

June 23, 1964

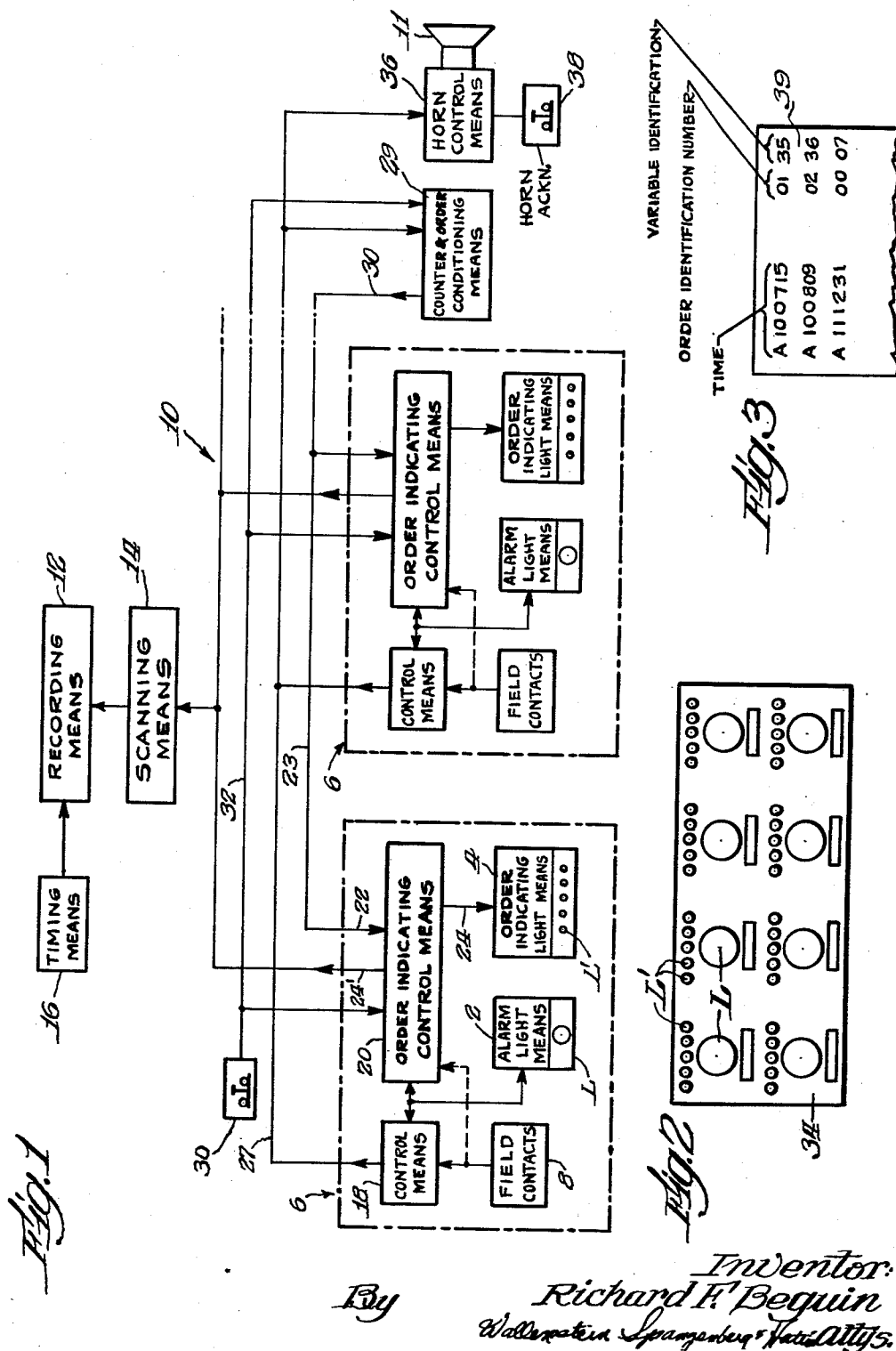
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3,138,791

SEQUENTIAL ANNUNCIATOR SYSTEM

Filed Sept. 19, 1960

4 Sheets-Sheet 1



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SEQUENTIAL ANNUNCIATOR SYSTEM

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4 Sheets-Sheet 2

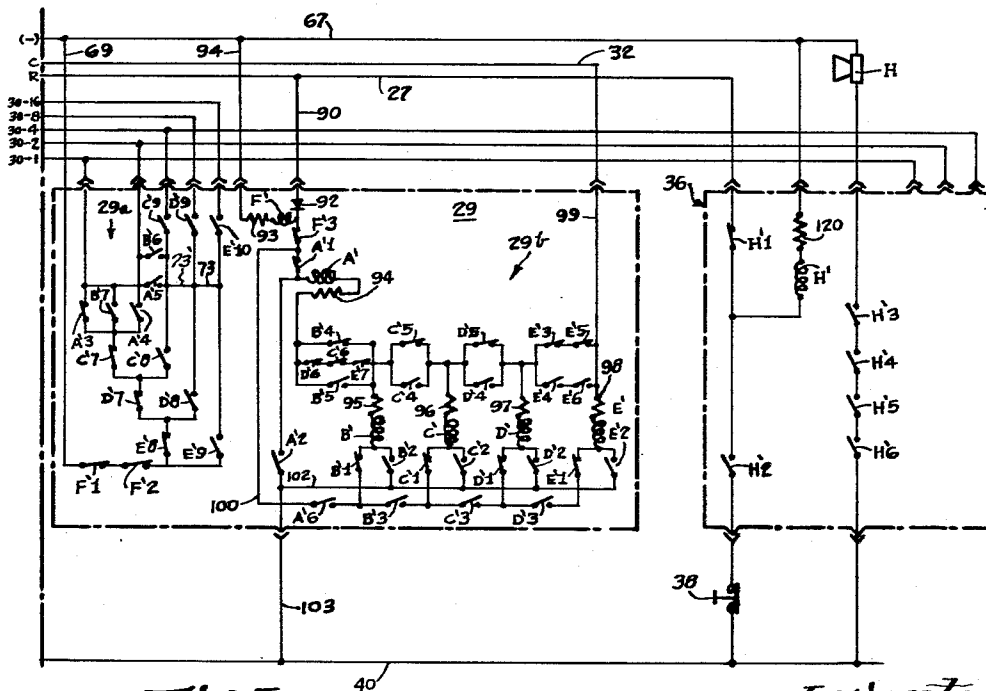
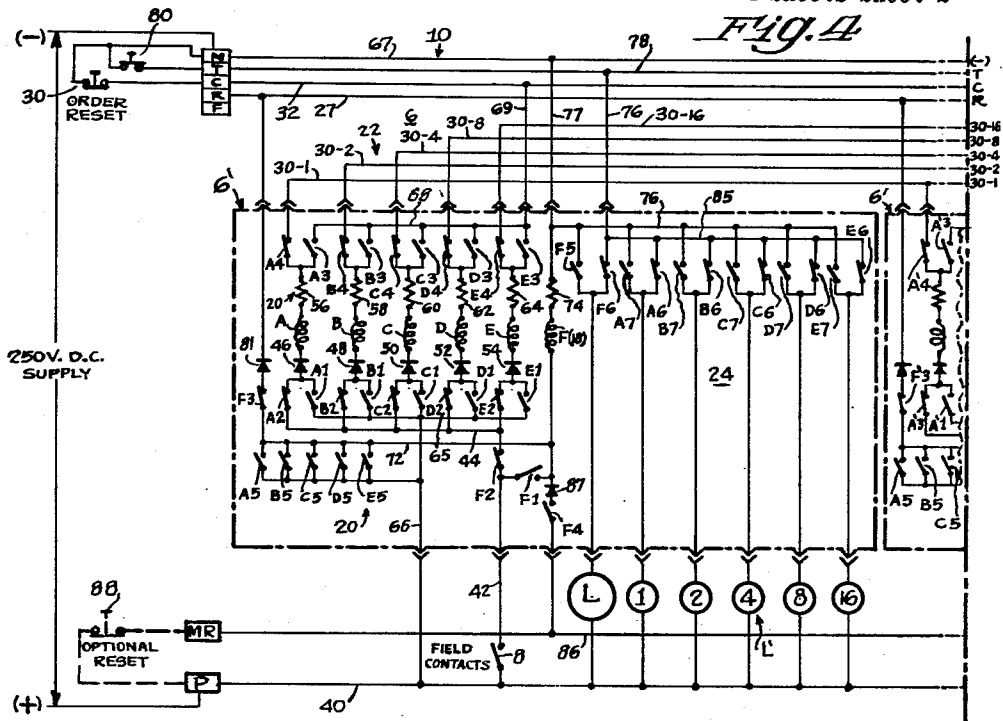


Fig. 5

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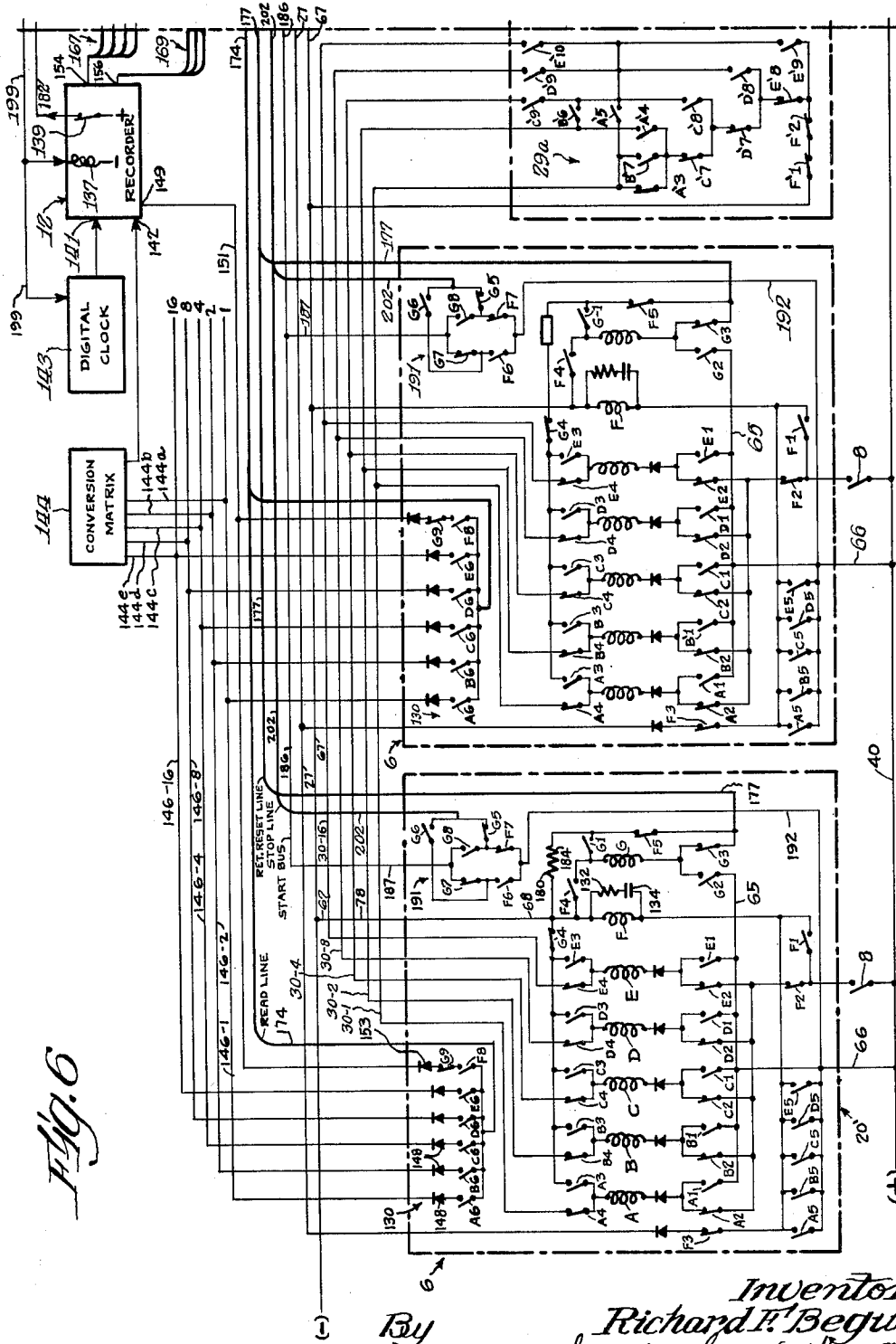
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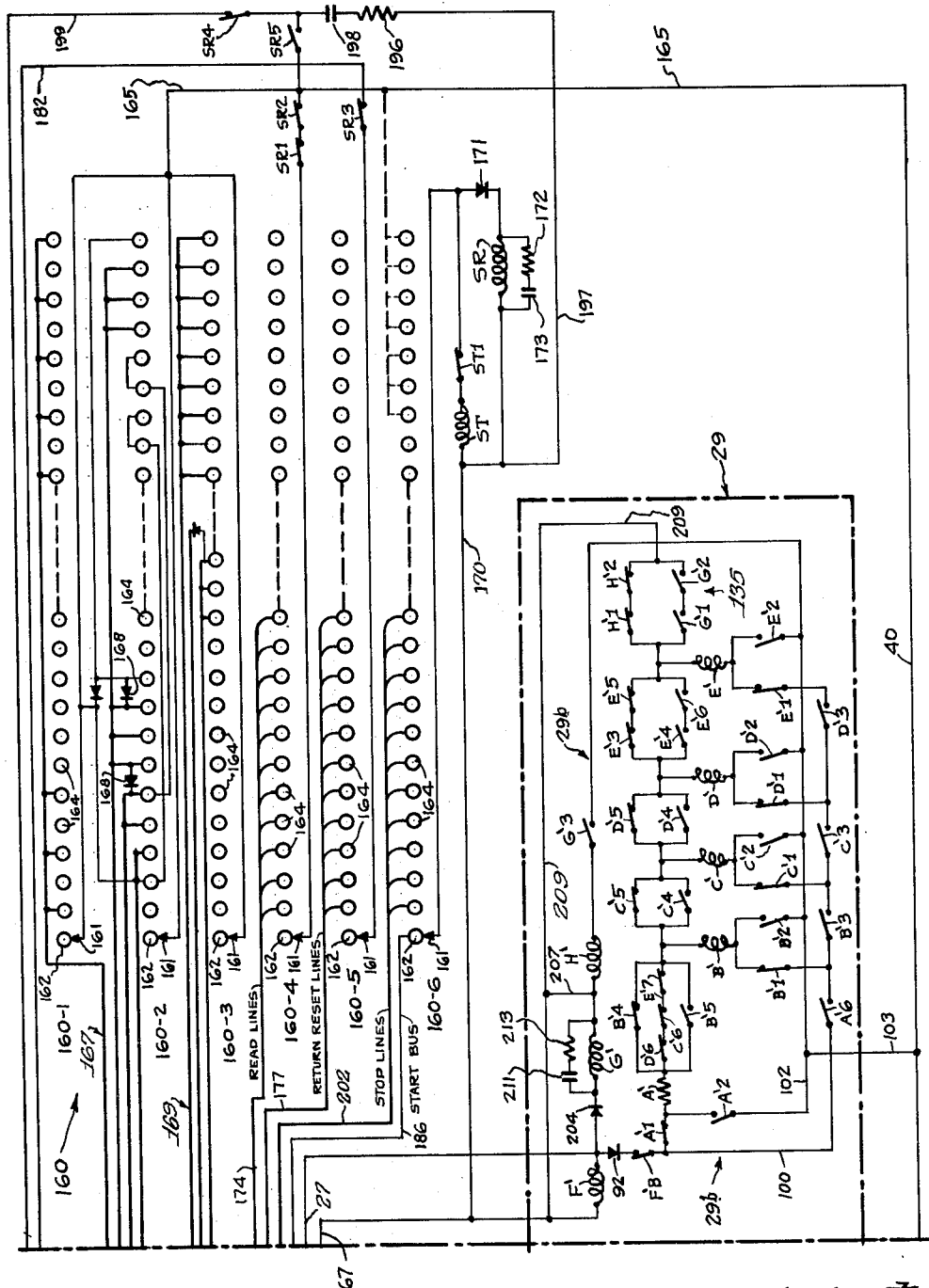


Fig. 7

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3,138,791

SEQUENTIAL ANNUNCIATOR SYSTEM

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10 Claims. (Cl. 340-223)

This invention relates to the monitoring of variables and, more specifically, to a variable monitoring system which indicates the order in which variables reach a given limiting condition to be monitored.

There are many situations in industrial processes where variables are so closely interrelated that trouble developing at one point in the process may almost immediately result in related difficulties at other points thereof. In such case, without information of the order in which the variables go abnormal, it is often difficult to pinpoint the source of trouble resulting in loss of costly production time. This problem has been overcome to a certain extent by the development of a visual sequence annunciator system which provides alarm light indications which distinguish between a variable which first reaches a limiting or abnormal condition and all other related variables which reach their limiting or abnormal conditions subsequent thereto. One such system is disclosed in U.S. Patent No. Re. 24,031, granted June 28, 1955 to Robert J. Marmorstone.

There are numerous annunciator applications where it is highly advantageous to indicate the numerical order in which the subsequent variables become abnormal. It is also frequently desirable in many instances to provide a permanent record of the time and order in which the variables go abnormal. In both the aforesaid annunciator and recording applications, it is important to be able to distinguish between variables which go abnormal at approximately the same time and those which go abnormal at widely spaced time intervals.

In accordance with one aspect of the present invention, an annunciator system is provided which, among other things, provides an immediate visual indication of the order in which the monitored variables go abnormal prior to operation of a manual order reset switch. The visual indication for each variable is preferably provided by lamps representing the binary or decimal digits of an order identifying number. Most advantageously, there is also associated with each of the variables a separate alarm lamp preferably mounted next to the associated order identifying lamps. The alarm lamp is operated independently of the order indicating lamps which can be de-energized by operating the aforesaid order reset switch, and so gives continuous information on the conditions of the associated variable. Operation of the order reset switch resets the order number identifying portions of the annunciator system to zero so that the system can indicate the order in which a new series of abnormal variables become abnormal before the variables of the first series have all returned to normal.

In accordance with another aspect of the invention, there is supplied in addition to or in place of the aforementioned lamp or equivalent indicating means a scanning recorder which sequentially prints numbers representing the variables which have gone abnormal, their order identifying numbers and the time of the recording operation. The recorder may not operate as fast as the resolution time of the order determining portion of the monitoring system and so memory means are provided for memorizing the order indicating number for each abnormal variable.

The means for controlling the operation of the sequence indicating lamps or the recorder preferably includes what will be sometimes referred to as the order indicating control means, one such means being provided for each vari-

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able. This control means may be a binary coded register having a number of operating states corresponding with various possible order numbers. Each of the order indicating control means is conditioned for operation by what will sometimes be referred to as a counter and order conditioning means preferably used in common with all of the variables. The counter and order conditioning means may include a pulse counter or the like which may be a stepping switch, or a relay or static element counter circuit, which receives a pulse or other signal as each variable becomes abnormal. The common counter and order conditioning control means is connected with each of the individual order indicating control means so as to condition the latter means to operate in the state corresponding to the count accumulated in the counter portion thereof when the associated variable becomes abnormal. Thus, initially each order indicating control means is conditioned to operate in a state indicating order No. 1 and the first variable which goes abnormal will operate field contacts or the like which, through associated means in the control circuit involved, operates and locks the associated order indicating control means in its No. 1 indicating state and operates a circuit which generates a pulse which advances the counter one unit. The individual order indicating control means effects energization of the associated order indicating lamps or operates the aforesaid recorder.

The next variable to become abnormal will operate its associated order control indicating means which is then conditioned to operate in its No. 2 indicating state since the aforesaid common counter has the No. 2 accumulated therein.

In the recorder application of the present invention, where completely automatic operation is desired, automatic reset means is provided for resetting the counter and order conditioning means only after a given time interval has elapsed between successive abnormal variables. This means is most advantageously a capacitor resistor network fed from the various count pulse generator means and having a discharge time constant in the order of the aforementioned time interval. As long as this capacitor-resistor circuit continues to receive count pulses separated by a time interval less than said time interval, the capacitor will remain charged to a level which will prevent a reset operation.

Other advantages and features of the present invention will become apparent upon making reference to the specification to follow, the claims and the drawings wherein:

FIG. 1 is a box diagram illustrating the present invention;

FIG. 2 is a view of a light panel containing the alarm and order indicating lights for eight variables;

FIG. 3 is a fragmentary view of a record strip upon which the variable and order number identifying information is printed;

FIGS. 4 and 5 together form a circuit diagram of an annunciator system including features of the present invention; and

FIGS. 6 and 7 together form a circuit diagram of a scanning variable monitoring and recording system including features of the present invention.

General Description

Refer now to FIG. 1 illustrating in box form the basic components of the present invention applied both to an annunciator system and a recording system. The most important application of the present invention, however, is in an annunciator system where the abnormal condition of a variable is immediately indicated on an associated light means 2 and the order in which the variable goes abnormal is indicated on a sequence or order indicating

light means 4. The alarm light means may comprise a single incandescent lamp L and the sequence indicating light means may comprise a number of lamps L' indicating in binary or decimal digital form the number corresponding to the order in which the variable in question went abnormal. The light means L and L' are controlled by a basic control circuit generally indicated by reference numeral 6 which is exclusive to the variable involved. Each control circuit includes a set of field contacts 8 or similar variable responsive means which responds directly to the condition of the variable to be monitored. Although it should be understood that various conditions of a variable can be monitored, the present invention is illustrated in connection with the monitoring a single limiting condition referred to as an abnormal condition. The control circuits 6 are connected in parallel across common lines or buses generally indicated by reference numeral 10 to be described.

A recording means 12, scanning means 14 and timing means 16 and other elements to be described are used in common with the various control circuits 6. The scanning means 14 sequentially connects the various control circuits 6 to the recording means which prints out information on abnormal variables on a record strip (or other recording medium) as illustrated in FIG. 3. This information includes a number identifying an abnormal variable being scanned at a given instant, a number indicating the order or sequence in which the variable went abnormal in a given series of abnormal variables, and the time of the recording operation as determined by timing means 16 connected to the recording means 12.

Each of the control circuits 6 includes control means 18 which may comprise one or more relays or other control elements. When the field contacts 8 are operated to their position indicating an abnormal variable, the control means 18 responds directly thereto or through an associated order indicating control means 20 to energize the alarm light means 2. The field contacts also effect energization or operation of the order indicating control means 20 into an operating state into which it is conditioned to operate by means of a conditioning signal fed thereto through one or more input lines generally indicated by reference numeral 22 extending from one or more coding buses generally indicated by reference numeral 23. The order indicating control means 20 may be a series of relays or other current control elements arranged to indicate in binary coded form the number corresponding to the order in which the associated variable went abnormal. If the associated variable was the first variable to become abnormal, the order indicating control means involved is operated into a state indicating No. 1 in a multi-bit binary code.

The order indicating control means 20 has an output 24 which controls the energization of the order indicating light means 4 and an output 24' which leads to or is controlled by the scanning means 14. Each of the outputs 24 and 24' may comprise a series of output lines representing binary or decimal digits. The output lines are energized in a given coded pattern which indicates the order identifying number involved.

Operation of the field contacts 8 to an abnormal indicating position also results in the pulsing of a common count bus 27 extending to a common counter and order conditioning means 29. The pulse appearing on the bus 27 will advance the count accumulated in the counter portion of the means 29 by one unit. The latter means has a series of binary code outputs generally indicated by reference numeral 30 which lead to the aforesaid coding buses 23. The coding buses are energized in a binary code pattern corresponding to the count accumulated in the aforesaid counter, and, when the field contacts 8 of a control circuit 6 operate to an abnormal variable indicating position, the associated input 22 is operative to energize or operate the associated order indicating control means 20 in a corresponding pattern. Once a

given order indicating control means 20 has been operated to one of its possible operating states, it becomes insensitive to any further conditioning signals from the coding buses 23.

The means for de-sensitizing the order indicating control means 20 once it has been operated may take a variety of forms. In its simplest form it may merely consist of a set of contacts which de-couples the coded input 22 from the coding buses 23. It is apparent that, when a series of variables become abnormal in sequence, the various order indicating control means 20 involved will be operated into operating states corresponding to a number indicating the order in which the associated variables went abnormal, provided the time interval between the successive alarms involved is greater than the minimum resolution time of the system. It is obviously most desirable that the counter and order conditioning means 29 as well as the rest of the system operate as quickly as possible so that the resolution time is at a minimum. This resolution time can be made as short as price and component limitation considerations will permit. A resolution time of from 10 to 25 milliseconds will be satisfactory for most applications. Successive alarms which are spaced apart less than the resolution time of the system will have the same order identifying number.

As previously indicated, as soon as a variable goes abnormal, the fact of the abnormality will be immediately indicated on the associated alarm lamp L and the order in which the variable went abnormal is indicated on the order indicating lamps L'.

Where the present invention is applied to an annunciator system, a manual order number reset switch 30 is provided in association with a reset bus 32 connected to the various order indicating control means 20 of the control circuits 6 and also to the counter and order conditioning means 29. Momentary operation of the switch 30 will reset the count in the counter and order conditioning means 29 to one and all of the order indicating and control means 20 to zero which, in turn, will de-energize the order indicating light means 4 until the associated variable returns to normal and then becomes abnormal again. The alarm lamp L, however, will remain energized to indicate the abnormality of the associated variable until the latter returns to normal. If desired, a separate reset switch may be provided for the lamp L in case it is desired to retain an abnormal light indication until an actual manual reset operation is carried out.

FIG. 2 shows the preferred arrangement of the alarm lamps L and the order indicating lamps L' for a number of variables on a display panel 34. The lamps L and L' associated with each variable are arranged together, the alarm lamp L being a large incandescent bulb and the order identifying lamps L' being much smaller than the lamp L and comprising, for example, neon lamps or the like. Where the largest order identifying number is 9, nine lamps L' could be provided to indicate the digits 1-9. However, when the order indicating numbers are two digits or more each of the lamps L' in a group most advantageously indicate the order identifying numbers in binary coded form such as the progressive powers of two, namely $2^0(1)$, $2^1(2)$, $2^2(4)$, $2^3(8)$, $2^4(16)$, etc.

To attract an operator's attention to the panel 34, the annunciator portion of the system preferably includes a horn H which is sounded whenever any variable goes abnormal. The horn H is controlled by suitable horn control means 36 which receives a signal from a common bus which in the illustrative embodiment of the invention is the pulse bus 27. A horn acknowledgement switch 38 may be provided which, when momentarily depressed silences the horn H.

As above indicated, the scanning means 14 scans the various control circuits 6 and the recording means 12 prints information on any new abnormal variable and also preferably on any variable which returns to normal. As shown in FIG. 3, the recording means 12 preferably prints on a record strip 39 the time in hours, minutes and

seconds in which the record was printed, the letter "A" adjacent the time number representing A.M. time and the letter "P" representing P.M. time. In the case where the variable has just become abnormal, the next number is the order identifying number which can be a number from one to the largest number which the equipment is designed to handle. In the case of data printed for return to normal variables, this fact may be indicated, for example, by the number 00 in the order identifying number column of the record strip.

In FIGS. 4 and 5 there is shown an exemplary circuit for an annunciator system incorporating features of the invention and in FIGS. 6 and 7 there is shown an exemplary circuit of a recording system incorporating the features of the invention. (It should be apparent that the two systems could readily be combined to form an integrated system similar to that shown in FIG. 1.) The annunciator system of FIGS. 4 and 5 uses a manual order reset switch 30 as just described whereas the recording system of FIGS. 6 and 7 uses an automatic reset means which automatically resets the order identifying circuits whenever the interim between successive abnormal variables is greater than a predetermined time interval which may be a few seconds or more.

Annunciator Circuit of FIGS. 4 and 5

In the circuit illustrated, each order indicating control means 20 of each control circuit 6 includes a series of relays A, B, C, D and E, sometimes referred to as coding relays. The relays are energized in a binary code pattern which indicates the order identifying number involved. The energized conditions of relays A, B, C, D and E represent the numbers 1, 2, 4, 8 and 16 respectively, and the order identifying number is the same as the number represented by the energized relays.

Most of the circuit components making up each control circuit 6 including the relays A through E are preferably mounted on a common frame forming a single plug-in unit outlined by a dotted box 6'. The field contacts 8 and the lamps L and L' are mounted externally of the associated plug-in unit 6'. These plug-in units are removably insertable within the associated sockets carried on a chassis support (not shown) on which the various buses 10 are also supported.

Each of the field contacts 8, which are illustrated as normally-open field contacts, is connected between a positive voltage bus 40 and a control line 42 extending to a normally-closed set of contacts F2 of a control relay F forming the control means 18 referred to in the box diagram of FIG. 1. The contacts F2 are connected to a common line 44 connected to corresponding terminals of normally-closed contacts A2, B2, C2, D2 and E2 of the coding relays A through E. (In the description to fol-

low the contacts of any relay are identified by the same reference character as the relay involved followed by a number identifying the particular contacts involved.) The other terminals of the latter contacts respectively extend through isolating rectifiers 46, 48, 50, 52 and 54, respectively, connected to the coils of the relays A through E respectively. The coils of the coding relays A through E are connected through respective resistors 56, 58, 60, 62 and 64 to normally-closed contacts A4, B4, C4, D4 and E4. The latter normally-closed contacts respectively are connected to coding buses 30-1, 30-2, 30-4, 30-8 and 30-16 which constitute the output lines of an order number conditioning control circuit 29a of the common counter and order conditioning means 29 (FIG. 5).

The control circuit 29a comprises a network of contacts of a set of counter relays, A', B', C', D' and E' of a pulse counter circuit generally indicated by reference numeral 29b. The network of contacts extends between a negative N bus 67 and the coding lines 30-1 through 30-16. The coding buses are energized in a pattern indicating the same number accumulated in the counter circuit.

The counter relays A' through E' are arranged in a circuit which provides a modified binary code to be described so that the initial reset condition of the counter circuit is the No. 1 rather than the No. 0 as in a conventional type binary counter. In the modified binary code, the energized condition of the relay A' represents the No. 2 and the de-energized condition thereof represents the No. 1 up through the count of 3. Thereafter, the energized condition of the relay A' follows the conventional binary code where the energized condition thereof represents the No. 1 and the de-energized condition thereof represents the No. 0 as in the case of the coding relay A in each of the control circuits 6. The energized condition of the counter relay B' represents the No. 1 and the de-energized condition thereof represents the No. 0 up through the count of 3 and thereafter the energized condition thereof represents the No. 2 and the de-energized condition thereof represents the No. 0 as in the case of a conventional binary code. The energized conditions of the counter relays C', D' and E' respectively represent the Nos. 4, 8 and 16 and the de-energized conditions thereof represent the Nos. 0. The contacts of the counter relays A' through E' are arranged in the control circuit 29a so to energize the coding buses 30-1 through 30-16 in a manner following the conventional binary code. The energized conditions of these buses thus respectively represent the Nos. 1, 2, 4, 8 and 16 and the de-energized conditions thereof represent the No. 0.

The following is a chart indicating the various combinations of the energized and de-energized conditions of the counter relays A' through E' and the coding buses 30-1 through 30-16 and the numbers which they represent:

Counter Relays					Order Number	Coding Relays (Lamps and Buses)				
A'	B'	C'	D'	E'		A (1)	B (2)	C (4)	D (8)	E (16)
0	0	0	0	0	1	1	0	0	0	0
1	0	0	0	0	2	0	1	0	0	0
1	1	0	0	0	3 (1+2)	1	1	0	0	0
0	0	1	0	0	4	0	0	1	0	0
1	0	1	0	0	5 (1+4)	1	0	1	0	0
0	1	1	0	0	6 (2+4)	0	1	1	0	0
1	1	1	0	0	7 (1+2+4)	1	1	1	0	0
0	0	0	1	0	8	0	0	0	1	0
1	0	0	1	0	9 (1+8)	1	0	0	1	0
0	1	0	1	0	10 (2+8)	0	1	0	1	0
1	1	0	1	0	11 (1+2+8)	1	1	0	1	0
0	0	1	1	0	12 (4+8)	0	0	1	1	0
1	0	1	1	0	13 (1+4+8)	1	0	1	1	0
0	1	1	1	0	14 (2+4+8)	0	1	1	1	0
1	1	1	1	0	15 (1+2+4+8)	1	1	1	1	0
0	0	0	0	1	16	0	0	0	0	1
1	0	0	0	1	17 (1+16)	1	0	0	0	1
0	1	0	0	1	18 (2+16)	0	1	0	0	1
1	1	0	0	1	19 (1+2+16)	1	1	0	0	1
0	0	1	0	1	20 (4+16)	0	0	1	0	1

See footnote at end of table.

Counter Relays					Order Number	Coding Relays (Lamps and Buses)				
A'	B'	C'	D'	E'		A (1)	B (2)	C (4)	D (8)	E (16)
1	0	1	0	1	21 (1+4+16)	1	0	1	0	1
0	1	1	0	1	22 (2+4+16)	0	1	1	0	1
1	1	1	0	1	23 (1+2+4+16)	1	1	1	0	1
0	0	0	1	1	24 (8+16)	0	0	0	1	1
1	0	0	1	1	25 (1+8+16)	1	0	0	1	1
0	1	0	1	1	26 (2+8+16)	0	1	0	1	1
1	1	0	1	1	27 (1+2+8+16)	1	1	0	1	1
0	0	1	1	1	28 (4+8+16)	0	0	1	1	1
1	0	1	1	1	29 (1+4+8+16)	1	0	1	1	1
0	1	1	1	1	30 (2+4+8+16)	0	1	1	1	1
1	1	1	1	1	31 (1+2+4+8+16)	1	1	1	1	1

Note: 0=De-energized
1=Energized

The control circuit 29a includes a line 69 extending between the negative N bus 67 and two sets of normally-closed contacts F'1 and F'2 of a pulse forming relay F' whose function will be described. (Two sets of contacts of the same relay are shown in series for reducing arcing in common current carrying portions of the circuit.) The latter contacts are connected through a set of normally-open contacts E'9 to the coding bus 30-16.

The contacts F'1 and F'2 are coupled to the coding bus 30-8 through a path including normally-closed contacts E'8, normally-open contacts D'8 and normally-open contacts D'9. A jumper 73 is connected between the juncture of contacts D'8 and D'9, on the one hand, and contacts E'9 and E'10 on the other hand.

The contacts F'1 and F'2 are coupled to the coding bus 30-4 through a path comprising normally-closed contacts E'8, normally closed contacts D'7, normally-open contacts C'8 and normally-open contacts C'9. A jumper 73' is connected between the juncture of contacts C'8 and C'9 and the juncture of contacts D'8 and D'9.

The contacts F'1 and F'2 are coupled to the coding bus 30-2 through a path including normally-closed contacts E'8, normally-closed contacts D'7, normally-closed contacts C'7 and normally-open contacts A'4. A set of normally-open contacts B'6 are connected between the negative sides of the contacts A'4 and the juncture of contacts C'9 and C'8.

The contacts F'1 and F'2 are coupled to the coding bus 30-1 through a path including normally-closed contacts E'8, normally-closed contacts D'7, normally-closed contacts C'7 and normally-closed contacts A'3 or normally-open contacts B'7 in parallel with the contacts A'3. A set of normally-open contacts A'5 are connected between the negative side of the contacts A'3 and the juncture of contacts C'9 and C'8.

The counter relays A' through E' receive a pulse from each control circuit 6 as the associated variable goes abnormal in a manner to be explained and thus energizes the coding buses 30-1 through 30-16 in a pattern representing an order identifying number one unit higher than the order identifying number associated with the last variable to go abnormal in the series or the number one in case the system has been reset.

It is apparent that the coding relays A-E will be initially energized in a conventional binary code pattern which indicates the number corresponding to the order in which the associated variable went abnormal. Upon the energization of one or more of the coding relays, holding circuits are established through associated normally-open contacts A1, B1, C1, D1 or E1. The contacts A1-E1 form a set make-before-break contacts with the associated normally-closed contacts A2-E2 so that with the energization of any of the relays A-E, momentarily the associated contacts A1-A2, B1-B2 or E1-E2 will both be closed, the normally-open contacts coupling the positive potential of the P bus 40 to the coding relays conditioned to be energized through a path including a common line 65 extending between the bottommost terminals

of the contacts A1-E1 and a line 66 connecting with the positive bus 40, to form a holding circuit for the associated energized relays. To complete a holding path to the negative bus 67, a series of normally-open contacts A3, B3, C3, D3 and E3 are provided which respectively form a set of make-before-break contacts with associated normally-closed contacts A4, B4, C4, D4 and E4. The holding contacts A3-E3 are coupled to common lines 68 and 69 joining a common order number reset bus 32. The reset bus 32 is connected through a set of connecting terminals C and a normally-closed order number reset push-button switch 30 to the negative bus 67.

Upon the energization of any of the coding relays, associated normally-open contacts A5, B5, C5, D5 or E5 will close. The latter contacts are connected between the line 66 extending to the positive P bus 40 and a common line 72 connected to the bottom of the aforementioned control relay F. The control relay F is connected through a resistor 74 and line 77 to the negative bus 67. Upon energization of any of the coding relays, the control relay F will be energized and seal-in through a set of normally-open contacts F1 connected to the line 42 extending to the field contacts. The control relay F will thus remain sealed-in until the associated variable returns to normal which opens the field contacts 8. Energization of the control relay F will open the associated normally-closed contacts F2 which breaks the connection between the positive bus 40 and the line 44 extending in common with the normally-closed contacts A2, B2 . . . E2 of the still de-energized coding relays, so that any change in the pattern of the energization of the coding buses 30-1 through 30-16 will have no effect on the coding relays. The coding relays are not responsive again to the coding buses until the control relay F becomes de-energized again which does not occur until the field contacts return to normal. Before the variable returns to normal, however, the coding relays can be reset to a condition where all the relays are de-energized by momentarily opening the order number reset switch 30 which breaks the holding circuits to all of the energized coding relays.

The control relay F has normally-open contacts F5 connected between one terminal of the alarm lamp L and a conductor 76 extending to line 77 leading to the negative voltage bus 67. Energization of the control relay F will thereby close the contacts F5 to energize the lamp L whose other terminal is connected to the positive bus 40. A set of normally-closed contacts F6 are connected between the lamp L and a common test bus 78 extending to a set of connecting terminals T. A normally-open pushbutton test switch 80 is connected between the connecting terminals T and the negative voltage bus terminal N. When the pushbutton switch 80 is depressed, this will couple the negative voltage of the bus 67 through the normally-closed contacts F6 of all of the control circuits 6' whose variables are normal to light the associated alarm lamps L. If the lamps light, the operator knows that the lamps are not defective.

As previously indicated, when any of the coding relays A through E are energized, the associated line 72 will be coupled through any one or more of the contacts A5 through E5 and line 66 to the positive voltage bus 40. The line 72 is connected through a set of normally-closed contacts F3 and an isolating rectifier 81 to the pulse bus 27 extending to the input to the counter circuit 29b. Since the contacts A5 through E5 must close before the control relay F is energized, it is apparent that the contacts F3 will open a short time interval after any one of the contacts A5 through E5 close to effect the pulsing of the bus 27. As the bus 27 receives a pulse, the count accumulated in the counter circuit 29b is advanced one unit to condition the still inoperative coding relays 20 of the various control circuits 6 to indicate the next higher order identifying number when the associated variable becomes abnormal. If two or more variables become abnormal simultaneously or separated by a time interval less than the minimum resolution time of the system, the variables involved will have the identical order identifying number.

As previously indicated, the coding relays A through E control the energized condition of the order identifying lamps L'. In the embodiment now being described there are five such lamps which respectively represent the binary code digits 1, 2, 4, 8 and 16. The order identifying number involved is the sum of the number represented by the energized lamps L' at any given time. The various lamps 1, 2, 4, 8 and 16 are respectively connected between the positive voltage bus 40 and normally-open contacts A7, B7, C7, D7 and E7 which are coupled through line 76 and line 77 to the negative voltage bus 67. Thus, the lamps L' will be energized when the associated coding relays are energized.

To test the order identifying lamps L', normally-closed contacts A6, B6, C6, D6 and E6 are connected between the lamps L' and lines 85 and 77 leading to the test bus 78.

As previously indicated, the control relay F will be automatically reset or de-energized whenever the field contacts 8 return to normal. The circuit illustrated provides an optional manual reset feature for each control circuit 6 which holds the control relay F energized until operation of a reset switch 88. To provide for such a manual reset, a set of normally-open contacts F4 are connected between a common manual reset bus 86 and an isolating diode 87 extending to the juncture of contacts F1 and the coil of relay F. The manual reset bus 86 extends to a connecting terminal MR to which one terminal of the manual pushbutton switch 88 is connected when manual reset operation is desired. The other terminal thereof is connected to the connecting terminal P of the positive voltage bus 40. The contacts F4 establish a holding circuit for control relay F which is independent of the field contacts 8. This holding circuit is broken by momentary opening of the manual reset switch 88.

The counter circuit 29b which controls the order conditioning contact network 29a will now be described. The input to the counter circuit 29b is a line 90 extending between the pulse bus 27 and an isolating diode 92. The diode 92 is connected between a set of normally-closed contacts F'3 of a pulse shaping relay F'. The coil of relay F' is connected between the juncture of the isolating diode 92 and the contacts F'3, and a resistor 93 connected to a line 94 connected to the negative voltage bus 67. The relay F' is a slow operating relay so that the contacts F'3 remain open a short time interval after a pulse appears on the pulse bus 27. The relay F' effectively controls the width of the pulse fed to the input of the counter circuit 29b which may be longer than desired for the proper operation of the counter circuit 29. The counter circuit 29b to be described is one where a continuous voltage will continuously advance the counter circuit 29b so that an abnormally long pulse length must be avoided to prevent a double count.

The contacts F'3 are connected to a set of normal-

ly-closed contacts A'1 of the counter relay A'. The coil of counter relay A' is connected through a resistor 94 to a contact network 95 comprising four sections connected in series. The first section includes three branches in parallel, the first of which comprises a set of normally-closed contacts B'4, the second of which comprises a series circuit of normally-closed contacts C'6, D'6 and E'7, and the third of which comprises normally-open contacts B'5. The contacts B'4 and B'5 are a make-after-break set of contacts so that the first branch is opened only when either the relay C', D' or E' is energized and the state of the B' relay is changed from a de-energized to an energized condition. Since the energized state of relay C' represents the No. 4, it is apparent that the relay A' remains energized for the counts of 2 and 3.

The second section of the contact network comprises make-after-break sets of contacts comprising normally-closed contacts C'5 in parallel with normally-open contacts C'4. The third section of the network comprises make-after-break sets of contacts comprising normally-closed contacts D'5 in parallel with the normally-open contacts D'4. The fourth section of the network comprises make-after-break sets of contacts comprising normally-closed contacts E'3 and E'5 in parallel with normally-open contacts E'4 and E'6.

The coil of relay B' is connected to the right hand end of the first section of the network through a resistor 95. The coil of relay C' is connected through a resistor 96 to the right hand end of the second section of the contact network. The coil of relay D' is connected through a resistor 97 to the right hand end of the third section of the contact network, and the coil of relay E' is connected through a resistor 98 to the right hand end of the fourth section of the contact network. The right hand end of the fourth section of the contact network is connected through a line 99 to the reset bus 32 and the order reset switch 30 to the negative voltage bus 67.

The first positive pulse received by the input to the counter circuit after reset thereof (to the count of one) will energize the relay A' through the various initially closed sections of the network leading to the output line 99. The relay A' will seal-in through holding contacts A'2 connected to a line 103 leading to the positive voltage bus 40. Access of input pulses to the relays B', C', D' and E' are through a line 100 extending through normally-open contacts A'6. It is apparent, therefore, that the relay A' must be energized in order to initiate energization of any of the other relays. The contacts A'6 are connected directly to the coil of relay B' through normally-closed contacts B'1. It is apparent that the second pulse fed to the input of the counter circuit representing the count 3 will pass through the then closed contacts A'6 to energize the relay B'. Relay B' will seal-in through normally-open holding contacts B'2 connected to a common line 102, in turn connected to the line 103 extending to the positive bus 40. As previously indicated, the relay A' is energized for the count of 2 and 3. This condition is obtained by the contacts C'6, D'6 and E'7 in the first section of the contact network referred to.

When the B' relay is energized, a set of normally-open contacts B'3 connected to the contacts A'6 close to couple the input circuit to a set of normally-closed contacts C'1 to the coil of relay C'. When the third pulse is received (count of 4) relay C' is energized and a set of contacts C'2 establishes a holding circuit for the relay C' between the bottom end of the latter coil and the common line 102. The energization of the relay C' will break the energization circuits of the counter relays A' and B' upon the opening of the contacts C'5 in the second section of the contact network. Since the contacts C'5 and the contacts C'4 in parallel therewith are make-after-break contacts, a circuit through the second section of the network is immediately established after the circuit breaking function just described. The relays B' and A' will not

re-energize because of the previous opening of contacts A'2, A'6 and B'2.

A set of normally-open contacts C'3 are connected between the contacts B'3 and normally-closed contacts D'1 connected to the coil of the relay D'. A set of holding contacts D'2 are connected between the bottom end of the coil of relay D' and the line 102 leading to the positive voltage bus 40. The sequence of operation of the relay D' (as well as the other relays) above the count 4 follows the pattern shown in the chart given above and will not be further described.

A set of normally-open contacts D'3 are connected between the contacts C'3 and normally-closed contacts E'1 connected to the coil of relay E'. A set of normally-open holding contacts E'2 are connected between the bottom end of the coil of relay E' and the line 102 extending to the positive voltage bus.

Operation of the order reset switch will momentarily de-energize all of the counter relays A'-E' to reset the counter to a count of No. 1 represented by the de-energization of all the counter relays.

As previously indicated, any pulses appearing on the pulse bus 27 are operative to effect energization of a horn H. To this end, the bus 27 is connected through a set of normally-closed contacts H1 of a horn relay H'. The contacts H'1 are connected to the bottom end of the coil of the horn relay H' which in turn is connected through a resistor 120 to the negative voltage bus 67. A positive pulse appearing on the bus 67 will, therefore, energize the horn relay H'. A holding circuit is established through a set of horn contacts H'2 connected to the positive voltage bus 40 through the aforesaid normally-closed manual acknowledgement pushbutton switch 38.

The horn H is connected between the negative bus 67 and a series of normally-open contacts H'3 through H'6 in turn connected to the positive voltage bus 40. A plurality of horn relay contacts H'3 through H'6 are necessary to avoid excessive sparking currents when these contacts open. The horn H takes an appreciable current which creates this problem.

Sequence Recording System of FIGS. 6 and 7

The recording systems of FIGS. 6 and 7 have many components in common with the annunciator system of FIGS. 4 and 5 just described and these components have been similarly numbered and will not be described in detail. Thus, there is a control circuit 6 associated with each variable whose condition is identified by the position of normally-open field contacts 8, and each control circuit includes an order indicating control means 20' comprising coding relays A-E arranged in a circuit substantially identical to that shown in FIG. 4 except for the addition of a set of normally-closed reset contacts G4 in series with the common line 68 in the holding circuit of the coding relays extending to the negative voltage bus 67 instead of a reset bus associated with a manual code reset switch 30 as in the embodiment of FIG. 4. The recording system now being described has an automatic reset circuit to be described and so the manual reset switch 30 and the associated bus is not here required. Also, the coding relays have normally-open contacts A6, B6, C6, D6 and E6 in an order number read-out circuit 130 instead of a light circuit as in the embodiment of FIGS. 4 and 5. The normally-closed contacts G4 are contacts of a reset relay G whose function will be described in more detail hereafter. Also, for reasons to be described, the control relay F is converted to a slow release relay by means of a resistor 132 and a capacitor 134 placed in parallel with the coil of the relay.

The coding relays A-E are conditioned to operate in a binary code pattern indicating the order identifying number involved by a common order number conditioning network 29a substantially identical to that previously

described, which network is controlled by a counter circuit 29b substantially identical to that previously described except for the addition of a fifth section 135 to the contact network therein which is tied in with the automatic resetting of the counter to be described below.

The recording means 12 may be any one of a number of types of recorders, such as a print strip recorder for printing on a strip shown in FIG. 3. One such recorder is model 400C of the Computer Measurements Corp. of N. Hollywood, California. The recording means illustrated has a print solenoid 137 which when energized effects a print-out operation of the various types of information fed to the recorder. The recording means also has a switch 139 which is normally-closed when the printer is not printing and which is opened during a printing operation.

The print strip recorder has a number of inputs which are adapted to receive binary coded information which is converted by the recorder into digital decimal form for print-out. One of these inputs 141 extends from a digital clock 143 which feeds time information into the recorder. Another input 142 is from a code conversion matrix 144 having a series of input lines 144a, 144b, 144c, 144d and 144e connected respectively to read-in buses 146-1, 146-2, 146-4, 146-8 and 146-16 extending respectively from circuits associated with the aforesaid order identifying contacts A6, B6, C6, D6 and E6 in the order number read-out circuit 130 associated with the coding relays A-E of the various control circuits 6. The latter contacts are respectively connected through isolating diodes 148 to the read-in buses 146-1, 146-2, etc. The conversion matrix 144 is needed only to convert the binary signals set up in the various order number read-out circuits 130 into the particular code which the recording means 12 is designed to receive. If the recording means is designed to operate with the straight binary code, the conversion matrix 144 is obviously not needed.

Two other inputs 154 and 156 are provided to the recording means which effect the recording of the tens and units digits of a number identifying the particular variable involved.

The scanning means 14 is shown as a multi-level stepping switch 160. The various levels of the stepping switch perform numerous functions, among them being the scanning of the order number read-out circuits 130 and the termination of a blind scanning operation when a control circuit is scanned associated with a newly abnormal or return to normal variable, the operation of the recording means, the generation of coded signals identifying the variable whose data is being scanned and printed, and the control of the automatic reset of the coding and counter relays. The stepping switch has six levels 160-1, 160-2, 160-3, 160-4, 160-5 and 160-6 each having a stationary home contact 162 and other stationary contacts 164 respectively associated with the different variables being monitored by the system, and a wiper 161 which is advanced in position in a forward direction when a stepping solenoid ST is pulsed once. The first and second levels 160-1 and 160-2 of the stepping switch system control the coded input 154 to the recording means 12 which control the units digit of the variable identifying number which is printed. The third level 160-3 of the stepping switch controls the coded input 156 to the recording means which controls the tens digits of the variable identifying number which is printed. It is assumed in the instant case that the system is capable of monitoring up to 99 points, although any larger number of variables could be handled by adding additional stepping switches in tandem.

The corresponding stationary contacts 164 of the levels 160-1 and 160-2 of the stepping switch are connected to associated output lines 167 so as to provide the proper code for printing the units digit of the numbers identifying the variables which are being scanned. Isolating rectifiers 168 are connected between pairs of the stationary

contacts to isolate the contacts of each pair from one another when the wiper involved is on one of the contacts and to connect the contacts to a common line when the wiper is on the other of the contacts.

The contacts of the third level 160-3 of the stepping switch are connected to associated output lines 169 extending to input 156 of the recording means 12 to provide the proper tens digits of the numbers identifying the scanned variables. The wipers 161 of the levels 160-1, 160-2 and 160-3 are all connected to a common feed line 165 leading to the positive voltage bus 40.

The fourth level 160-4 of the stepping switch, to be hereinafter sometimes referred to as a read level, has a wiper 161 connected through normally-closed contacts SR1 and SR2 of a slow release relay SR to the positive line 165. The coil of the slow release relay SR has one end connected to a line 170 extending to the negative voltage bus 67 and the other end connected through an isolating diode 171 to the wiper 161 of the sixth level 160-6 of the stepping switch, sometimes to be referred to as the start-stop level. A resistor 172 and a capacitor 173 are connected in parallel with the coil to relay SR to slow up the action thereof. As will appear, the slow release relay becomes de-energized soon after a variable initially becomes abnormal or a variable returns to normal and the control circuit involved is scanned.

The home contact 162 of the read level 160-4, as are the home contacts of all the other levels except level 160-6, is not connected to any external circuit. The other stationary contacts 164 of the read level are connected through lines 174 respectively extending to the various order number read-out circuit 130 of the control circuits 6. When a read line is pulsed through the associated wiper 161 in the manner to be described, the binary code set up in the read-out circuit being scanned is read into the conversion matrix 144.

The fifth level 160-5 of the stepping switch is to be sometimes referred to as the return-reset level. Its stationary contacts 164 are connected through respective lines 177 leading to normally-closed contacts G3 of the reset relays G in the various control circuits 6. Each set of contacts G3 connect with one end of the coil of the associated reset relay G. The other end of the coil is coupled through normally-open contacts F4 to the line 68 extending to the negative voltage bus 67. As will appear, a pulse will appear on a return-reset line 177 to effect energization of the reset relay G at the termination of a recording operation which occurs if the variable associated with the control circuit involved has just become abnormal or has returned to normal. The reset relay G is locked-in through a set of normally-open holding contacts G2 connected between the former end of the coil of reset relay G and the line 65 connected to line 66 extending to the positive voltage bus 40. Normally-open holding contacts G1 are connected between the upper end of the coil of relay G and a resistor 180. Normally-closed contacts F5 are connected between line 177 and the juncture of contacts G1 and the resistor 180. The contacts F5, as will appear, are for the purpose of de-energizing the reset relay G after a print-out operation of data on a previously abnormal variable which has just returned to normal. In such a case, a positive pulse appearing on the associated return-reset line 177 will be applied to the upper terminal of the coil of reset relay G to effectively short circuit the same to break the holding circuit of the reset relay G. The resistor 184 provided between the juncture of contacts G1 and F5 and the line 68 extending to the negative voltage bus 67 limits the current flow when the coil of the reset relay G is short circuited.

The wiper 161 of the reset-return level 160-5 is connected through a set of normally-closed contacts SR3 and a line 182 to the aforesaid normally-closed switch 139 in the recorder 12. The switch 139, in turn, is connected to the positive voltage bus 40. When the wiper

161 of stepping switch level 160-5 rests upon any of the stationary contacts 164 to which the return-reset lines 177 extend, de-energization of the slow release relay will result in the coupling of a positive potential to the return reset line 177 involved to effect the energization (or de-energization) of the associated reset relay G as previously explained. It should be remembered that the switch 139 is opened only when the recorder 12 is in the process of printing a line of information and, therefore, the positive voltage referred to will be fed to the return-reset line 177 involved immediately after a printing operation is completed.

The sixth level 160-6 of the stepping switch, sometimes referred to as a start-stop level, has a home contact 162 which is connected through a start bus 186 in common with all of the control circuits 6 to individual branch lines 187 leading to a contact network 191 in each control circuit 6 including parallel contact branches, one of which comprises normally-open contacts F6 in series with normally-closed contacts G7 and the other of which comprises normally-closed contacts F7 in series with normally-open contacts G8. The branch lines are connected by a line 192 to line 66 leading to the positive voltage bus 40. The start bus 186 will be coupled to the positive voltage bus 40 through contacts F6 and G7 when a variable initially becomes abnormal and through contacts F7 and G8 when the variable initially returns to normal.

Each of the stationary contacts 164 associated with the start-stop level 160-6 is connected to stop line 202 leading to parallel branches of one contact network 191 coupled through lines 192 and 66 to the positive voltage bus 40. One of the branches comprises normally-closed contacts G5 in series with normally-closed contacts F7 and the other branch comprises normally-open contacts G6 and normally-open contacts F6. The former branch is open when the associated variable is abnormal or when the variable returns to normal and before printout of data thereon. The latter branch is open when a variable is normal or when the variable is abnormal and printout of data thereon is completed. As will appear, the presence of a positive voltage on the start bus 186 will start a scanning operation which continues as long as the stop line 202 extending to the stationary contact 164 on which the wiper 161 of level 160-6 rests at any instant has positive potential thereon. When the positive potential on the stop line 202 is removed, the scanning operation ceases. To this end, the wiper 161 of the start-stop level 160-6, as previously indicated, is connected through an isolating diode 171 to the slow release relay SR. The wiper is also connected through a set of interrupt contacts ST1 of the stepping solenoid ST to one end of the coil of the solenoid ST. The other end of the solenoid is connected to the line 170 extending to the negative voltage bus 67. When the stepping solenoid coil is energized, its interrupt contacts ST1 will open to thereby de-energize the coil to effect the advancement of the wipers of the various levels to the next stationary contact 164 or to the home contact 161 when the wiper starts from the last of the stationary contacts 164. Such a scanning operation ceases whenever the solenoid ST is de-energized.

A branch line 197 connecting with a resistor 196 and a capacitor 198 extends from the negative line 170. The capacitor 198 is connected through a set of normally-open contacts SR5 to the positive line 165 and through normally-closed contacts SR4 and a line 199 to the print solenoid 137 of the recorder 12 in turn connected to the negative bus 67. It is thus apparent that, when the slow release relay SR becomes energized, capacitor 198 will be charged positively through contacts SR5, and when the slow release relay SR becomes de-energized the voltage on the capacitor 198 will discharge through normally-closed contacts SR4 and a line 199 through the print solenoid 137 to effect a printing operation. Part of the discharge current flows through an inhibit line 199' extending to the digital clock 143 to prevent any change in the movement of the

time indicating mechanism therein during the printing operation, as is conventional in digital clocks used in recording systems.

As previously indicated, the recording system of FIGS. 6 and 7 provides for automatic reset of the coding relays A through E and the counter relays A' through E' whenever the time interval between successive abnormal variables is greater than a predetermined minimum time interval which, for example, could be in the neighborhood of 1 to 2 seconds or more. Variables which become abnormal a time interval apart greater than this minimum time interval may be normally so unrelated that it becomes unimportant to relate the order of the later abnormal variable to the immediately precedent abnormal variable. The later of these variables may be the beginning of a new related series of abnormal variables which should be distinguished from the precedent series. To obtain this result, a reset relay G' is associated with the counter circuit 29b. This relay has a coil with one end connected by lines 207 and 209 to the negative voltage bus 67 and the other end connected through an isolating diode 234 to the pulse bus 27 leading to the various control circuits which receive a pulse when the associated variable initially goes abnormal. A capacitor 211 and a resistor 213 are connected in parallel with the relay G' and are designed to maintain energization of the relay G' provided the pulses on the pulse line are spaced less than the aforesaid minimum (1 to 2 seconds, etc.) time interval.

A relay H' is associated with the G' relay and the coil thereof has one end connected to the negative line 207 and the other end connected through a set of normally-open contacts G'3 to lines 102 and 103 to the positive voltage bus 40. Energization of the reset relay G' will, therefore, result in the energization of the H' relay. These relays have contacts in a fifth section of the contact network of the counter circuit 29b following the fourth section thereof. The fifth section has one branch with normally-closed contacts H'1 and H'2 in series and another branch with normally-open contacts G'1 and G'2 in series. As long as the relay G' remains energized, there will be continuity between the fourth section of the aforesaid contact network and line 209 extending to the negative voltage bus 67, so that the counter circuit works in its normal manner. However, when the time interval between successive pulses on the pulse bus 27 exceeds said minimum interval, relay G' will become de-energized along with the relay H'. The resultant opening of normally-open contacts G'1 and G'2 will thereby de-energize the counter circuit to reset the same to 1. The normally-closed contacts H'1 and H'2 will not reclose until after contacts G'1 and G'2 open. Reclosure of the contacts H'1 and H'2 will prepare the counter circuit for a new cycle of operation.

A complete review of the operation of the recording system is as follows:

When the first variable of a series of variables becomes abnormal, the associated coding relays A through E, conditioned to be energized in a binary code pattern indicating the No. 1 by the coding buses 30-1 through 30-16, will be so energized upon the closure of the associated field contacts 8 and lock-in through holding contacts A1-A3, B1-B3 . . . or E1-E3 in a manner previously described. The associated control relay F will also become energized upon closure of any of the contacts, A5, B5 . . . or E5 and lock-in through contacts F1 in series with the field contacts. The control relay F is made a slow release relay to ensure that momentary alarms are responded to by the system. Initial closure of any of the contacts A5, B5 . . . or E5 followed by opening of contacts F3 pulses the pulse bus 27 to advance the counter circuit 29b one unit to condition the remaining unoperated coding relays to be energized in a pattern indicating the No. 2. Contacts F6 in the associated contact network 191 close to couple the positive bus to the start bus 186 through lines 66 and 192, contacts F6 and contacts G7 leading to the start bus. The start bus, as above indicated, is connected

to the home contact 162 of the sixth stepping switch level 160-6 of the stepping switch 160. The wiper 161 thereof will have a positive potential applied thereto which energizes the stepping solenoid ST through interrupt contacts ST1 and the slow release relay SR through the isolating diode 171. When interrupt contacts ST1 open, this will advance the wipers 161 of the various levels 160-1 through 160-6 to the first stationary contacts 164.

The stop line 202 connected to the last mentioned stationary contact extends to the contact network 191 of the control circuit of a given variable. If this variable is not an abnormal variable, the positive voltage of bus 40 will be applied through associated contacts G5 and F7 to the associated stop line 202. In such case, the relay SR and the solenoid ST will be energized to continue a stepping operation of the stepping switch wipers. The relay SR is made slow to release so that its normally-closed contacts will remain open during the movement of the wiper of the sixth level 160-6 to the next contact. When the wiper 161 reaches a stationary contact 164 which is de-energized, this will indicate that the variable of the associated control circuit is abnormal indicated by the opened condition of the associated contacts F7 which de-couple the positive voltage bus from the associated stop line 202. The stepping switch solenoid ST (as well as the slow release relay SR) will then be de-energized stopping the scanning operation. As the relay SR becomes de-energized, its normally-open contacts SR5 will open and its normally-closed contacts SR4 will close to discharge the capacitor 198 through the line 199 extending to the print solenoid 137 of the recorder 12 to effect a recording operation. Simultaneously, the closure of normally-closed contacts SR1 and SR2 will feed the positive voltage on line 165 to the wiper 161 of the read level 160-4 connected through a stationary contact 164 to the read line 174 extending to the order number output circuit 130 of the control circuit involved. The code output lines of the circuit 130 extending from any of the then closed contacts A6 through E6 will send the proper code to the conversion matrix 144 which feeds a coded signal to recorder input 142 to effect the print-out of the order identifying number corresponding to this code. The coded inputs 154 and 156 extending from the first three stepping switch levels 160-1 through 160-3 of the stepping switch will cause the recorder 12 to print the proper variable identifying number. The time of the digital clock fed to the recorder input 141 will likewise be printed.

When the recorder is in the process of printing, the normally-closed switch 139 thereof will be open until completion of the print operation when the switch will reclose to send a positive pulse down the line 182 and through the then closed contacts SR3 to the wiper 161 of the return-reset level 160-5 of the stepping switch. This will feed a pulse through the stationary contact 164 on which the wiper then rests which pulse is coupled through the associated return-reset line 177 to the normally-closed contacts G3 of the associated control circuit 6. As previously indicated, this will result in the energization of the reset relay G and the establishment of a holding circuit therefor through holding contacts G2 and G1. Energization of the reset relay G will open the reset contacts G4 of the associated control circuit to reset the associated coding relays A through E to a de-energized state indicating the No. 0. As soon as the reset relay G is energized, its contacts G6 will close coupling the potential of the positive bus 40 to the stop line 187 associated with the stationary contact 164 of the stepping switch level 160-6 on which the wiper 161 then rests. This will energize the solenoid ST (and relay SR) to initiate another scanning operation similar to the one just described. Upon the re-energization of the SR relay, contacts SR4 thereof will open and the contacts SR5 will close coupling the potential of positive bus 40 to the capacitor 198 to recharge the same. Also, contacts SR1, SR2 and SR3 will open to disconnect the positive volt-

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age bus 40 from the wipers 161 of the read and return-reset levels 160-4 and 160-5 of the stepping switch. When the wiper 161 of the switch level 160-6 reaches another stationary contact 164 which is de-energized, the scanning will again stop to repeat a printing operation just described.

Any unused stationary terminals 164 of the start-stop switch level 160-6 are connected to the positive voltage bus 40 so as to continue a stepping operation when the wiper 161 reaches them. When the wiper reaches the home contact 162, the absence of a positive voltage thereat will stop the scanning operation, the absence of such a voltage indicating that all abnormal (and return to normal) variable information has been recorded.

As previously indicated, as long as a given variable remains abnormal, the associated reset relay G will remain energized. Upon the return to normal of a given variable, the positive voltage bus 40 will become de-coupled from the control relay F of the associated control circuit to de-energize the control relay F involved. This opens the normally-open contacts F6 in the associated contact network 191 to de-energize the associated stop line 202, and closes normally-closed contacts F7 thereof to energize the start bus 186. It is thus apparent that the stepping switch will then scan for the return to normal variable (or other abnormal variable not yet printed out). When the stop line associated with the control circuit of the variable just returned to normal is reached, the wiper 161 of the switch level 160-6 will be de-energized so as to de-energize the stepping solenoid ST to terminate a scanning operation. Another print-out operation will then occur similar to that previously described, except that the associated order number output circuit 130 of the associated control circuit 6 will indicate the No. 0 which is accordingly printed on the record strip to indicate that a return to normal variable is involved.

After print-out and reclosure of the recorder switch 139, the resultant positive pulse appearing on line 182 is coupled through contacts SR3 associated with the return-reset level 160-5, the associated wiper 161 and the return line 177 leading to the then normally-closed contacts F5 and normally-open contacts G1 in the associated control circuit 6. A positive voltage is thereby fed to the upper end of the reset relay G which shorts out the relay coil and de-energizes the same. The holding circuit for reset relay G including contacts G1 and G2 will thereby be broken to maintain the reset relay G de-energized.

It should be understood that numerous modifications may be made in the preferred embodiments of the invention above described without deviating from the broader aspects of the invention.

What I claim as new and desire to protect by Letters Patent of the United States is:

1. A visual sequence annunciator system for indicating the order in which a group of variables reach a given monitored condition comprising: variable responsive means for each variable which means has a first condition when the associated variable reaches a given value to be monitored and a normal condition when the variable is in a normal or unmonitored condition, visual order indicating means for each variable having a number of different operating states corresponding with various order numbers and responsive to the operation of the associated variable responsive means to said first condition by operating in the state in which it has been conditioned to operate, visual alarm indicating means for each variable responsive to the first condition of said variable responsive means by providing an alarm indication, counter and order conditioning means in common with all the variables and responsive to the change in condition of any variable responsive means from said normal to said first condition by increasing the count accumulated in the counter and order conditioning means by one

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unit and conditioning the still unoperated visual order indicating means to operate in the state corresponding to the count accumulated in the counter and order conditioning means, and manually operable reset means for resetting said counter and order conditioning means and said visual order indicating control means each time it is operated for conditioning the still unoperated visual order indicating means to indicate the order in which a new series of variables reach their monitored values and for removing the order indication on the visual order indicating means without disturbing the indication on the associated visual alarm indication means.

2. Means for indicating the order in which a group of variables reach a given monitored condition comprising: a control circuit for each variable comprising variable responsive means which means has a first condition when the associated variable reaches a given value to be monitored, and order indicating means having a number of different operating states corresponding with various order numbers and responsive to the operation of the associated variable responsive means to said first condition by locking in an operating state to which it has been operated; counter and order control means in common with all the variables for operating said order indicating means of a control circuit whose variable responsive means has just been operated to said first condition to an operating state corresponding to the count accumulated in the counter and order control means and responsive to the operation of any variable responsive means to said first condition by increasing the count accumulated by one unit; and manual reset means for resetting said counter and order control means to the count of one, to condition the still unoperated order indicating means to indicate the order in which a new series of variables reach their monitored values, and for cancelling the order indication in the previously operated order indicating means until the associated variables return to normal and then become abnormal again.

3. A sequential indicating system for indicating the order in which variables go abnormal, said system comprising: variable responsive means for each variable which indicates the condition of the associated variable, common counter means responsive to operation of any of the variable responsive means to an abnormal variable indicating condition for increasing the count accumulated therein by one unit, order indicating means for each variable having a number of different operating states corresponding with various possible order numbers, conditioning means responsive to the count accumulated in said common counter means for conditioning the order indicating control means to operate in the state corresponding to the count in said counter means, means responsive to operation of each variable responsive means to an abnormal variable indicating condition for operating the associated order indicating control means in the operating state in which it is conditioned to operate by said conditioning means, visual order indicating light means for each variable responsive to said order indicating control means for digitally indicating the number corresponding to the order in which the associated variable goes abnormal, means for rendering each of the order indicating control means non-responsive to said conditioning means following operation thereof to one of said operating states, and manually operable reset means for resetting said counter means and said order indicating control means each time it is operated for preparing the annunciator system to indicate the order in which a new series of abnormal variables go abnormal, and for cancelling the order indication on all of said visual order indicating means until the associated variables return to normal and go abnormal again.

4. A sequential recording system for indicating the order in which a group of variables reach a given monitored condition comprising: a control circuit for each variable comprising variable responsive means having a

first condition when the associated variable reaches a given value to be monitored and a normal condition when the variable is in a normal or unmonitored condition, condition sensing means having a first condition when the associated variable is abnormal and data thereon has not been recorded and a second condition, and order indicating means having a number of different operating states corresponding with various order numbers and responsive means to said first condition of the associated variable responsive means by locking in an operating state to which it has been operated; a common counter and order control means for operating said order indicating means of a control circuit whose variable responsive means has just been operated to said first condition to an operating state corresponding to the count accumulated in the counter and order control means and responsive to the change in condition of any variable responsive means from said normal to said first condition by increasing the count accumulated in the counter and order control means by one unit; recording means selectively responsive to said first condition of the condition sensing means in said control circuits for recording the number indicated by the order indicating means associated with the condition sensing means responded to, and information identifying the variable involved; and means responsive to completion of a recording operation by said recording means for changing a first condition of the condition sensing means involved to said second condition.

5. A sequential recording system for indicating the order in which a group of variables reach a given monitored condition comprising: a control circuit for each variable comprising variable responsive means having a first condition when the associated variable reaches a given value to be monitored and a normal condition when the variable is in a normal or unmonitored condition, condition sensing means having a first condition when the associated variable is abnormal and data thereon has not been recorded and a second condition, and order indicating means having a number of different operating states corresponding with various order numbers and responsive means to said first condition of the associated variable responsive means by locking in an operating state to which it has been operated; a common counter and order control means for operating said order indicating means of a control circuit whose variable responsive means has just been operated to said first condition to an operating state corresponding to the counter accumulated in the counter and order control means and responsive to the change in condition of any variable responsive means from said normal to said first condition by increasing the count accumulated in the counter and order control means by one unit; automatic resetting means for resetting said counter and order control means when the time interval between the occurrence of successive abnormal variables exceeds a predetermined interval, recording means selectively responsive to said first condition of the condition sensing means in said control circuits for recording the number indicated by the order indicating means associated with the condition sensing means responded to, and information identifying the variable involved, and means responsive to completion of a recording operation by said recording means for changing a first condition of the condition sensing means involved to said second condition thereof.

6. A sequential recording system for indicating the order in which a group of variables reach a given monitored condition comprising: a control circuit for each variable comprising variable responsive means having a first condition when the associated variable reaches a given value to be monitored and a normal condition when the variable is in a normal or unmonitored condition, condition sensing means having a first condition when the associated variable is abnormal and data thereon has not been recorded, a second condition when the associated variable is abnormal and data thereon has been recorded,

a third condition when the associated variable has returned to normal and data thereon has not been recorded and a fourth normal condition, and order indicating means having a number of different operating states corresponding with various order numbers and responsive means to said first condition of the associated variable responsive means by locking in an operating state to which it has been operated; a common counter and order control means for operating said order indicating means of a control circuit whose variable responsive means has just been operated to said first condition to an operating state corresponding to the count accumulated in the counter and order control means and responsive to the change in condition of any variable responsive means from said normal to said first condition by increasing the count accumulated in the counter and order control means therein by one unit; recording means selectively responsive to said first and third conditions of the condition sensing means in said control circuits for recording the number indicated by the order indicating means associated with the condition sensing means responded to, and information identifying the variable involved; and means responsive to completion of a recording operation by said recording means for changing a first condition of the condition sensing means involved to said second condition, and for changing a third condition thereof to said fourth condition.

7. A sequential recording system for indicating the order in which a group of variables reach a given monitored condition comprising: a control circuit for each variable comprising variable responsive means having a first condition when the associated variable reaches a given value to be monitored and a normal condition when the variable is in a normal or unmonitored condition, condition sensing means having a first condition when the associated variable is abnormal and data thereon has not been recorded, a second condition when the associated variable is abnormal and data thereon has been recorded, a third condition when the associated variable has returned to normal and data thereon has not been recorded and a fourth normal condition, reset means for resetting the associated order indicating means to a zero indicating state, and order indicating means having a number of different operating states corresponding with various order numbers and responsive means to said first condition of the associated variable responsive means by locking in an operating state to which it has been operated; a common counter and order control means for operating said order indicating means of a control circuit whose variable responsive means has just been operated to said first connection to an operating state corresponding to the count accumulated in the counter and order control means responsive to the change in condition of any variable responsive means from said normal to said first condition by increasing the count accumulated in the counter and order control means by one unit; recording means selectively responsive to said first and third conditions of the condition sensing means in said control circuits for recording the number indicated by the order indicating means associated with the condition sensing means responded to, and information identifying the variable involved; and means responsive to completion of a recording operation by said recording means for changing a first condition of the condition sensing means involved to said second condition, and, in such case, to also operate said reset means of the control circuit involved to reset the associated order indicating means, and for changing a third condition thereof to said fourth condition.

8. A system responsive to the order in which a number of variables go abnormal, said system comprising: a control circuit for each variable comprising variable responsive means having normal and abnormal conditions when the associated variable is respectively normal and abnormal, a number of binary code indicating means arranged to indicate in a binary code pattern at least three

different order identifying numbers, means responsive to the abnormal condition of the associated variable responsive means for holding the initial binary code pattern set in said code indicating means, and pulse generating means responsive to operation of the associated variable responsive means to said abnormal condition for generating a count pulse; pulse counter means in common with all of said control circuits and having a common input extending to the output of the pulse generating means of said control circuits, said counter means being responsive to a pulse received therefrom by increasing the count accumulated therein by one unit; order control means controlled by said counter means and including a series of code lines which provide signals in said binary code pattern to indicate the count accumulated in the counter means and which are connected to said code indicating means in each of said control circuits for conditioning the same to operate in the same pattern when the associated variable responsive means is operated to its abnormal condition; and means responsive to the code indicating means of each control circuit associated with an abnormal variable.

9. A system responsive to the order in which a number of variables go abnormal, said system comprising: a control circuit for each variable comprising variable responsive means having normal and abnormal conditions when the associated variable is respectively normal and abnormal, a number of binary code indicating means arranged to indicate in a binary code pattern various possible order identifying numbers, means responsive to the abnormal condition of the associated variable responsive means for holding the initial binary code pattern set in said code indicating means until the same are reset, and pulse generating means responsive to operation of the associated variable responsive means to said abnormal condition for generating a count pulse; pulse counter means in common with all of said control circuits and having a common input extending to the output of the pulse generating means of said control circuits, said counter means being responsive to a pulse received therefrom by increasing the count accumulated therein by one unit; order control means controlled by said counter means and including a series of code lines which provide signals in said binary code pattern to indicate the count accumulated in the counter means and which are connected to said code indicating means in each of said control circuits for conditioning the same to operate in the same pattern when the associated variable responsive means is operated to its abnormal condition; reset means for resetting the binary code indicating means of a control circuit whose variable responsive means has been operated to an abnormal condition and for holding the same in the reset condition until the associated variable responsive means returns to the normal condition and is operated to its abnormal condition again, and for resetting said counter means to condition the system to indicate the order in which a new series of abnormal variables go abnormal; and means responsive to the code indicating means of each control circuit associated with an abnormal variable.

10. A sequential annunciator system which indicates the order in which a number of variables go abnormal, said system comprising: a control circuit for each variable including variable responsive means having normal and abnormal conditions when the associated variable is respectively normal and abnormal, visual order indicating means, control means for controlling said visual order indicating means and comprising a number of binary code indicating means arranged to be energized in a binary code pattern which indicates various possible order identifying numbers and wherein the de-energized conditions of all the code indicating means represents the number 0, means for holding the initial energized binary code pattern in said code indicating means until the same are reset, means responsive to said code indicating means for de-energizing associated visual order indicating means when the code indicating means indicates the number 0 and for energizing the same to indicate a number which represents the order in which the associated variable went abnormal in accordance with the energized binary code pattern set up in the binary code indicating means, and pulse generating means responsive to operation of the associated variable responsive means to said abnormal condition for generating a count pulse; resettable pulse counter means in common with all of said control circuits and having a common input extending to the output of the pulse generating means of said control circuits and responsive to a pulse received therefrom by increasing the count accumulated therein by one unit, the reset condition of said pulse counter means constituting the number 1; order conditioning means controlled by said counter means and including a series of code lines which are energized in said binary code pattern to indicate the count accumulated in the counter means and which are connected to said code indicating means in each of said control circuits for conditioning the same to be energized in the same pattern when the associated variable responsive means is operated to its abnormal condition; and reset means for resetting said binary code indicating means of each control circuit to zero and for holding the same in this condition until the associated variable returns to normal and becomes abnormal again, and for resetting said counter means to the number 1 to condition the system to indicate the order in which a new series of abnormal variables go abnormal.

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