied to the control input A of the last program control module of the master program control modules which turns the preceding program control module off. The isolating diode 268 prevents the control inputs A and B of the program control module 3B from being directly coupled.

When the last program control module is turned on, it supplies a current on the end cycle line 257 to turn off the power initiate module.

From the foregoing, it can be seen that any type of program can be readily set up utilizing the program control modules and that, in addition to the master program, sub-programs can be readily utilized. These sub-programs can be repeated any number of times.

It is apparent from the foregoing that we have provided a new and improved programming and telemetering system and apparatus. It is designed in such a manner that there is always low power operation because at any given time there are no more than two program control modules on and generally there is only one on. The ones that are not on do not draw any power and the one that is on sensitizes or primes the next program control module which is in line to receive the shift pulse. When the shift pulse is received, both of the program control modules are on and then the one which has just been turned on turns the preceding one off. This is a more positive operation than is utilized in conventional computer techniques in which the bistable device is being turned off, turns the next one on. This is particularly advantageous where there is a time lag or an aging of components which

may affect the sequence of operation. Such aging of components would not affect the positive operation of our system and apparatus.

Our system and apparatus is preferably comprised of all solid state components and, therefore, has a very low power requirement.

Our apparatus is also advantageous because both the positive and negative voltages are provided by the program control modules which can be utilized for energizing equipment having differing polarity requirements. The system and apparatus is comprised of modules, many of which are identical or substantially identical. This greatly reduces the cost and increases the flexibility of the system and apparatus. Printed circuit cards can be utilized which can be mounted in stacked connectors. Thus, if it is desired to add new functions to the program, it is merely necessary to add more connectors to the stack and plug in the necessary printed circuit cards. This also facilitates changes in the field by relatively unskilled personnel. The number of characters in the message can be readily changed by increasing or decreasing the number of program control modules.

It is evident that the 10 information lines of the output lines 54 may be energized by a variety of decimal output devices known to those practiced in the art, such as manual selector switches or Veeder-Root decimal output mechanical counters, with the interrogate conductors 52 being applied to the wipers of such decimal output devices. In addition, the data signals presented on these 10 information lines may be used to operate a solenoid operated printing device, such as a typewriter with solenoid keyboard, without using the diode matrix or transmitting distributor, by amplifying the signals with 10 amplifiers and using the amplified signals to actuate the solenoids. In such a case conductor 158 would be connected to an output of the printing device that signals the completion of printing a character, so that the program would advance after each printing cycle. Alternatively, the binary output lines 57 of the diode matrix could be amplified to actuate a parallel-entry printer or a parallel entry tape punch. In such a case the data true line 49 would be amplified to provide the print command for the printer or punch, which would furnish a signal on conductor 158 at the end of the printing or punching cycle to advance the program.

We claim:

1. In a telemetering system, a digitizer, a logic unit connected to the digitizer, counting means including a plurality of counting units having parallel 10-line output information connected to the logic unit, said logic unit including means for interrogating said digitizer and causing said digitizer to send information pulses through the logic unit to the counting means, a transmitting distributor connected to said parallel 10-line output of the counting means, a plurality of program control modules each having on and off conditions, one module being provided for and coupled to each counting unit, and means for sequentially placing each module in an on condition, each of such on modules performing a predetermined and unique function, said modules coupled to said counting units causing said transmitting distributor to interrogate the counting means and to supply pulses in accordance with information contained in the counting means and means including another of said modules connected to said logic unit and causing operation of said logic unit.

2. A telemetering system as in claim 1 wherein a diode matrix is connected between the transmitting distributor and the counting means and wherein the diode matrix converts parallel 10-line information into parallel binary information.

3. A telemetering system as in claim 1 wherein the transmitting distributor converts the parallel binary information into synchronous serial pulses.

4. A telemetering system as in claim 2 wherein the transmitting distributor converts the parallel binary in-

formation supplied by the counting means into synchronous serial pulses in teleprinter code.

5. In a telemetering system, a plurality of digitizers, a logic unit connected to the digitizers, a plurality of counting units connected to the logic unit, the logic unit causing operation of the selected digitizer and causing the selected digitizer to send information pulses through the logic unit to the counting units, the counting units placing information received from the information pulses in at least ten parallel lines, a diode matrix connected to the parallel lines and converting the information on the parallel lines into five binary lines, a transmitting distributor connected to the five binary lines, a plurality of program control modules each having on and off conditions, one module being provided for and coupled to each counting unit, and means for sequentially placing each module in an on condition and all other modules in an off condition, each of such on modules performing a predetermined and unique function, said modules said counting units causing the transmitting distributor to interrogate the binary lines in sequence and to supply information in synchronous serial pulses and means including others of said modules connected to said logic unit causing operation of said logic unit and for selecting a predetermined digitizer.

6. A system as in claim 5 together with means for introducing a time delay between the operation of predetermined program control modules.

7. In a telemetering system, a plurality of digitizers, a logic unit connected to the digitizers, a plurality of decimal counting units connected to the logic unit, digitizer control means connected between the logic unit and each of the digitizers, a plurality of program control modules, each of the program control modules being capable of assuming on and off conditions, a power initiate module, means for initiating operation of the power initiate module for supplying power to the program control modules so that the first program control module is turned on and the remainder of the program control modules are turned off, means connecting the first program control module to the logic unit and to a predetermined digitizer control means which when the first program control module is turned on serves to initiate operation of the logic unit and to cause selection of a predetermined digitizer, the logic unit having means for initiating operation of the selected digitizer and causing the selected digitizer to send a plurality of information pulses through the logic unit to the decimal counting units, the decimal counting units receiving the information pulses and placing them in 10-line information, a diode matrix connected to the decimal counting units and serving to convert the 10-line

information into five line binary information, and a transmitting distributor connected to the diode matrix, the program control modules after the first program control module automatically causing the transmitting distributor to interrogate the diode matrix to ascertain the binary information and converting the same into synchronous serial pulses representing characters.

8. A system as in claim 7 wherein the transmitting distributor produces a shift pulse after every character has been transmitted for causing the succeeding program control module to be turned on, the succeeding program control module when turned on serving to turn the preceding control module off.

9. A system as in claim 7 wherein when a control module includes means when it is turned on which causes the succeeding program control module to which it is connected to be primed for the receipt of a shift pulse.

10. A system as in claim 7 wherein the last program control module turns off the power initiate module.

11. A system as in claim 7 together with means at a remote station for receiving the information transmitted by the transmitting distributor.

12. A system as in claim 7 wherein the transmitting distributor converts the 5-line binary information into synchronous serial pulses representing teleprinter characters together with means at a remote location for receiving the teleprinter characters.

13. A system as in claim 7 wherein the plurality of program control modules includes a plurality of master program control modules and a plurality of subprogram control modules representing at least one subprogram, the program control modules being connected so that a subprogram is inserted in a predetermined position in a master program.

14. A system as in claim 13 wherein the program control modules are changed so that a subprogram is repeated within a master program by using the same subprogram control modules in the repeated subprogram.

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