

[72]	Inventors	Leon J. Arp Blacksburg, Va.; Wayne C. Dowling, Sioux City, Iowa
[21]	Appl. No.	727,387
[22]	Filed	May 8, 1968
[23]		Division of Ser. No. 637,153, May 9, 1967, Pat. No. 3,500,154
[45]	Patented	Sept. 28, 1971
[73]	Assignee	Iowa State University Research Foundation, Inc. Ames, Iowa by said Arp

Primary Examiner—Maynard R. Wilbur
Assistant Examiner—Robert F. Gnuse
Attorney—Henderson & Strom

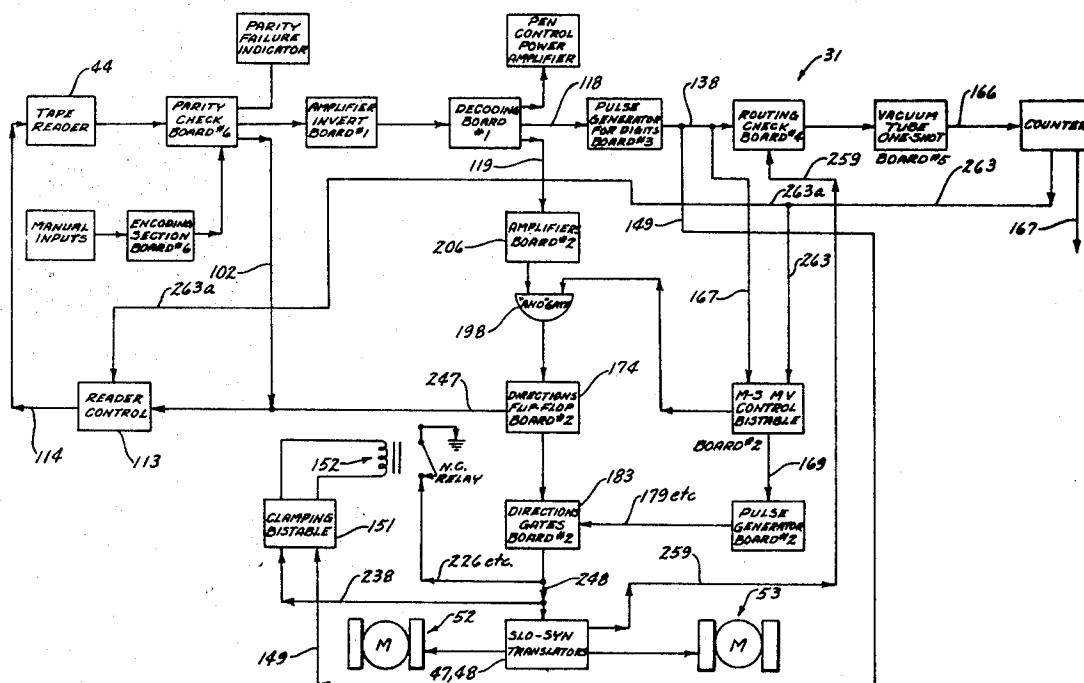
[54] ELECTRIC PULSE COUNTER APPARATUS
5 Claims, 18 Drawing Figs.

[52]	U.S. Cl.....	235/92 PE, 235/92 AC, 235/92 CM
[51]	Int. Cl.....	H03k 21/36
[50]	Field of Search.....	235/92 (21), 92 (51), 92 (63), 92 (29 FL)

[56] **References Cited**
UNITED STATES PATENTS

3,039,685	6/1962	Bagley.....	235/132
3,163,747	12/1964	Veverka.....	235/92

ABSTRACT: This invention pertains to the electrical circuitry for a counter apparatus which accepts a command number in the form of a sequence of digits in the usual manner, i.e., the most significant first, and then decrements from the command number down to zero, the circuitry comprising a plurality of cold cathode glow transfer tubes conventionally electrically connected in a left-to-right arrangement with a borrowing gate for each pair of adjacent tubes, including an inhibitor against borrowing during the loading of the tubes, only, and including further a gating distributor circuit for loading the tubes from left-to-right with the last tube loaded being the units tube, and wherein the gating circuit to the units tube is left open after loading of the counter, the circuit including a pulse generator for generating a plurality of pulses transmitted through the gating circuit to the units tube for decrementing the tubes from the command number down to zero, at which time a signal is emitted from the apparatus, using the borrowing gate for decrementing purposes.



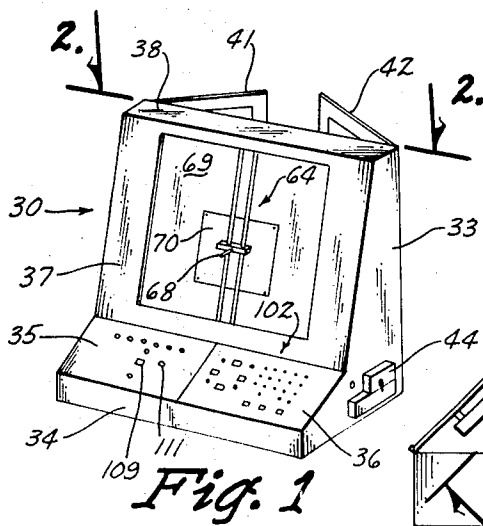


Fig. 1

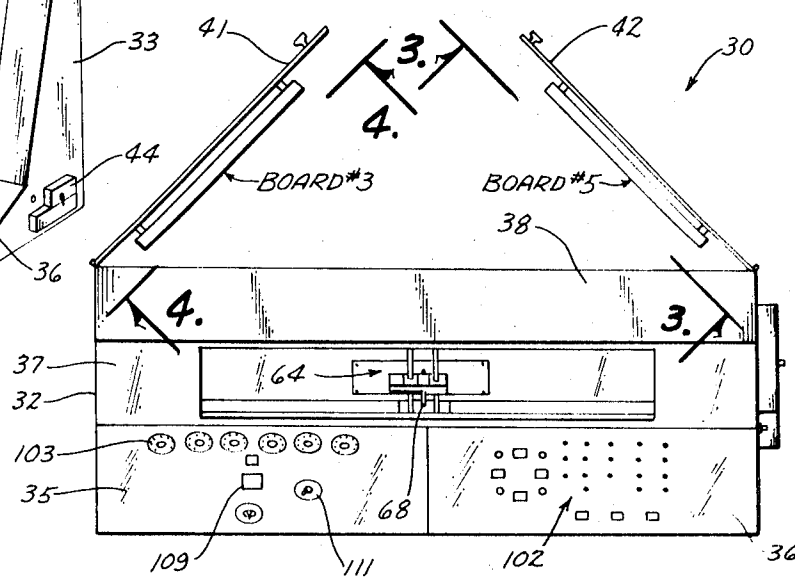


Fig. 2

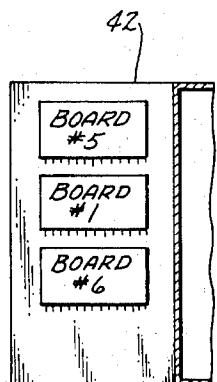


Fig. 3

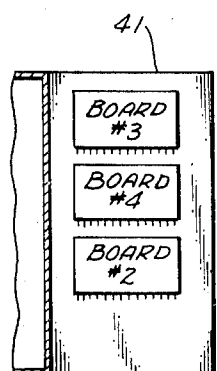


Fig. 4

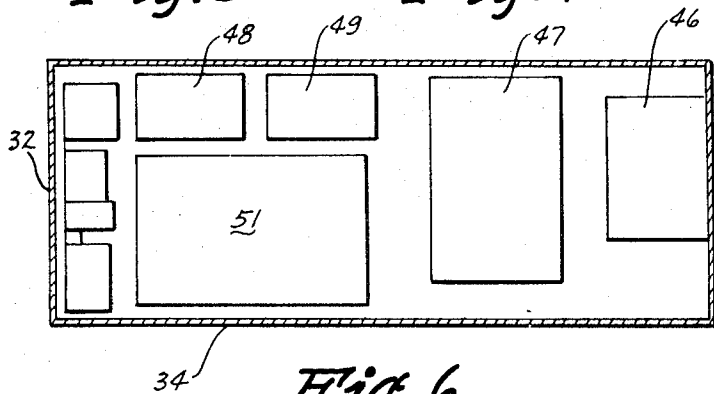


Fig. 6

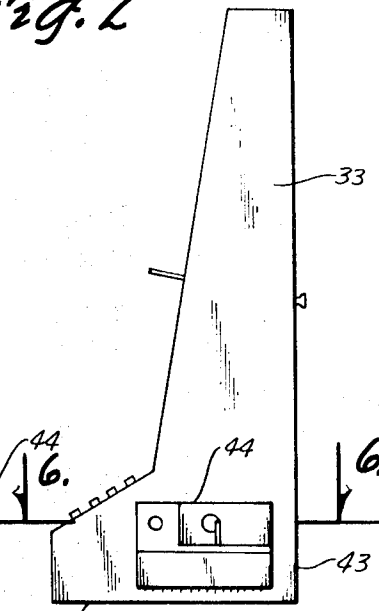


Fig. 5

INVENTORS
LEON J. ARP
WAYNE C. DOWLING
BY *Robert Z. Anderson*
ATTORNEY

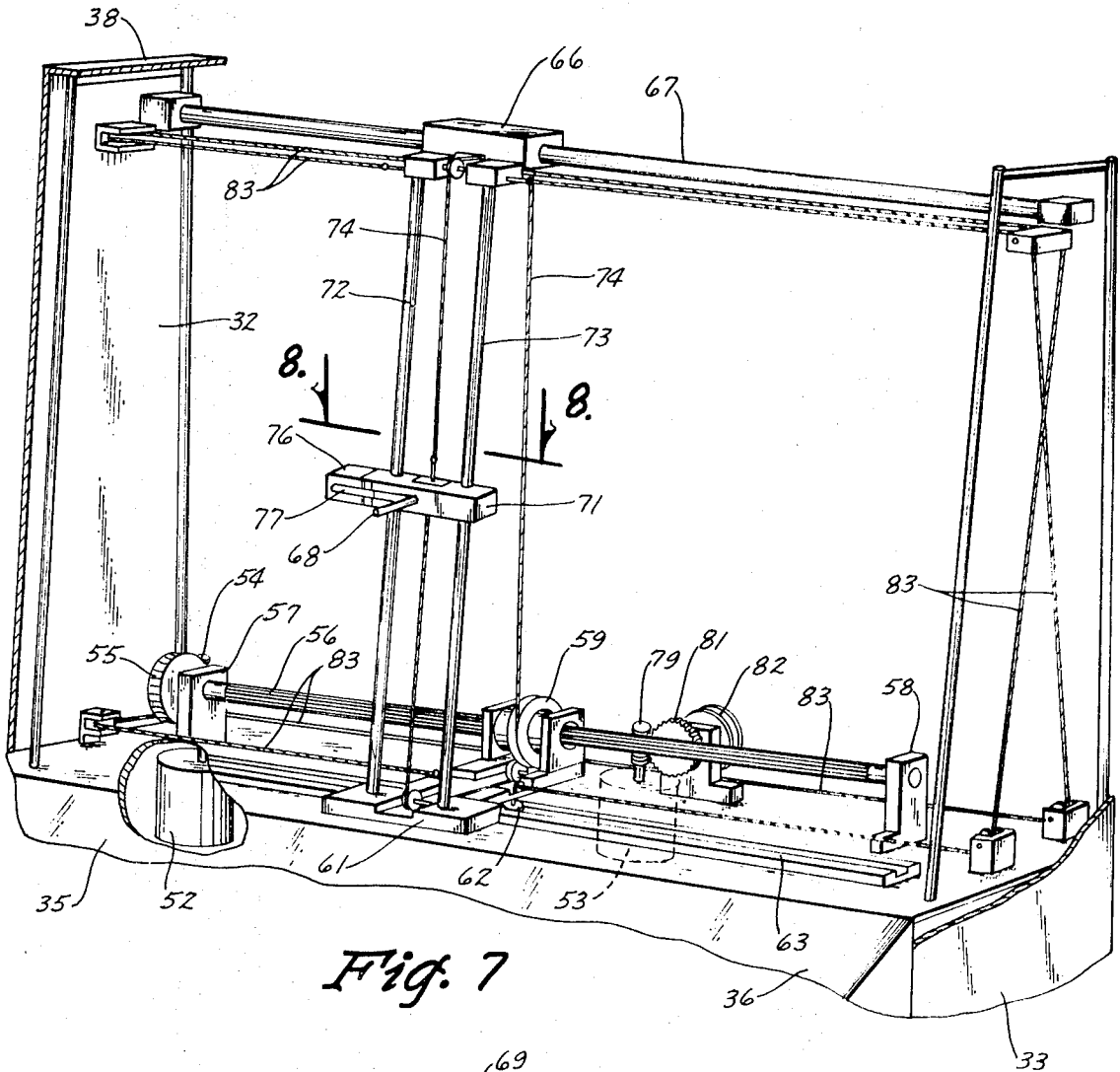


Fig. 7

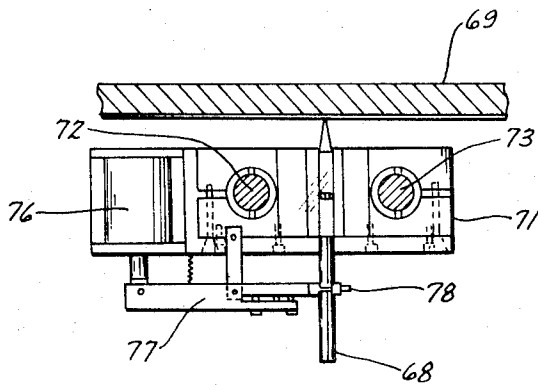


Fig. 8

INVENTORS
 LEON J. ARP
 WAYNE C. DOWLING
 BY *Robert E. Anderson*
 ATTORNEY

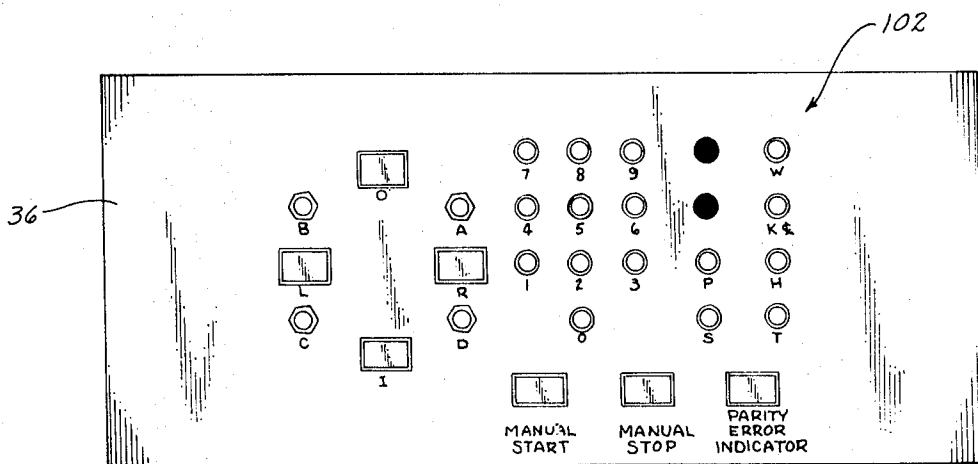


Fig. 9

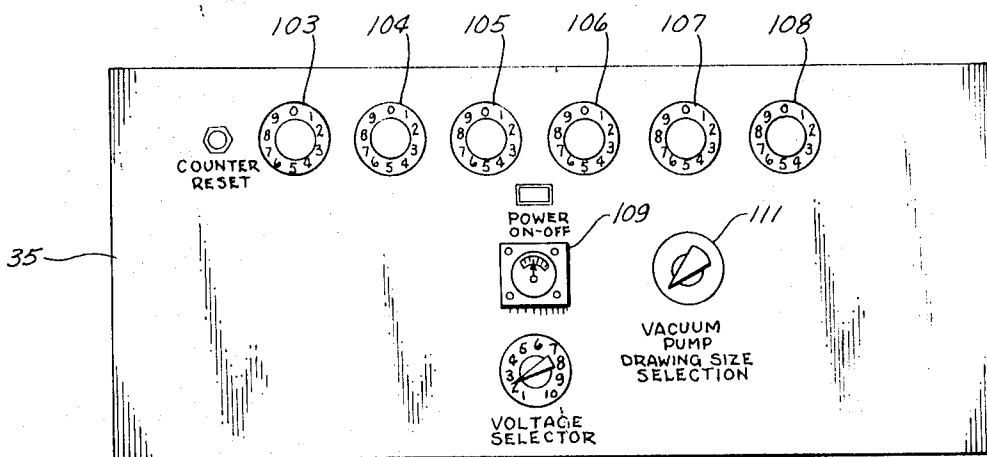
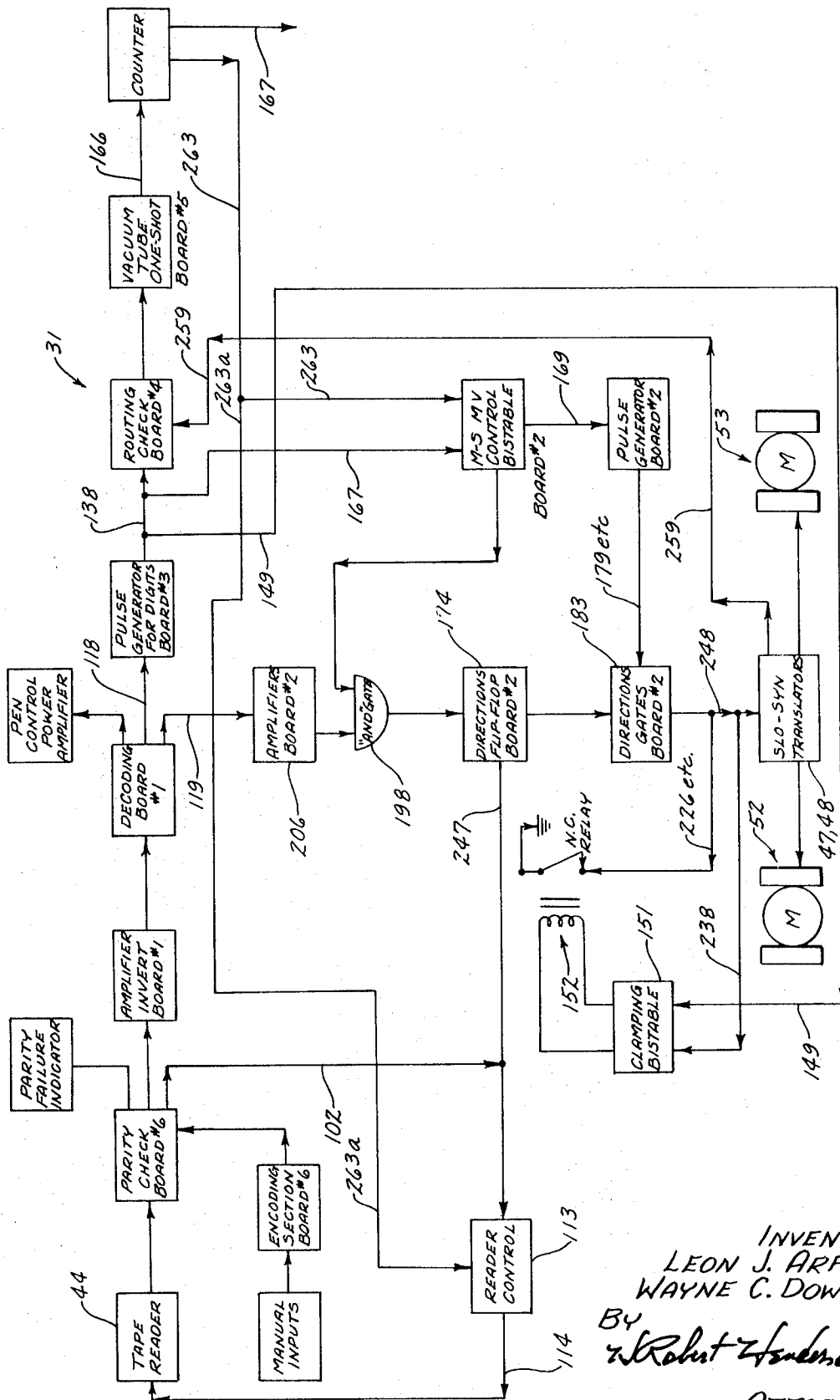


Fig. 10

INVENTORS
LEON J. ARP
WAYNE C. DOWLING

By *Robert Z. Anderson*
ATTORNEY



11.5.24

INVENTORS
LEON J. ARP
WAYNE C. DOWLING
BY
Robert F. Anderson
ATTORNEY

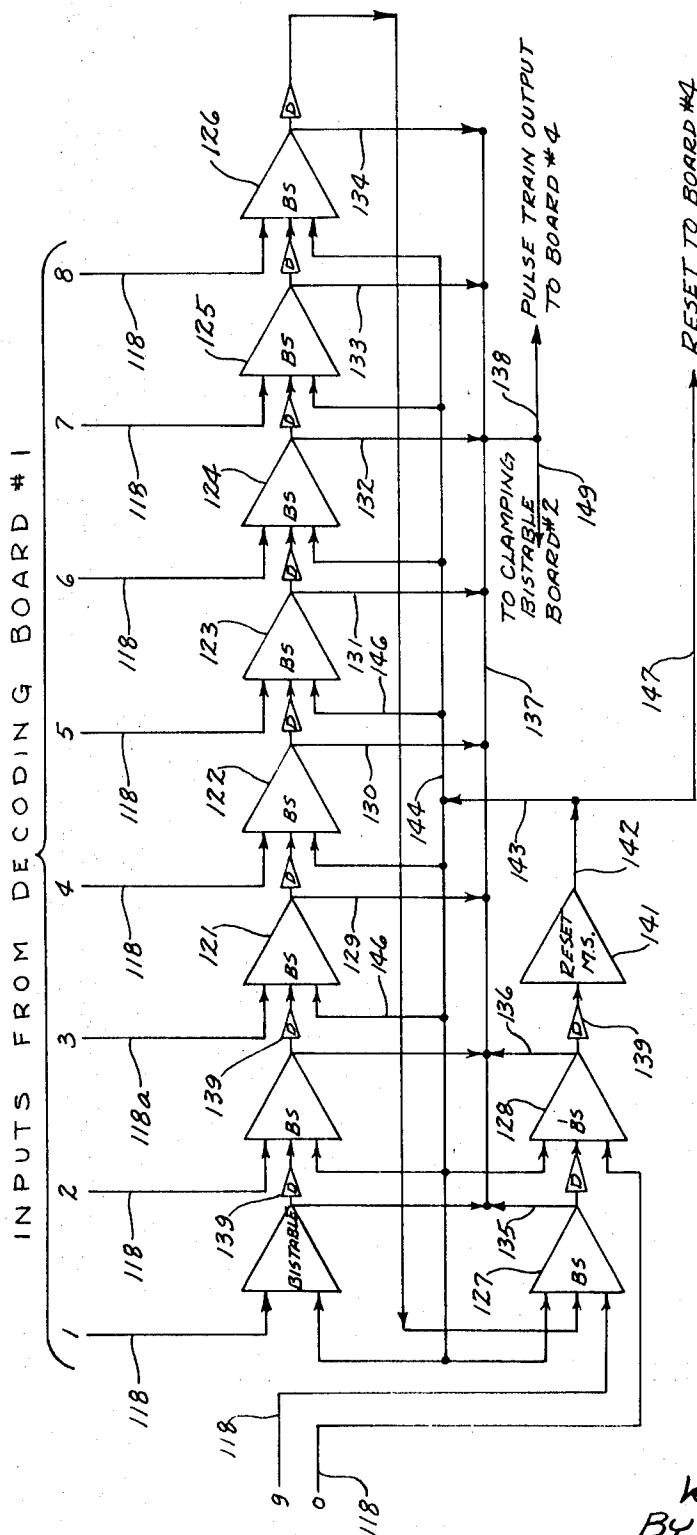


Fig. 12

PULSE GENERATING BOARD #3

INVENTORS
LEON J. ARP
WAYNE C. DOWLING

BY *Robert S. Anderson*
ATTORNEY

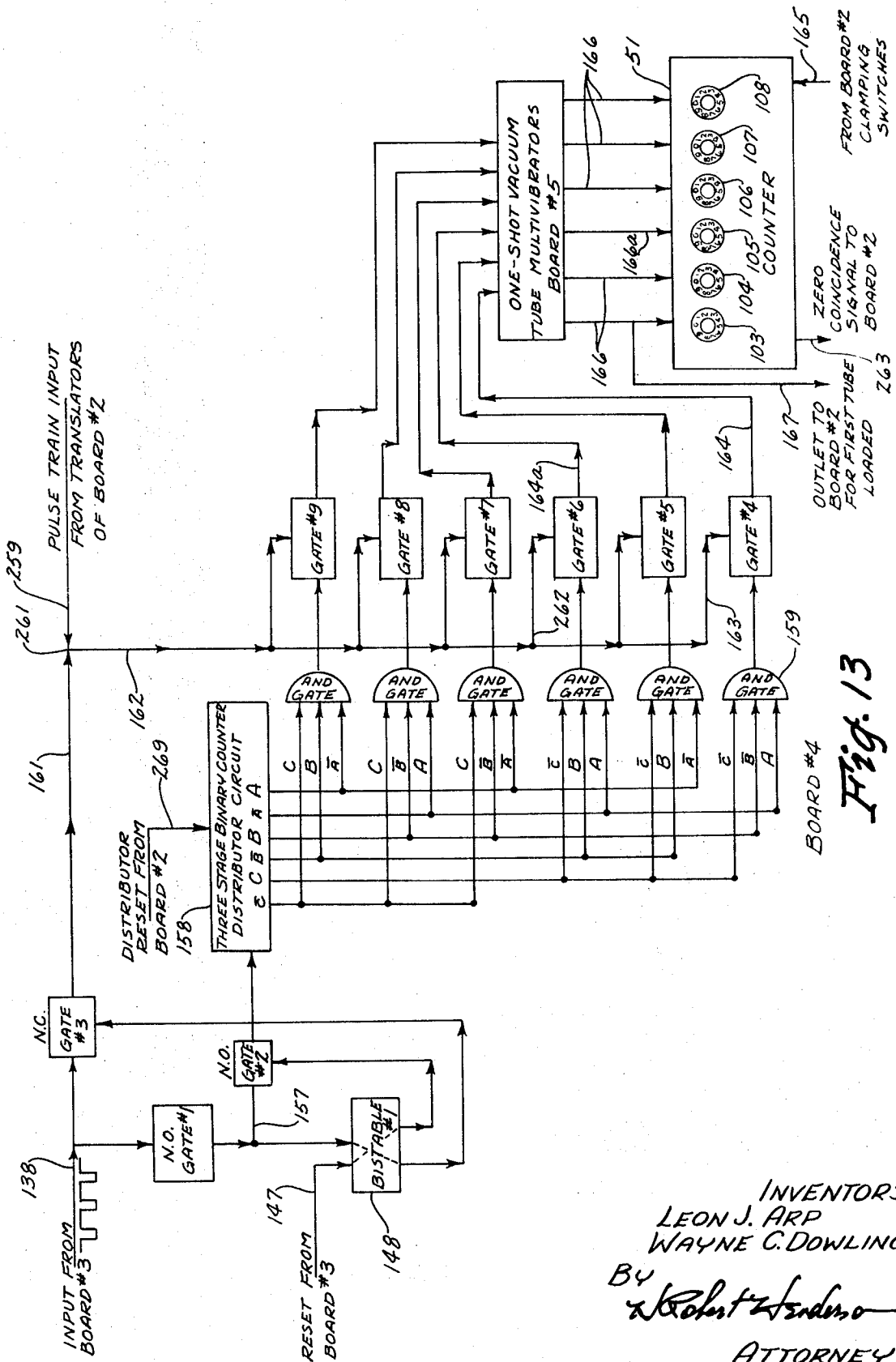
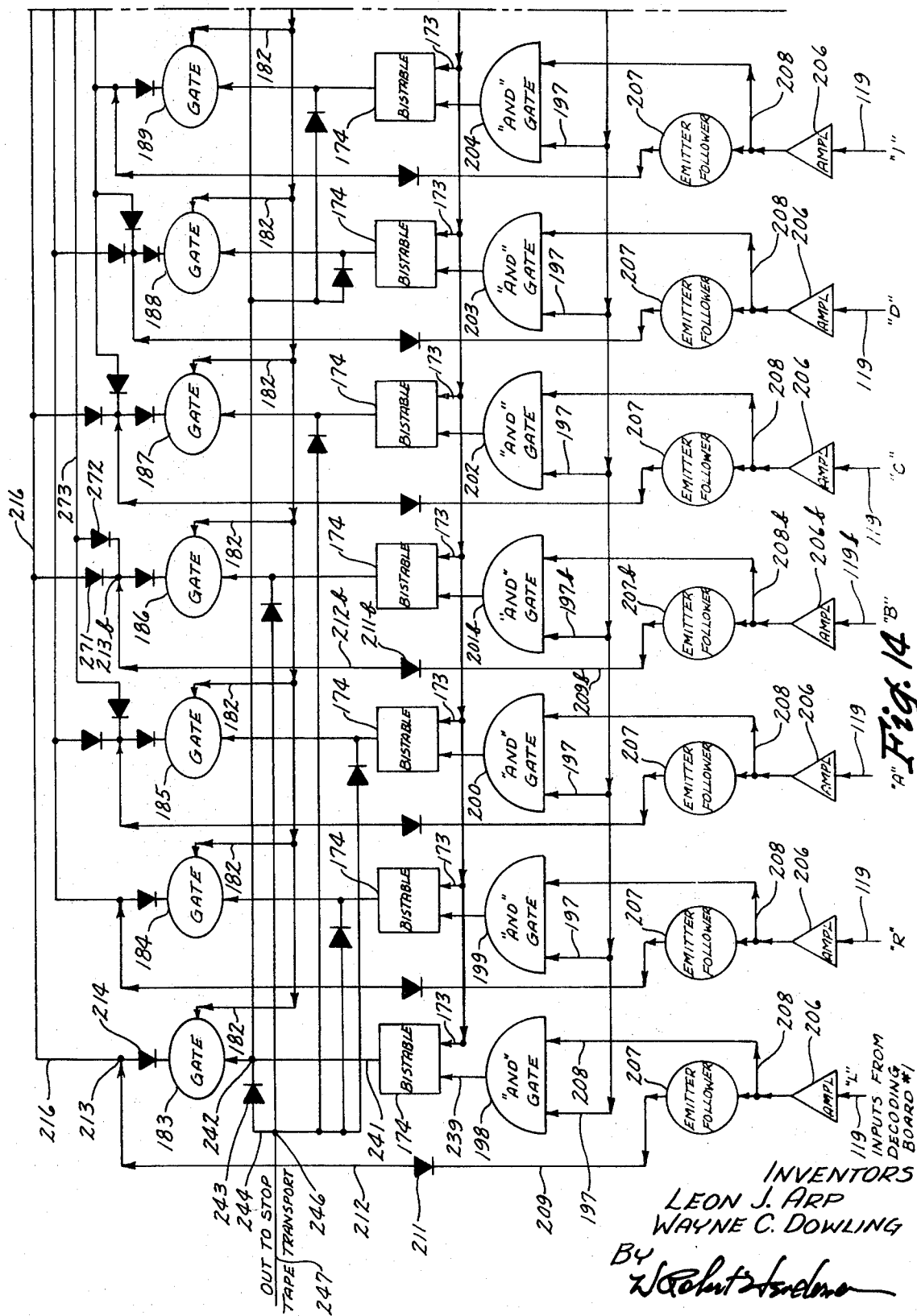


Fig. 13

INVENTORS
LEON J. ARP
WAYNE C. DOWLING
BY *Robert Henderson*
ATTORNEY



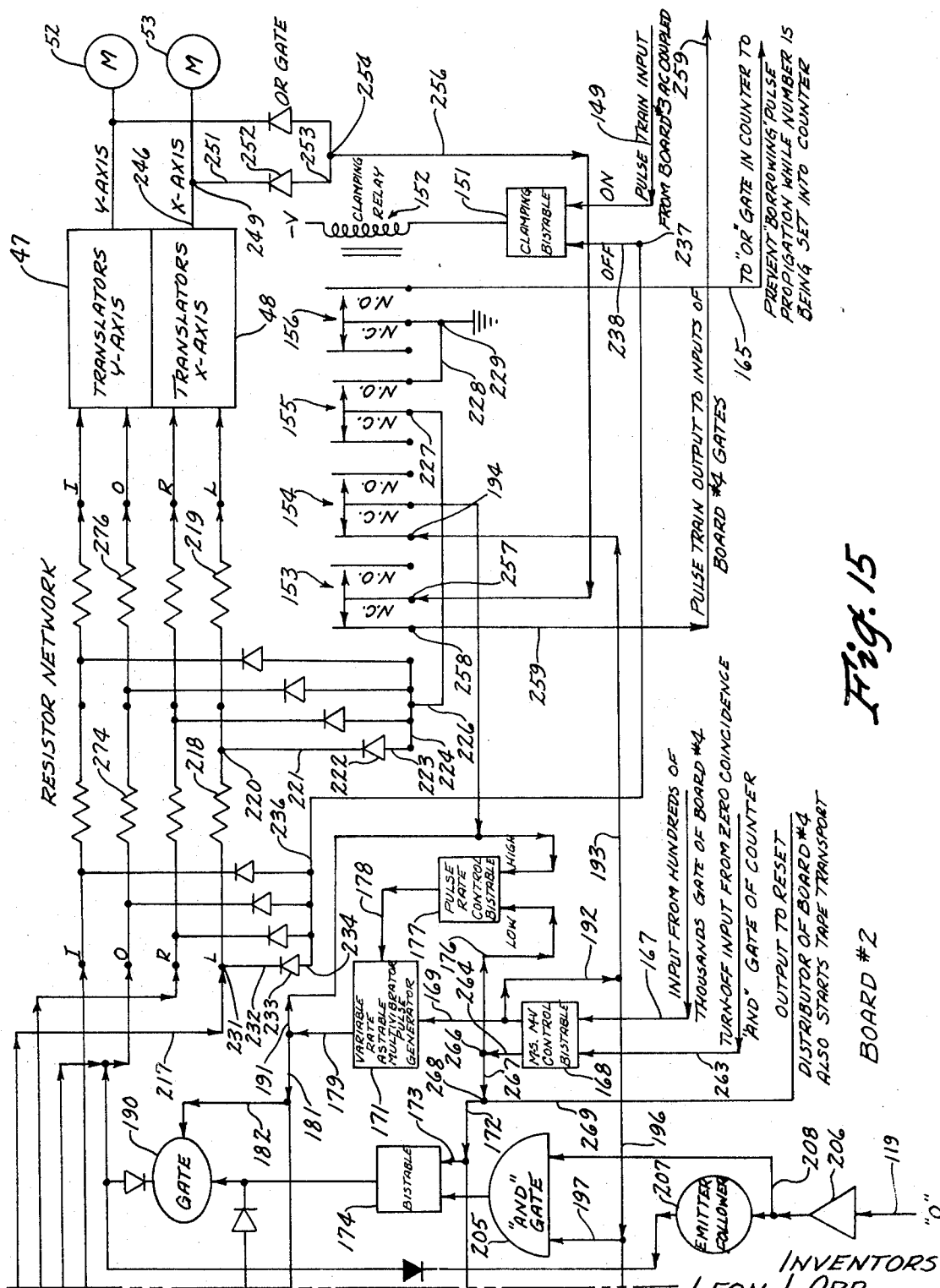


Fig. 15

BOARD #2

INVENTORS
LEON J. ARP
WAYNE C. DOWLING
BY *Robert F. Anderson*
ATTORNEY

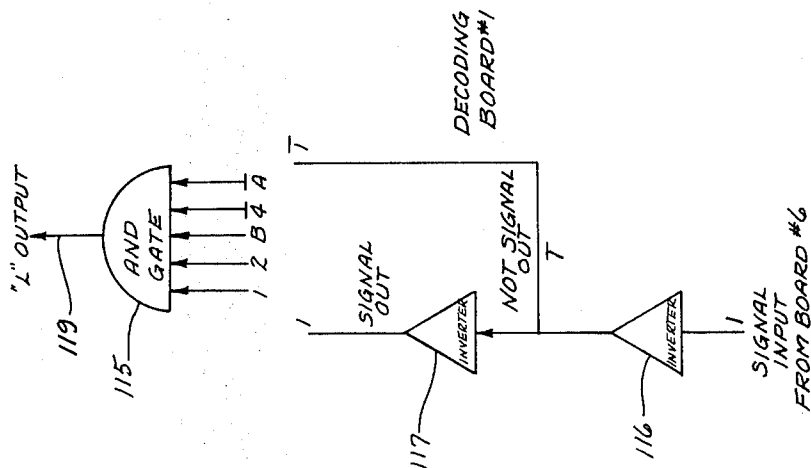


Fig. 17

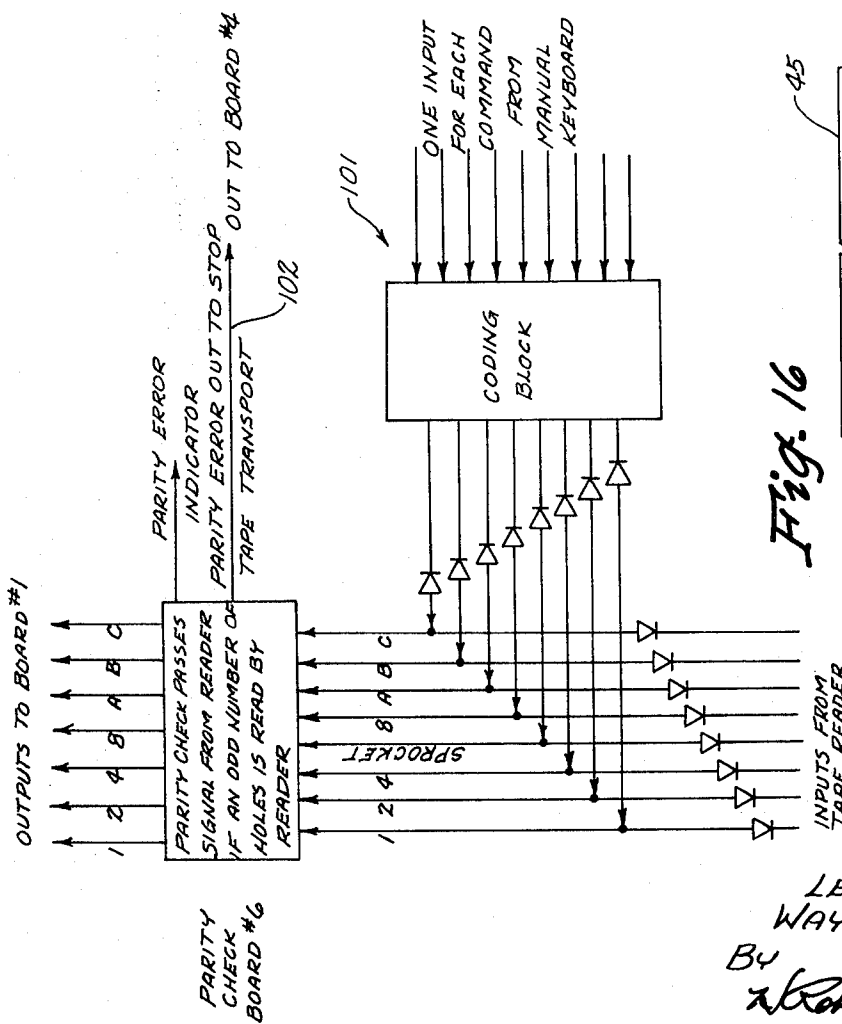


Fig. 16

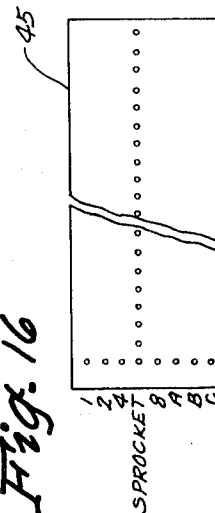


Fig. 18

INVENTORS
LEON J. ARP
WAYNE C. DOWLING
By *Robert J. Hendon*
ATTORNEY

ELECTRIC PULSE COUNTER APPARATUS

This is a divisional application of copending patent application Ser. No. 637,153 entitled **ELECTRIC CIRCUITRY FOR AUTOMATIC DRAFTING MACHINE**, filed May 9, 1967, issued as U.S. Pat. No. 3,500,154 on Mar. 10, 1970.

BACKGROUND OF THE INVENTION

The electrical connection of a plurality of cold cathode glow transfer tubes for counting purposes, whether positive or negative mathematical incrementation, is not new. The manner and circuitry for loading digits into such an arrangement of tubes, however, is believed novel as hereinafter presented, in that the usual arrangement is in one of three forms.

First, assuming a plurality of six cold cathode glow transfer tubes arranged in a left-to-right connection, and assuming it is desired to load a command number 321 into same, for example, the counting apparatus would be loaded from the right tube, with the least significant, or units, digit first. Thus the units digit, 1, would be loaded into the rightmost tube, the tens digit, 2, next, and the hundreds digit, 3, would be loaded into the third tube from the right. This system has two disadvantages: first, the person manually loading the tubes, or preparing the data stream has to accomplish same backwards, and thus in an unnatural manner. Secondly, should one desire to read the number, whether from the beginning in loading same, or on the tape, or when loaded into the counting mechanism, the command number has to be read backwards; again, an unnatural action.

A second approach is to always require a digit number to be loaded that has the same number of digits as there are tubes. Thus for a six tube arrangement, the command numeral 000321 would need to be loaded into this arrangement such that upon normal decrementation, only 321 pulses would be needed to decrement the command number to zero. This system requires the use and provision of additional characters in the data stream and usually additional time in all respects except when the full digit capacity of the counter is utilized, as all tubes would require loading.

The third approach would be to provide circuitry wherein a shifting technique is available, in which the first digit is loaded into the rightmost tube. When an additional digit is sensed, all previous digits would be shifted to the tube immediately left of the tube wherein previously located, and the new digit would be located in the rightmost tube. This type of circuitry requires a complex arrangement for accomplishing the electronic shifting.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a counter apparatus wherein the apparatus will function to accept a command number comprised of not more than a predetermined number of digits, wherein the number is loaded into the apparatus with the most significant digit first, with the next-to-the most significant digit next, etc., until the least significant digit, the units digit, is loaded last.

It is another object of this invention to provide a counter apparatus wherein only the exact number of digits which the command number actually has is loaded into the apparatus.

Yet another object of this invention is to provide a counter apparatus wherein the units digit may be positioned in any tube, depending upon the number of digits in the number being loaded, rather than always being in the rightmost tube, with decrementation always taking place from the units tube containing the units digit.

Another object of this invention is to provide a counter circuit wherein the shifting of a digit from one tube to another tube and the circuitry for accomplishing said shifting are rendered unnecessary.

It is another object of this invention to provide a counter apparatus capable of detecting when the number loaded therein has been decremented to zero.

Still another object of this invention is to provide a counter apparatus wherein the number which is loaded into the apparatus, or that number which remains after certain decrementation thereof, is always directly readable.

Still another object of this invention is to provide a counter apparatus capable of accomplishing the aforementioned objectives, which is uncomplicated in circuitry, economical as to cost and parts, and effective and rugged in service.

These and other objects of this invention will become more readily apparent upon reference to the following description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a small perspective view of an automatic drafting machine with which this invention is used, the rear door thereof shown slightly ajar;

FIG. 2 is an enlarged plan view of the machine;

FIGS. 3 and 4 are fragmentary elevational views of both doors, showing banks of control circuits, as seen from the lines 3-3 and 3-4 in FIG. 2, respectively;

FIG. 5 is a side elevation view of the machine;

FIG. 6 is a sectional view as taken along the line 6-6 in FIG. 5, and showing interior electric gear in schematic form;

FIG. 7 is an enlarged, fragmentary, perspective view of the drive and control structure of the machine, certain parts broken away and other shown in section for clarity of illustration;

FIG. 8 is an enlarged plan view of the drafting pen carrier in relation to a drafting board, as taken on the lines 8-8 in FIG. 7;

FIG. 9 is an enlarged plan view of the right side of the control panel of FIG. 2;

FIG. 10 is an enlarged plan view of the left side of the control panel of FIG. 2;

FIG. 11 is a schematic block diagram of the circuit of the present invention;

FIG. 12 is an embodiment of the Board 03 network for generating pulses;

FIG. 13 is an embodiment of the Board 04 and Board 05 networks for routing the numbers pulses to the counter;

FIGS. 14 and 15, when laid end-to-end with FIG. 14 on the left of FIG. 15, shows an embodiment of the Board 02 network for directing the direction signals to the correct translator and motor, and showing the multivibrator subcircuit which takes the place of the command signals;

FIG. 16 shows an embodiment of the Board 06 network for checking parity of the incoming automated or manual signals;

FIG. 17 shows an embodiment of the Board 01 network for decoding the incoming pulses; and

FIG. 18 is a foreshortened plan view of the eight level punched tape used by the present machine.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The automatic drafting machine of this invention is indicated generally at 30 in FIGS. 1 and 2, with the general schematic therefor indicated generally at 31 in FIG. 11. The machine is housed by a pair of side panels 32 and 33, a front lower panel 34, left and right control panels 35 and 36 respectively, a drafting board panel 37, top panel 38, and bottom panel 39.

The rear of the housing comprises a pair of hinged door panels 41 and 42 over a stationary rear base panel 43. On each door panel is mounted a trio of Boards, each Board comprising in the main a definable subcircuit as a part of the whole 31. Suffice it at this time to identify the Boards on door panel 41 as 03, 04, and 02 from top to bottom, and on door panel 42 as Boards 05, 01, and 06.

A punched tape reader 44 (FIG. 1) mounted on one side of the machine housing is provided for reading a conventional paper tape 45 (FIG. 18) having in this instance seven punch columns plus one column used for the tape transport sprocket.

Within the base of the housing, as shown in FIG. 6, the heavier

electrical gear is mounted, the main part of the tape reader indicated at 46, the power supply at 47, a pair of translators at 48 and 49, and a counter at 51. To any power supply at 47, a 117 v. AC current is converted to a DC current. This drives the other electronic equipment, which equipment reads a 0-to-15 volt signal fed out from the tape reader 46, amplifying that to -24 v., and converts the signals to energize a pair of synchronous motors 52 and 53 (FIG. 7).

Operation of the motor 52 rotates by means of a worm gear 54 an antibacklash worm wheel 55 which in turn rotates a spline shaft 56 extended completely across the machine on an X-axis. The shaft 56 is rotatably mounted by a pair of supports 57 and 58. Slidably mounted on the shaft 56 is a wheel 59 which in turn is rotatably mounted on and carries a slide block 61, adapted to horizontal movement as maintained by a roller connection at 62 with a guide track 63.

Mounted on and movable with the slide block 61 is an upright unit 64 having a block 66 at its upper end supported on and movable across a rod 67 secured to the machine housing. The drafting pen 68 for the drafting board 69 (FIG. 8), drafting paper 70 shown in FIG. 1, is carried by a carrier unit 71 slidably mounted on the upright members 72 and 73 of the upright unit 64, and is controlled as to its movement by a pulley and cable unit, the cable 74 wrapped about the wheel 59.

Thus, in response to energization of the synchronous motor 52, that in response to actuation of the circuitry 31 (FIG. 11), the drafting pen is moved upwardly and downwardly on a Y-axis. A solenoid 76 (FIG. 8) is provided for raising and lowering the pen 68 relative to the board 69, via a pivot arm 77, and with a floating arm 78 provided for maintaining fine control of the pen 68.

Operation of the other motor 53 also causes via a worm gear 79 and an antibacklash worm wheel 81 rotation of a hub 82. Another continuous cable 83 is connected, by a series of pulleys about which the cable is entrained, to both sides of the upper and lower slide blocks 61 and 66, wherein operation of the motor 53 results in reciprocal movement of the slide wheel 59, the blocks 61 and 66, the upright unit 64 and the drafting pen carrier unit 71 mounted thereon. It is to be noted that operation of both motors 52 and 53 can therefore move the drafting pen 68 in a direction other than on either an X or Y-axis.

Referring to FIGS. 16 and 18, the arrangement is such that either manual command inputs at 101 from the manual keyboard 102 (FIG. 9) can be put into a Coding Block for transmission to a parity check of conventional arrangement on Board 06, or the coded binary inputs from the tape reader 44 (FIG. 1) can be forwarded to the parity check. From FIG. 9, where a plurality of push-return switches are shown, it is seen that eight direction commands can be put into the Coding Block, namely 0 for driving the pen 68 upwardly, A for driving the pen upwardly and to the right at 45°, R for a straight right movement, D for right and down at 45°, I for straight down, C for left and down at 45°, L for straight left, and B for left and up at 45°. Digital number inputs of from 0 through 9 are provided, with the other lettered switches calling for special auxiliary functions, such as setting the pen down on the board 69, and traversing it while lifted.

A light for Parity Error Indicator is provided for visual notification of same, and Manual Start and Stop buttons are provided. The Stop button enables the tape reader 44 to be stopped so that data may be inserted into a drawing manually if desired.

On the left counter 35 (FIG. 10), the six cold cathode glow transfer tubes 103, 104, 105, 106, 107, and 108, representing the number 999,999 or any division thereof, reading from left to right, are shown. These tubes are specified at a counting rate of 4,000 pulses per second and are commercially available. Below the tubes, a Power On-Off switch is shown with a voltage check meter 109 for all the system's voltages, the Voltage Selection knob being shown. A valve 111 for turning on a Vacuum pump (not shown) to place a vacuum on a certain area of the drafting board 69 is provided.

The specific tubes 103-108, inclusive, used in this embodiment were manufactured by Baird Atomic, Inc. of Cambridge, Massachusetts under designation GS 10/S. Each tube 103-108 was identical, and comprised a deci-stable device capable of transferring states, designated 0 through 9, sequentially and cyclically from one state to the next lower state upon receiving a pulse through line 166 leading to each respective tube, or from the borrowing gate in the counter 51 as described hereinafter.

Referring back to FIGS. 16 and 18, coded inputs 1, 2, 4, 8, A, B, C and D from the eight level tape 45 are shown coming into the Parity Check Board 06. A digit or a direction is coded in terms of a combination of holes punched in the eight level tape 45, and is read by the reader 44 into the Parity Check Board 06. If an odd number of holes 1, 3, 5 or 7 are passed to the parity check Board 06, the signal is then passed on to Board 01 (FIG. 17); if not, the Parity Error Indicator on the control panel 36 goes on, and a signal is sent by line 102 (See FIG. 11) to a Tape Reader control 113 to stop, via line 114. the Reader 44.

Upon a signal, 1 for example, being sent out from the Parity Check Board 06, it is received at the Board 01, having been charged from a 15 v. pulse to a -24 v. pulse, where it is inverted by a transistor 116 for amplification purposes. The signal, as a pulse, is then split into two paths, one a Not Signal out as 0 volt pulse, indicated by a bar over the number 1, and the other as a Signal out, just 1, having been inverted again by another transistor 117. There is an inverter circuit for each of the seven levels of the tape 45, and wherein each inverter circuit produces either a Signal Out or a Not Signal Out. The eight level D of the tape 45 is not used herein, but is available.

At the upper part of FIG. 17, an "AND" gate 115 is shown for passing the signal "L" therethrough. Should a number command, such as 321, meaning 321 increments it is desired the pen 68 move, be received by the Decoding Board 01 (See FIG. 11), this command is sent directly via line 118 to a Pulse Generating Board 03 (See FIG. 12), described hereinafter. Conversely, an "AND" gate 115 (FIG. 17) is provided for each direction and other commands, with a certain code therefor. For example, the code for transmitting an "L" output signal from Board 01 is 1, 2, B, $\bar{A}$, and $\bar{A}$, with the other commands having their own predetermined codes. Thus, by electrically connecting the inverter channels with the "AND" gates of Board 01, directions are transmitted out on lines 119 (See FIGS. 11 and 14) to the ROUTING BOARD 02 (FIGS. 14 and 15) and numbers are transmitted on lines 118 to the PULSE GENERATING BOARD 03 (FIG. 12).

On Board 03 (FIG. 12) the first input signal, for example the digit 3 for the command number 321, comes in on line 118a to the top side of a bistable multivibrator 121 of a string of bistable multivibrators arranged to cascade down and trigger a number of pulses from the number ten down to the value of the digit put in, plus one for all nonzero digits, or only one pulse for the digit zero. Thus, when the digit 3 was put in, seven plus one or eight total pulses are triggered, with BS-MV 121 through 128 providing the eight pulses sent through lines 129-136 to line 137, and from there on line 138, the PULSE TRAIN OUTPUT Line, to Board 04 (FIG. 13). The purpose for these pulses will be described hereinafter.

Between each bistable is a delay 139, which delays passing the signal on to the next bistable for a few milliseconds. Next to the last bistable is a reset monostable 141 which, when tripped by the last pulse of the bistable circuit 128 sends a signal through lines 142, 143, 144, and all lines 146 to the lower side of each bistable to reset same for the next digit command to be put therein. Thus, the second command digit of 2 will result in nine pulses out, and the third command digit of 1 resulting in ten pulses out through line 138. The reset monostable 141 also sends a pulse through lines 142 and 147 to Board 04 (FIG. 13) for resetting a bistable 148 (FIG. 13) to be in position to receive the next command digit series of pulses, namely the digit 2. The digit 0, however, requires no pulses being transmitted on line 118 directly to the bistable 128, with one pulse being sent out through line 137.

The first pulse of each group of pulses out of the Board 03 Pulse Generating circuit has a dual function, and shows the reason for providing an extra pulse. It is forwarded through line 138 to Board 04, and also through line 149 to a clamping bistable 151 (FIG. 15), which energizes a clamping relay 152 to change the position of four banks of switches 153, 154, 155, and 156 as illustrated. The importance of this will be seen hereinafter.

The first pulse to Board 04 (FIG. 13) enters on line 138, meets a normally closed Gate 03, and passes through a normally open Gate 01 to trip a Bistable 01. The same pulse passes through line 157 and a normally open Gate 02 to a Three Stage Binary Counter Distributor Circuit 158. The Distributor Circuit 158 is a conventional binary circuit comprising three bistables (not shown) making a three stage binary counter for emitting A or $\bar{A}$, B or $\bar{B}$, and C or $\bar{C}$ pulses depending upon the number of input pulses. The first pulse into the Distributor Circuit 158 is used to set up the circuit 158 to use the remaining pulses according to their digit command. Thus, as the left most tube 103 is always set first, the first pulse coming into the Distributor Circuit is set to result in an $\bar{A}$, $\bar{B}$, $\bar{C}$ combination which then transmits a signal from the "AND" Gate 159 to open Gate 04.

At the same time that the Bistable 01 was tripped, and after Gate 02 had passed the first pulse, the tripping resulted in closing Gate 02 and opening Gate 03 such that all succeeding pulses, seven for the digit three, are then routed through lines 161 and 162 to the six Gates for the six Counter tubes. As all gates are closed, but Gate 04, the pulses are passed through line 163 to Gate 04, and line 164 to Board 05 which comprises six one-shot vacuum tube multivibrators (not shown) for amplifying the signal pulses to get a needed high voltage. The seven pulses are then fed through line 166 to the cold cathode glow transfer tube 103, with the 0 to 9, 9 to 8, 8 to 7, 7 to 6, 6 to 5, 5 to 4, and 4 to 3 pulses stepping the glow in the tube backwards, all tubes having been set initially at zero, setting thereby the number 3 into the left most tube 103.

The second digit 2, of the command number 321 changes the Distributor Circuit 158 to open Gate 05, and the third digit 1, both having passed through Board 03 in the same manner as the digit 3 causes Gate 06 to open whereby the numbers 2 and 1 are set into the tubes 104 and 105, sequentially in the same manner as the digit 3. What has occurred therefore is an electronic setting of the number 321 into the Counter 51.

While the command digit pulses are being set into the tubes 103-108, it is necessary to prevent one tube, such as tube 104, from borrowing a pulse from another, such as tube 103. The counter 51 includes an "or" gate (not shown) electrically connected between each adjacent pair of tubes, utilized in its count down wherein the tube 104 does borrow from tube 103, for example, in much the same manner as a mechanical subtracting machine. The left tube, 103 for example, is decremented by one upon the right tube, 104 for example, decrementing from state 0 to state 9. To prevent, however, the tubes from borrowing during the pulse input, the borrowing gate is grounded through line 165, changed switch 156, and junction 229 (FIG. 15). As will be seen hereinafter, the switch 156 is returned to its illustrated condition during the count down of the counter 51 such that the borrowing "or" gate is no longer grounded.

When the first tube 103 was receiving its loading pulses, a signal from the line 166 was derived therefrom to be transmitted via line 167 to a monostable multivibrator control bistable 168 (FIG. 15) to create a potential via line 169, whereby a variable rate astable multivibrator pulse generator 171 is activated at approximately 100 pulses per second. At the same time, a signal is applied from control bistable 168 through lines 264, 267, junction 268, line 172, and lines 173 to the right side of a bistable 174 for each of the direction commands.

The signal generated by the pulse generator 171 is delivered by lines 179, 181 and 182 to all of the upper gates 183, 184, 185, 186, 187, 188, 189 and 190. It is also sent via line 191 to the high side of the pulse rate control bistable 177, whereby

the pulsing rate of the pulse generator 171 is slowly increased to 200 pulses per second, and wherein it can safely run as high as 300 pulses per second.

This safeguards the operation of the stepping synchronous motors 52 and 53, and allows them to start up slowly from a standing stop, to always track and be synchronous with the pulse generator 171, whereby the stepping motors will not miss a single pulse, and will always match the rate of the pulse generator 171. Another line 192 from the control bistable 168 connects with a line 193 to the left junction 194 of switch 154, but as the switch is in a N. O. position due to energization of the clamping relay 152, that lead stops. The line 192 is also connected to line 196 which leads to lines 197 for the left side of each direction "AND" Gate 198, 199, 200, 201, 202, 203, 204 and 205.

When the direction "L" comes from Board 01 into Board 02, via a line 119, it is directed to an amplifier 206, there being an amplifier and an identical emitter following circuit as illustrated for each direction command. From the amplifier 206, the signal is directed in two paths, one through an emitter follower 207, and one through a line 208 to the right side of the "AND" Gate 198.

From the follower 207, the signal passes through a line 209, diode 211, line 212 to a junction 213 where it is prevented from backing into the Gate 183 by a diode 214. It passes on through lines 216 and 217 into a resistor network, in this case, resistances 218 and 219. Due to such resistance, the signal goes to ground through junction 220, line 221, diode 222, lines 223, 224 and 226 to the center terminal 227 of the switch 155. As the relay 152 had been activated by a pulse from pulse generating Board 03 having been placed into the bistable 151, the switch 155 is closed to ground through the line 228 and junction 229.

The resistance 218, however, permits a signal to be sent from line 217 through junction 231, line 232, diode 233, lines 234 and 236 to a junction 237 and line 238 leading to the clamping bistable 151, thus unclamping it and returning the switches 153-156 to their illustrated conditions.

Returning to the "L" "AND" Gate 198, with the pulse generator 171 working, both the control bistable 168 signal and the direction signal 208 are present at the Gate 198, which therefore produces an output through line 239 which trips the bistable 174, producing thereby an output through line 241 to open the Gate 183, whereby all pulses being generated by the pulse generator 171 flow through the Gate 183 and diode 214 to line 216. It should be noted here that the first pulse through line 241, due to a numbers command followed by a direction command being received at the Gate 198, is directed from junction 242, diode 243, line 244, junction 246, and line 247 (See FIG. 11) to the Tape Reader Control 113, whereby the Tape Reader 44 is stopped.

The pulses through line 216, generated by the pulse generator 171 are then transmitted through the resistances 218 and 219 to an appropriate Translator, in this case 48 for the X-axis. Each Translator is designed for use with its respective synchronous motor, and is designated to step the motor so as to provide an incremental pen movement of 0.002 inch per pulse. As the pulses are transmitted through line 248 to energize the motor 53, they are also fed as signals through a junction 249, line 251, diode 252, line 253, junction 254, line 256, terminal 257 of switch 153, through the normally closed switch 153 to junction 258 and line 259 to a junction 261 on Board 04 (FIG. 13) for being applied through a gate to a respective tube. It will be remembered that Gate 06 was the last and only Gate open when the digit 1 of the command number 321 was put into tube 105.

Thus with the command number 321 set into the counter tubes 103, 104 and 105, the pulses coming through line 259 are directed through junction 261, line 262 to Gate 06, and through line 164a for Gate 06 to and through the one-shot multivibrator and line 166a to tube 105. Each pulse causes the glow in tube 105 to move from 1, 1 having been set therein, to 0 to 9, whereupon the counter circuit causes the glow in tube

104 to move from 2, 2 having been set therein, to 1. Tube 105 continues to count down. This action continues, with each time the glow transferring from 0 to 9 in a tube resulting in the tube to the left thereof losing a digit, until all tubes 103, 104 and 105 reach zero. A mechanical counterpart of this electronic count down arrangement is found in a Veeder-Root-type counter running backwards.

When the counter 51 (FIG. 13) reaches zero, it sends a signal out through line 263 (FIG. 15) to the control bistable 168. The signal effects a removal of the -24v supply for the pulse generator 171, which then stops such that no more pulses are sent to the Translator 48. Secondly, a -24v pulse is delivered through line 264, junction 266, line 267, junction 268, and line 269 to the binary counter distributor circuit 158 (FIG. 13). This causes all the Gates, 4-9 inclusive, to close, and simultaneously, using line 263a (FIG. 11) starts the tape reader 44.

The same pulse is forwarded through lines 173 to trip the bistables 174, and therefore closing all Gates 183-190, readying the Gate circuitry for the next command. A pulse is also sent from the control bistable 168 through line 264, junction 266, line 176, to the low side of the pulse rate control bistable 177. This leaves the bistable 177 in the low rate condition for the next numbers command, as described hereinbefore. The desired line segment of 321 0.002 inch increments has now been completed, and the tape transport 44 is again running.

Assume the next command results in a direction B passed through the parity Board 06 and decoded at Board 01, then sent through line 119b (FIG. 14) to the amplifier 206b. The pulse is then again routed the two paths through the line 208b to the right side of the "AND" Gate 201b; and also through the path of the emitter follower 207b, line 209b, diode 211b, line 212b, and to junction 213b. At the "AND" Gate 201b, the signal is stopped because no signal is present on line 197b, as no number command preceded the direction command B.

From the junction 213b, the signal is directed through a pair of diodes 271 and 272, wherein pulses are transmitted through lines 216 and 273 through the resistances 218 and 219 for line 216, and 274 and 276 for line 273, to both Translators 47 and 48. Thus, both motors are stepped one pulse, resulting in the pen 68 moving left and out simultaneously such that a 45° diagonal line, the length of which is equivalent to two times the square root of 0.002 inch squared, is drawn. The motors stop again until the next command.

Although a preferred embodiment of the invention has been described hereinbefore, it is to be remembered that various modifications and alterations can be made thereto without departing from the true spirit and scope of the invention as defined by the appended claims.

We claim:

1. Electrical pulse counter apparatus comprising:

counter means, initially containing zero, for accepting a number in the form of a sequence of digits with the most significant digit first and with the units digit last, each nonzero digit loaded into said counter means by a series of first pulses equaling 10 minus the digit value, the digit zero requiring no pulses;

distributor means for loading said counter means including for each digit a normally closed distributor gate leading into said counter means, the distributor gate utilized to load the last digit being the units gate;

means for generating a string of second pulses;

means for transmitting said second pulses to said counter means through said distributor means units gate;

said counter means operable to decrement from said number to zero in response to receiving said second pulses, and operable further to emit a signal when the number being decremented reaches zero;

said distributor means includes a distributor counter circuit for counting the number of digits received by the counter apparatus, said distributor counter circuit including further an "AND" gate for each distributor gate, said distributor counter circuit operable to emit a plurality of

combinations of signals to said "AND" gates, each "AND" gate responding to one of said combinations of signals to open the associated distributor gate to pass said series of first pulses into said counter means, said distributor counter circuit upon receiving a signal for each digit of said number being incremented thereby emitting the combination of signals corresponding to the current digit count, actuating the appropriate "AND" gate and thereby opening the associated distributor gate.

2. Electric pulse counter apparatus as defined in claim 1, and including means comprising a plurality of bistable multivibrators arranged to receive a digit and to emit a sequence of pulses the number of which is one greater than the said series of first pulses required for the digit received, said emitted pulses transmitted to said distributor means, said distributor means operable to receive said augmented pulse series, using the additional pulse to increment said distributor counter circuit.

3. Electric pulse counter apparatus as defined in claim 1, and wherein said pulse generating means for said second pulses comprises an astable multivibrator actuated in response to a signal upon the loading of the first digit of said number into said counter means, said multivibrator operable to cease generating said second pulses in response to said signal from said counter means emitted therefrom when the number is decremented to 0.

4. An electric pulse counting means comprising:

counter means having a plurality of digit display means operable by application of electric pulses, said display means being arranged to display in order digits of a preset number from the most significant digit to the least significant digit, each of said display means initially displaying the digit 0;

a pulse generating means;

a distributor having a normally nonconductive gate connected between said pulse generating means and each of said display means;

input means connected to said pulse generating means for controlling said pulse generating means to cause it to apply to said gates a sequence of groups of pulses, each group corresponding to a digit of a desired number to be preset on said display means, said sequence being applied in the order from the most significant digit to the least significant digit thereof, the number of pulses for each of said digits being the initial digit minus the desired digit modulo of the base number system;

distributor control means connected between said pulse generating means and said distributor to apply to said distributor a distributor-control signal in response to the generation of each of said groups of pulses, said distributor in response to the application of each of said distributor-control signals operating to make conductive one of said gates, the sequence in which said gates are made conductive one at a time during application of said groups of pulses for each of said desired numbers being in the order from that one connected to said display means for displaying the most significant digit to that one connected to said display means for displaying the least significant digit of the number being preset on said counter means, the number of said gates becoming conductive sequentially for a desired number to be preset being equal to the number of said groups of pulses for said desired number; and

each of said digit display means while the respective one of said gates is conductive being operated decrementally in response to the application of a respective one of said groups of pulses.

5. An electric pulse counting means as claimed in claim 4 including decremental pulse means for decrementing said counter means, means responsive to the termination of the generation of said group of pulses that is used for presetting said desired number to connect said decremental pulse means to said gates of said distributor, whereby pulses generated by

said decremental pulse means in applied through that one of said gates that has been made conductive for presetting the least significant digit in said counting means, said counter having a borrowing circuit for decrementing said display means in order from that one used to display the least significant digit of said desired number to that one used to display the most significant digit of any number to be preset in said counter

means;

and disabling means connected to said pulse generating means and to said borrowing circuit, said disabling means operating in response to generation of pulses by said pulse generating means for presetting said desired number to inhibit the operation of said borrowing circuit.

10

15

20

25

30

35

40

45

50

55

60

65

70

75