April 10, 1962 R. F. BÉGUIN 3,029,421

ANNUNCIATOR SYSTEM

Filed May 15, 1958 4 Sheets-Sheet 1

Fig. 1.

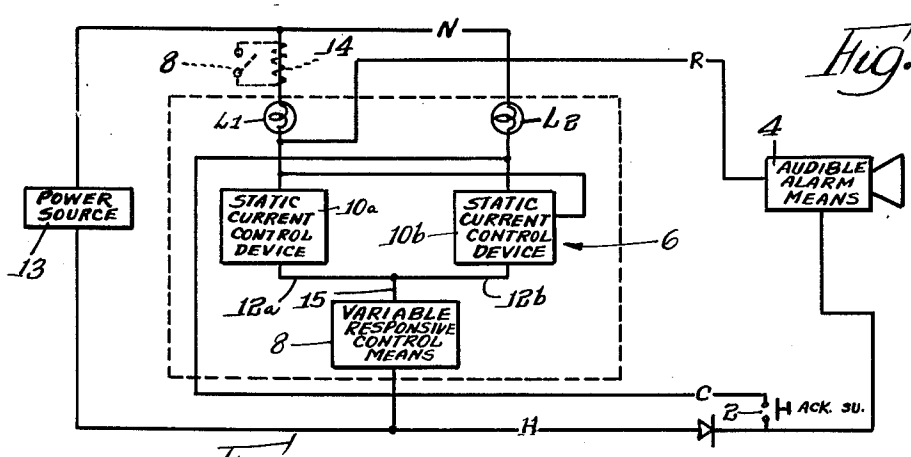


Fig. 3

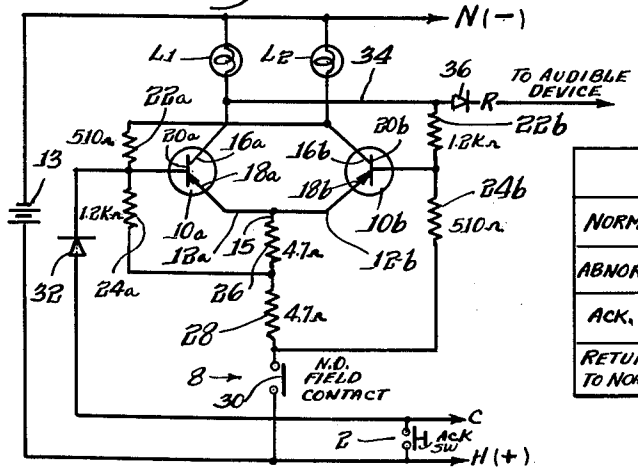


Fig. 2.

	CONTROL DEVICE 10a	CONTROL DEVICE 10b	L_1	L_2
NORMAL	NON COND.	NON COND.	OFF	OFF
ABNORMAL	COND.	NON COND.	ON	OFF
ACK.	NON COND.	COND.	OFF	ON
RETURN TO NORMAL	NON COND.	NON COND.	OFF	OFF

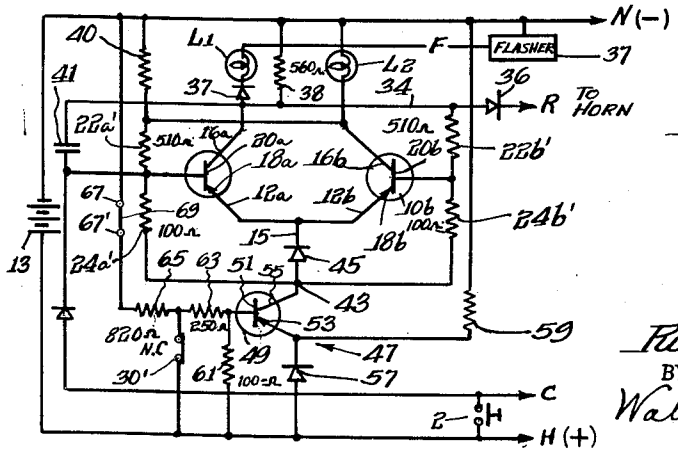


Fig. 4.

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ANNUNCIATOR SYSTEM

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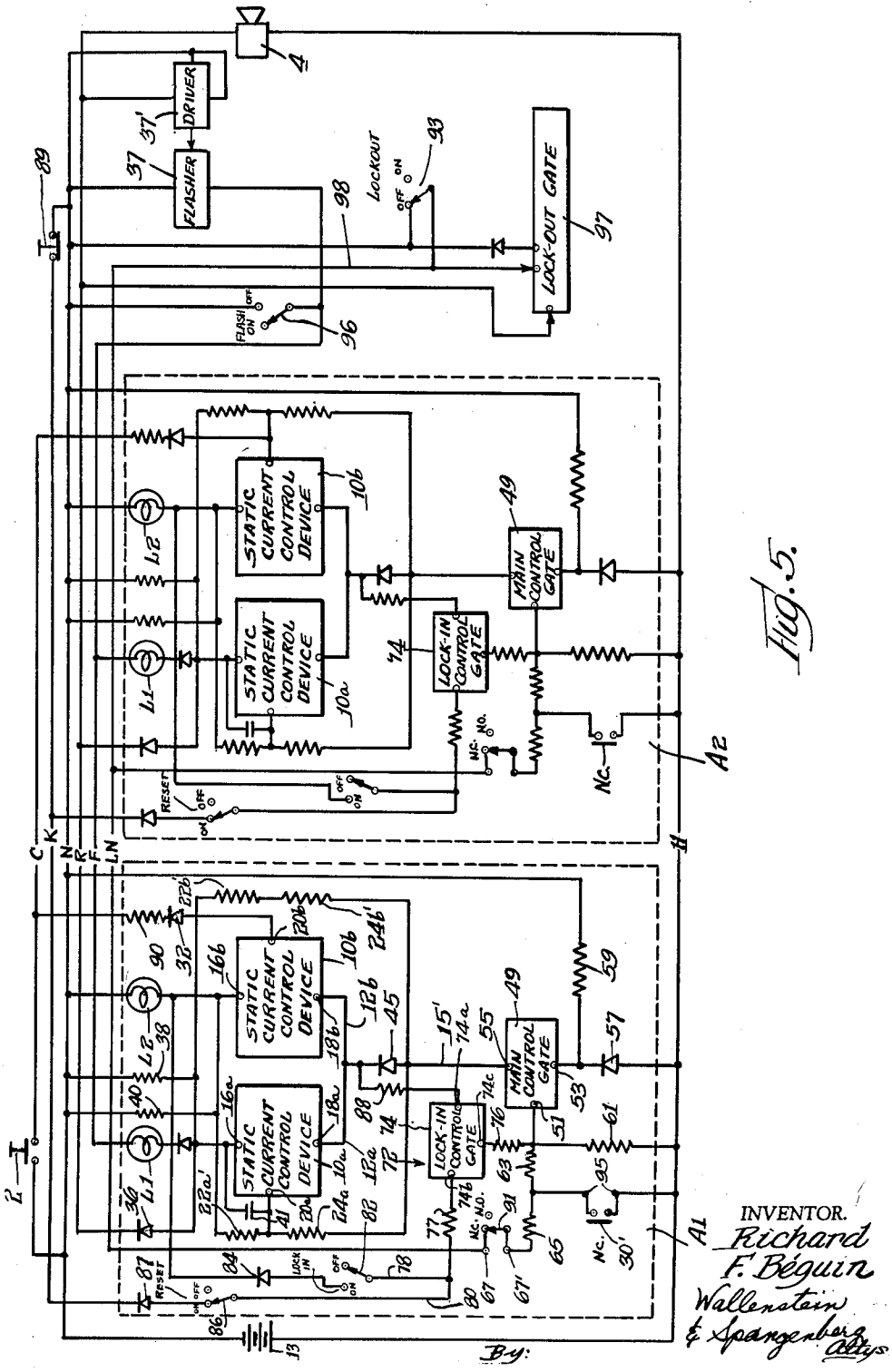


Fig. 5.

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ANNUNCIATOR SYSTEM

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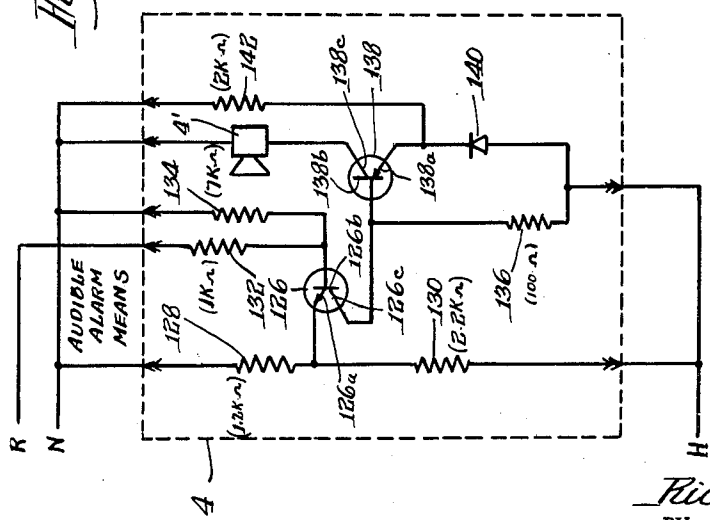
Fig. 6.

LOCK-IN AND RESET-NO LOCK-OUT				
	CONTROL DEVICE 10a	CONTROL DEVICE 10b	L1	L2
NORMAL	NON COND.	NON COND	OFF	OFF
MOMENTARILY ABNORMAL	COND.	NON COND.	ON	OFF
CONTINUOUS ABNORMAL	COND.	NON COND.	ON	OFF
ACKNOWLEDGED	NON COND.	COND.	OFF	ON
RETURN TO NORMAL	NON COND.	COND.	OFF	ON
RESET	NON COND.	NON COND.	OFF	OFF

Fig. 7.

LOCK-IN (NO RESET) WITH LOCK-OUT AND FLASHER										
	FIRST ABNORMAL				SUBSEQUENT ABNORMAL					
	10a	10b	L1	L2	10a	10b	L1	L2		
NORMAL	NON COND	NON COND.	OFF	OFF	NON COND.	NON COND.	OFF	OFF		
CONTINUOUS ABNORMAL	COND.	NON COND.	FLASH ON	OFF	NON COND.	NON COND.	OFF	OFF		
ACKNOWLEDGED	NON COND	COND.	OFF	STEADY ON	NON COND.	COND.	OFF	STEADY ON		
RETURN TO NORMAL	NON COND.	NON COND.	OFF	OFF	NON COND.	NON COND.	OFF	OFF		

Fig. 8b.



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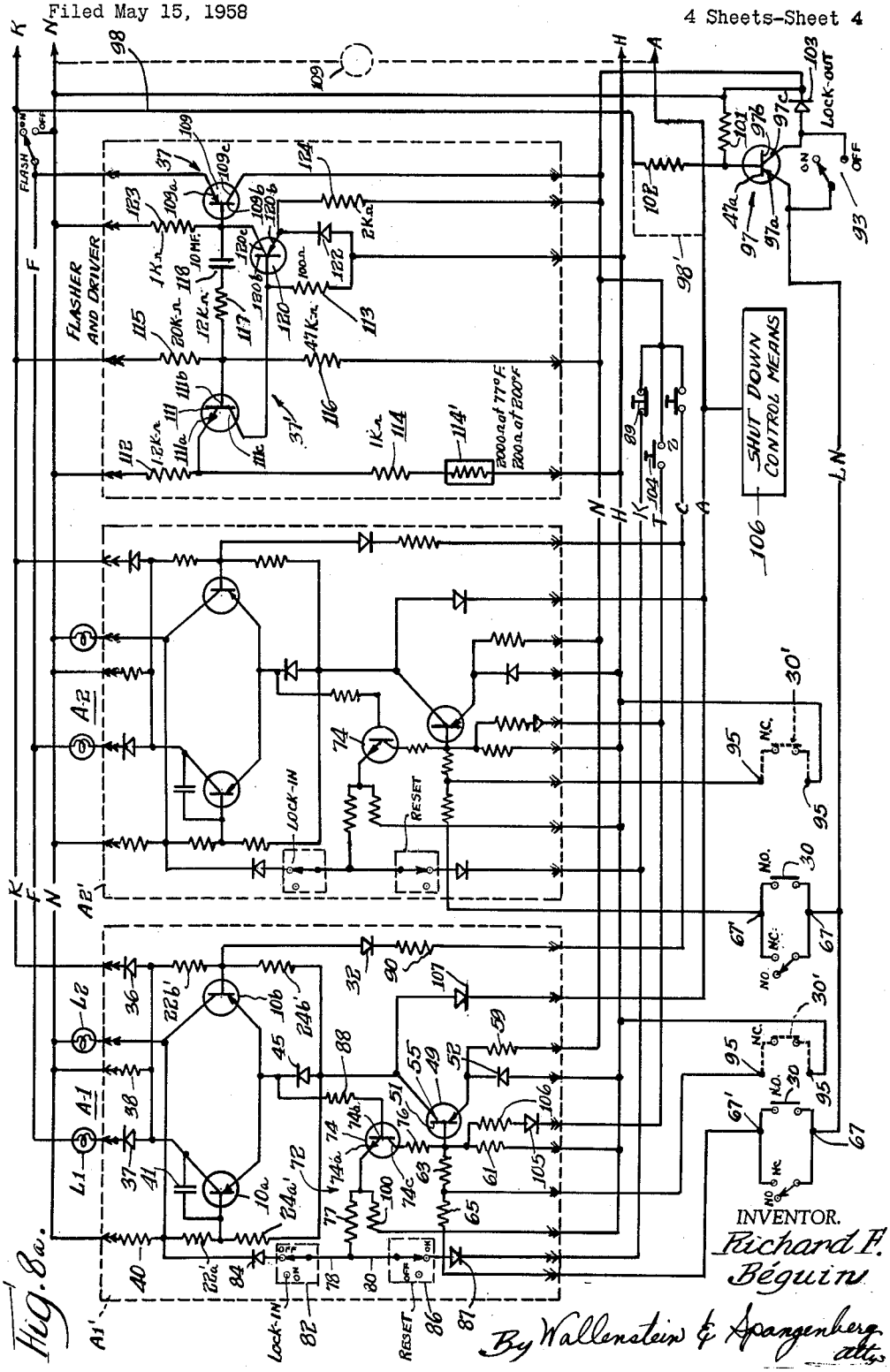


Fig. 8a.

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Patented Apr. 10, 1962

3,029,421

ANNUNCIATOR SYSTEM

Richard F. Béguin, Chicago, Ill., assignor, by direct and mesne assignments, to ISI, Incorporated, Los Angeles, Calif., a corporation of Delaware

Filed May 15, 1958, Ser. No. 735,552
22 Claims. (Cl. 340—213)

This invention relates to annunciator systems of the type wherein a visual alarm unit, such as a light unit, is provided for each variable to be monitored, and, when the variable becomes abnormal, a pair of field contacts are actuated to operate a visual alarm unit which indicates that the variable involved has just become abnormal. A manually operable acknowledgement switch is usually provided, which, when operated, changes the indication of the visual alarm unit to indicate that the alarm has been acknowledged by the operator. Usually, an audible alarm is also included to attract the operator's attention to a central control panel containing the visual alarm units associated with practically all of the variables to be monitored in the plant involved, so that the operator can determine at a glance the condition of all of the variables.

For the most part, annunciator systems of the kind just described have heretofore been hydraulically or relay controlled systems, and these systems left much to be desired from the standpoint of reliability because of mechanical wear and, in the case of the relays, additionally because the relay coils sometimes burned out. Obviously, it is quite important for annunciator systems to be reliable, since otherwise, they could not fulfill their intended purpose. More recently, static control elements, such as magnetic cores, have been used in annunciator systems to replace relays to provide a system of improved reliability. Such an annunciator system is disclosed in U.S. application Serial No. 660,137, now Patent No. 2,931,018, filed by H. Tellefsen, R. White, and Sergio Allesio and in application Serial No. 706,605, filed by Sergio Allesio. These applications disclose embodiments wherein the magnetic core elements are arranged to form a bistable flip-flop circuit controlled, at least in part, by a pair of field contacts. The bistable flip-flop circuit in turn, controls a first alarm lamp. A second alarm lamp is provided which is controlled by the field contacts independently of the flip-flop circuit. Under normal conditions, both lamps are de-energized, under initial abnormal conditions both lamps are energized, and, when the acknowledgement switch is operated, the bistable circuit is operated to de-energize the first alarm lamp.

One object of the present invention is to provide an annunciator system using static control elements, such as transistors, magnetic core elements and the like, which offers advantages not present in the annunciator systems disclosed in the above mentioned applications, such as greater flexibility in adapting a basic circuit to different visual sequences and to both normally open and normally closed field contacts. These visual sequences include a flashing light sequence wherein a flashing light is displayed when the variable initially becomes abnormal and a steady light is displayed upon acknowledgement, a two light sequence wherein three different combinations of steady or no light indications of the two lights indicates respectively normal, initial abnormal and acknowledged conditions, and sequences wherein either or both the initial abnormal and the acknowledged abnormal indications are locked-in even though the variable returns to normal.

Another important phase of the present invention relates to the use of transistor control elements as distinguished from magnetic cores, vacuum tubes and the like.

One of the difficulties heretofore encountered in adapting transistors for various control functions is that transistor circuits have been sensitive to temperature variations and, up to the present time, it has been difficult if not impossible to make transistors at a reasonable price with substantially identical characteristics, the small differences between characteristics of transistors often making a circuit quite marginal in operation. For this and other reasons, the use of transistors as prime control elements in annunciator circuits has, heretofore, never been seriously considered. The use of transistors as the prime control elements has certain advantages over the use of magnetic cores in that transistors utilize more convenient power sources, direct current power supplies, which can be more easily and economically constructed to supply the level of power required in lighting circuits than the relatively high frequency pulse-generating power supplies required for an economical magnetic core system. Although magnetic core systems can be constructed to operate at commercial power frequencies, such systems suffer from many disadvantages including the relatively large size of the core components and the related high cost of the equipment involved. Accordingly, it is an object of the present invention to provide an annunciator system utilizing transistors substantially exclusively as the prime control elements and wherein the circuit is designed such that it is very reliable and economical, reliable to the extent that wide temperature fluctuations and wide differences in transistor characteristics do not affect significantly the operation of the annunciator control circuit involved. A related object of the present invention is to provide a transistor annunciator system satisfying the previously mentioned objects relating to circuit flexibility.

In accordance with one aspect of the present invention, the annunciator circuit is provided with a flip-flop control circuit utilizing a pair of static current control devices, most advantageously although not necessarily transistors, and an alarm lamp is placed in the main output current path of each current control device, rather than in the current path of only one of the control devices. The current control devices are preferably interconnected so that a relatively high conductive state of either device will maintain the other device in a relatively low conductive state (low includes zero current) and momentary reversal of the conductive state of either device will flip or trigger the bistable circuit. The field contacts are arranged to prevent substantial current flow through both alarm lamps when the variable involved is normal. This is most effectively carried out by forming a common path for the current which flows through both current control devices and inserting either the field contacts or a gate controlled thereby in this common path. When the variable is normal, the common path is open ensuring deenergization of the alarm lamps. When the variable goes abnormal, the field contacts close or the gate is opened to allow the bistable flip-flop circuit to operate. The bistable flip-flop circuit is arranged to favor one of the current control devices for initial conduction so that the latter device will initially be in a relatively high conductive state to energize the first alarm lamp when the field contacts are intially positioned to indicate an abnormal variable, and the other current control device remains substantially non-conductive, to maintain the associated second alarm lamp deenergized. An acknowledgement switch is connected to the bistable flip-flop circuit so that operation thereof will reverse the conducting states of the current control devices to stop substantial current conduction through the first alarm lamp and its current control device and to initiate substantial current conduction in the second alarm lamp and its associated current control device. A flashing light sequence can be obtained by

simply connecting the output or load circuit of the former current control device to a flashing circuit which alternately energizes and de-energizes the output circuit thereof while the output or load circuit of the latter current control device leads directly to a source of relatively steady voltage. The flashing indication is changed to a steady light when the bistable circuit is thus triggered by the acknowledgement switch. Appreciable circuit flexibility results from the circuit just described especially when the current conduction in said common path is controlled by a gate since either or both the initial alarm and acknowledged alarm conditions can be locked-in, that is, made independent of the condition of the field contacts, by establishing a holding circuit for the gate which is broken either by operation of the acknowledgement switch or a reset switch added to the circuit. The holding circuit and the gate each most advantageously includes a current control device, and these current controlled devices are preferably interconnected to form a second bistable circuit. The provision of lock-in until acknowledgement effected by means of the use of a gate circuit in the current paths of both current control devices of the first mentioned bistable circuit and an associated holding circuit is applicable to an annunciator circuit where an alarm lamp is associated with only one of the current control devices thereof. Lock-in until reset, however, makes desirable an alarm lamp in the output circuit of the other current control device of this bistable circuit. In a manner to be explained hereinafter in more detail, the above-mentioned holding circuit is provided with separate parallel branches, one of which is controlled from the output circuit of one of the control devices so as to be responsive to operation of the acknowledgement switch and the other of which is controlled directly from the reset switch. In this way, a selection of non-lock-in, initial lock-in and reset can be simply obtained by opening or closing one or the other or both of these branches.

The utilization of the above mentioned gate with or without the accompanying holding circuit enables the operation of the annunciator circuit from either normally-open or normally-closed field contacts by using different circuits for connecting these two field contacts to the gate by inserting the normally-open field contacts in one circuit where closure thereof can be made to open the gate and by inserting the normally-closed field contacts in the other circuit where opening thereof can be made to open the gate circuit.

In accordance with a still further aspect of the present invention, the first mentioned bistable flip-flop circuit and the acknowledgement switch are connected so that the latter can have no effect on the bistable circuit until the variable initially becomes abnormal. Also, the reset switch is connected to the circuit so that it cannot flip the bistable circuit until after the circut has been acknowledged. The use of the above mentioned parallel branches for controlling the reset operation obtains this latter function of the invention.

In accordance with a still further aspect of the present invention, the current control devices used in the first bistable control circuit are preferably transistors, most advantageously PNP junction type transistors. Although transistor bistable flip-flop circuits are broadly old, the present invention utilizes a bistable flip-flop circuit in a unique way for controlling alarm lamps and, furthermore, incorporates certain features not found in prior transistor flip-flop control circuits. In this connection, the circuit includes means associated with the control electrode of one of the transistors so that it always initially assumes a high conductive state when operation of the bistable circuit is permitted. In accordance with a specific aspect of the present invention, this action is preferably obtained through the use of a bypass capacitor which under transient operating conditions provides more favorably biasing conditions for one of the control devices without affect the bistable action of the circuit. This capacitor furthermore greatly reduces the possibility of initial conduction of the wrong transistor due to dissimilarities in the transistor characteristics. Another aspect of the present invention relates to the incorporation of other stabilizing facts in the transistor circuit.

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

FIG. 1 is a box diagram of an annunciator circuit including features of the present invention;

FIG. 2 is a chart illustrating the conditions of operation of the alarm lamps and current control devices shown in FIG. 1;

FIG. 3 is a schematic diagram of a transistor annunciator circuit illustrating one application of the present invention;

FIG. 4 illustrates a transistor annunciator circuit which represents an improvement over the circuit shown in FIG. 3;

FIG. 5 is a box diagram of a universal type annunciator circuit constructed in accordance with the present invention, showing a variety of visual sequences which are possible with either normally-open or normally-closed field contacts, using the same bistable flip-flop circuit operated in connection with jumpering terminals or selector switches in a relatively simple circuit;

FIG. 6 is a table illustrating the operating conditions of the alarm lamps and the current control devices in FIG. 5 when the circuit is adjusted for initial lock-in and reset operation;

FIG. 7 is a table illustrating the operating condition of the alarm lights and the current control devices when the circuit of FIG. 5 is arranged to provide a visual sequence of operation of the alarm lamps which indicates which of a number of related abnormal variables became abnormal first and which variables became abnormal immediately following this variable;

FIG. 8*a* is a schematic diagram of a transistor annunciator circuit following the arrangement shown in FIG. 5; and

FIG. 8*b* is a schematic diagram of a transistor horn operating circuit which forms a continuation of the circuit shown in FIG. 8*a*.

Referring now to FIG. 1, the annunciator circuit there shown includes a pair of alarm lamps L1 and L2, a normally-opened, momentarily manually operable acknowledgement switch 2, an audible alarm means 4 including a bell or horn, and a bistable flip-flop control circuit 6 for controlling the operation of the lights L1 and L2 and the horn 4 in response to operation of the acknowledgement switch and variable responsive means generally indicated by reference numeral 8. Variable responsive means 8 may include field contacts, with or without associated gating devices, which respond to the condition of the variable. The field contacts are sometimes referred to in the claims as a primary variable responsive means responsive directly to the value of the variable involved and having a normal condition when the variable is normal and an abnormal condition when the variable is abnormal.

Although a variety of sequences can be obtained with the circuit shown in FIG. 1 with certain additions or modifications, the sequence which will now be described illustrates a sequence wherein both lamps L1 and L2 are normally de-energized (i.e. not lighted brightly) when the variable is normal, only lamp L1 lights brightly and the horn 4 is sounded when the variable initially becomes abnormal, and only alarm lamp L2 lights brightly when the acknowledgement light switch 2 is momentarily operated.

The bistable flip-flop control circuit 6 utilizes as primary control elements a pair of static (i.e. non-mechanical) current control or devices 10*a* and 10*b* which, in accordance with the broadest aspect of the present invention, could be magnetic cores, transistors, and theoretically

at least, less desirable vacuum tubes or analogous devices. However, the static current control devices are preferably transistors, most advantageously PNP junction type transistors. As illustrated, the static current control devices are located in distinct current paths **12***a* and **12***b* which respectively include the filaments of the alarm lamps **L1** and **L2**. Alarm lamps **L1** and **L2** are connected to a power bus N connected to the terminal of a source of operating potential **13**. It should be appreciated that the line extending from the alarm lamp **L1** to the power bus N can extend through a suitable flasher unit where it is desired to provide a flashing sequence. The current control devices may be connected in any well-known fashion to form a bistable flip-flop control circuit wherein a high conductive state of one of the control devices maintains the other current control device in a relatively low conductive state and momentary reversal of the conductive states of either control means will flip the stable conductive states of both of the current control devices. Most preferably, the circuit is designed to favor the left-hand current control device **10***a* for initial conduction which would place the right-hand current control device **10***b* in a relatively low-conductive state to de-energize the associated alarm light **L2**. The initial condition of the alarm lamp **L1** could be controlled in a number of ways. For example, the left-hand current control device **10***a* could be conducting when the variable is normal, and, in such case, the alarm lamp **L1** could be relatively de-energized by the insertion of an impedance **14** (shown in dotted lines) in series with the alarm lamp **L1** which reduces the current in path **12***a* to a relatively low value. The impedance would then be shunted directly by part of the variable responsive means **8**, such as normally-open field contacts, so that when the variable initially went abnormal, the above mentioned field contacts would close to shunt the above mentioned impedance to increase the current in path **12***a* to light the alarm lamp **L1** brightly, that is, energize the same. However, this arrangement greatly limits the flexibility of the circuit in that lock-in, automatic reset, operation with either normally-open and normally-closed contacts and other advantageous functions are not conveniently obtainable. In the preferred form of the present invention illustrated in solid lines, the field contacts are associated directly or indirectly with a common path **15** through which the current in both paths **12***a* and **12***b* flows. The common path **15** leads to a power bus H connected to the bottom terminal of the potential source **13**.

A previously indicated, the variable responsive means **8** may comprise the field contacts alone, or may additionally a gate circuit controlled by the field contacts so that, when the field contacts are in a position indicating a normal variable, the common path **15** is open preventing the conduction of either of the static current control devices **10***a* and **10***b*. This, of course, will de-energize both lamps **L1** and **L2**. When the variable initially becomes abnormal, the variable responsive means **8** closes the common path **15** to allow conduction of the bistable flip-flop control circuit **6**. Since initial conduction of the left-hand static current control means **10***a* is favored, it will initially be in a relatively high conductive state so as to energize the left hand alarm lamp **L1**, and the right-hand current control device **10***b* will remain in a relatively low conductive state so that alarm lamp **L2** will remain de-energized. When the left-hand current path **12***a* is in this highly conductive state, a bus R is energized to operate the audible alarm means **4**.

The manually operable acknowledgement switch **2** is connected to one of the current control devices so as to momentarily reverse its conductive state to reverse the stable conductive states of both of the current control devices **10***a* and **10***b*, so as to render the left-hand current path **12***a* nonconductive and the right-hand current path **12***b* conductive. This will de-energize the alarm lamp **L1** and energize the alarm lamp **L2** which indicates an acknowledged alarm condition. As will appear in the description of the other figures, the variable responsive control means **8** may be associated with suitable control circuitry for maintaining the common current path **15** closed even though the field contacts return to a position indicating an abnormal variable to provide what may be referred to as lock-in operation.

All of the components enclosed in dotted lines in FIG. 1 form a single annunciator unit associated with a single variable. This basic unit can be duplicated to service a large number of variables, in which case the additional annunciator units can be connected in parallel across the various busses shown with the annunciator unit just described.

Although in accordance with a broader aspect of the present invention the static current control devices **10***a* and **10***b* can be either one of a number of different type static devices as above indicated, it is much preferred to utilize transistors. As previously indicated, the manufacture of transistors with uniform characteristics at reasonable prices has not presently been realized. Also, transistors are temperature responsive devices which render them non-reliable in many cases where temperature variations may be substantial. Since it would be undesirable to design a separate circuit for each particular application and each particular pair of transistors, it is obviously desirable that the transistor circuit be a standard circuit which is insensitive to expected variations in temperature and transistor characteristics. Another aspect of the present invention relates to such a transistor annunciator circuit. Reference should now be made to FIG. 3 which shows one form of the present invention wherein transistors are utilized as the control devices **10***a* and **10***b* of the bistable circuit.

Transistor elements **10***a* and **10***b* are shown as PNP junction-type transistors, although the present invention could be utilized with NPN or point contact-type transistors, the PNP transistor being preferred, however, because of its normally greater current handling qualities which make it is especially useful for handling the current required for the alarm lamps **L1** and **L2**. As illustrated, the transistor **10***a* has a collector electrode **16***a* connected to the bottom terminal of the alarm lamp **L1**, an emitter electrode **18***a* connected to upper end of the common path **15**, and a base electrode **20***a* connected between a pair of resistors **22***a* (510 ohms) and **24***a* (1200 ohms). The values of these resistors and others to be described are exemplary only, and therefore, are not a limitation upon even the transistor aspects of the invention. The outer end of the lower value resistor **22***a* is connected to the load circuit of the other transistor **10***b*, more particularly the collector electrode **16***b*. The collector electrode **16***b* is also connected to the bottom terminal of the alarm lamp **L2**. The upper ends of lamps **L1** and **L2** are, as above explained, connected to the N bus which, in the particular PNP transistor circuit illustrated, is connected to the negative terminal of voltage source **13**. The transistor **10***b* has an emitter electrode **18***b* connected to the upper end of common path **15** as is the emitter electrode **18***a* of the first mentioned transistor **10***a*. The transistor **10***b* has a base electrode connected between a pair of resistors **22***b* (1200 ohms) and **24***b* (510 ohms). The outer end of the higher value resistor **22***b* is connected to the load circuit of the first mentioned transistor **10***a*, more particularly the collector electrode **16***a* thereof.

The common path **15** includes a first low value resistor (4.7 ohms) **26** connected to the emitter electrodes **18***a* and **18***b*, a second low value resistor (4.7 ohms) **28** in series with the resistor **26**, and the upper end of variable responsive means **8** which, in the embodiment illustrated, is a set of normally-open field contacts **30**. When

the variable being monitored is normal the contacts 30 are open, and, when the variable is abnormal, the contacts are closed. The bottom terminal of the field contacts 30 is connected to the H bus, which, in the particular PNP transistor circuit illustrated, is connected to the positive terminal of the voltage source 13.

The bottom terminal of the left hand resistor 24*a* associated with the base electrode 20*a* of the transistor 10*a* is connected between the common path resistors 26 and 28, whereas the corresponding terminal of the right hand 24*b* associated with the base electrode 20*b* of the transistor 10*b* is connected to the bottom end of the lower resistor. This produces an unbalance in the circuit which favors the left hand transistor 10*a* for initial conduction. A PNP type transistor is in a relatively high conductive state when its base electrode is negative relative to its emitter electrode and in a non-conductive state when this polarity is reversed. Accordingly, since the H bus is positive and the N bus is negative, it can be seen that, with respect to the voltage drop across the common path resistors 26 and 28, a greater positive, conduction-inhibiting voltage is applied to the right hand transistor 10*b* than is applied to the left hand transistor 10*a*, so that initial conduction of the left hand resistor 10*a* should be expected. Moreover, the resistor 24*a* (1200 ohms) connected between the base electrode 20*a* and the common path 15 is made substantially greater than the corresponding resistor 24*b* (510 ohms) between the base electrode 20*b* and the common path 15, so that the base electrode 20*a* of the left hand transistor 10*a* receives, by voltage division, the greater negative conduction favoring potential than does the base electrode 20*b*, further favoring initial high conduction of the left hand transistor 10*a*. Thus, when the normally-open field contacts 30 close, the left hand transistor begins to conduct and effects the lighting of the lamp L1, and the potential of the collector electrode 16*a* thereof drops close to the potential of the H bus due to the low values of the transistor output impedance and the resistors 26—28. This potential is coupled to the base electrode 20*b* of the right hand transistor and thus maintains the latter transistor non-conductive.

A line 34 extends from the collector electrode of the left hand transistor through an isolating diode 36 polarized to pass potential changes in a positive direction to the bus R leading to the audible alarm means 4 previously mentioned. The audible alarm means 4 is sounded when bus R is rendered positive by the conduction of transistor 10*a*.

Any momentary reversal of the conductive states of either of the transistor devices (by reversal is meant changing a conductive state to a non-conductive state or vice versa) will trip the bistable circuit and render the right hand transistor highly conductive thereby lighting the lamp L2 brightly, and the left hand transistor non-conductive, thereby turning off the lamp L1 and the audible alarm means 4. In the circuits shown, this tripping action is effected by means of the aforementioned acknowledgement switch 2 connected between the C bus and the H bus. Thus, when the acknowledgement switch is momentarily closed, positive potential is applied through a properly polarized diode 32 to the base electrode 20*a* of the left hand transistor device, which voltage momentarily stops conduction of the transistor 10*a*. This makes the potential of the collector electrode 16*a* negative which is coupled to the base electrode 20*b* of the right hand transistor via resistor 22*b*, to start high conduction of the right hand transistor 10*b*. The potential at the collector electrode 16*b* of the right hand transistor 10*b* then drops to a potential near the H bus which is coupled via resistor 22*a* to the base electrode 20*a* of the left hand transistor 10*a*, thereby maintaining the left hand transistor 10*a* in a non-conductive state.

In the embodiment illustrated in FIG. 3, for the values of the resistors given, the circuit operates most satisfactorily with a voltage of 24 volts between busses H and N, type 2N235 transistors for control devices 10*a* and 10*b* and lamps L1 and L2 with filament resistances of about 150 ohms.

Although the design illustrated in FIG. 3 is satisfactory for many purposes, the design illustrated in FIG. 4 is a substantially more reliable and less sensitive circuit than is the circuit of FIG. 3. The circuit of FIG. 4 differs from the circuit of FIG. 3 in numerous respects, one being that an initial alarm condition causes the left hand alarm lamp L1 to flash; also, the common path 15′ of the circuit is modified so that normally-closed field contacts can operate the circuit in the same general manner in which the circuit of FIG. 3 operates. Any common elements in the circuits of FIGS. 3 and 4 have been similarly numbered.

To effect an initial flashing indication of the alarm lamp L1, instead of connecting the upper terminal of the latter lamp directly to the N bus, this terminal is connected to a common bus F extending to suitable flashing apparatus 37 connected between the busses F and N, which alternately produces a high and low impedance condition at a visible flashing rate. Also, an isolating diode 37 is preferably placed in series with alarm lamp L1. The right hand alarm lamp L2, which is to provide a steady indication upon acknowledgement, is connected as before to the N bus. In the absence of voltage stabilizing impedance means to be described, the alternate variation of the impedance of the circuit in which the alarm lamp L1 is connected could create unstable conditions which might trip the bistable circuit at a time when such triggering is not desired. Accordingly, voltage stabilizing means are provided in the form of a resistor 38 (e.g. 560 ohms) coupled between the collector electrode 16*a* of the left hand transistor 10*a* and the N bus. To provide a balanced circuit for the two transistor devices 10*a* and 10*b*, a similar resistor 40 is coupled between the bottom end of alarm lamp L2 and the N bus.

As above indicated, it has been known for some time that transistor devices are quite sensitive to temperature variations and also that it is quite difficult to produce transistor devices with substantially similar characteristics. These factors tend toward circuit instability which could be highly undesirable in transistor-type circuits used as annunciator control elements. For example, such instability could result in the initial high current conduction of the right hand transistor instead of the left hand transistor, or the inadvertent internal triggering of the bistable circuit from a condition where the right hand transistor begins to conduct without depression of acknowledgement switch 2. To minimize this circuit instability, it has been found desirable to provide generally symmetrical control circuits for the base electrodes 20*a* and 20*b* of the transistors 10*a* and 10*b*, insofar as quiescent or non-transient conditions are concerned. Also, to the end of improving stability, it has been found desirable to render the base electrode of a PNP transistor during the non-conduction thereof as positive as possible, that is at a potential closest to the bus potential which effects the non-conductive state of the transistor. In such case, self-starting or run-away effects created by high temperature conditions of a transistor are greatly minimized, and the operating temperature at which the transistors may be utilized is increased appreciably. This is very desirable where the annunciator equipment must be kept in boiler rooms of power plants and the like where the ambient temperature is quite high.

In the circuit of FIG. 4, this stability is obtained by making the resistors 22*a*′ and 22*b*′ interconnecting the collector and base electrodes of the transistors the same relatively high value (e.g. 510 ohms) and resistors 24*a*′ and 24*b*′ connected between the base electrodes 20*a* and 20*b* and the common path the same relatively low values (e.g. 100 ohms) and connected to the same point 43 in

the common path 15'. It can be seen that this base electrode circuit, unlike that shown in FIG. 3, is a symmetrical circuit which does not appear to have any means for ensuring initial conduction of the left hand transistor 10*a*, which is required for a proper sequence of operation of the lamps L1 and L2. The latter means, however, is most advantageously formed by a capacitor 41 which, for example, may be a 10 microfarad capacitor connected into the circuit so that, under transient conditions only, it effectively bypasses the uppermost resistor 22*a'* associated with the left hand transistor 10*a'*. In such case, closure of the common path 15' will apply a higher negative or conduction-inducing voltage to the left hand base electrode 20*a* than the right hand base electrode 20*b*. Accordingly, the capacitor 41 may be connected between the base electrode 20*a* and the bottom terminal of the alarm lamp L1 which effectively bypasses the resistor 22*a'*. Although the capacitor 41 is not actually connected and parallel with the resistor 22*a'*, it can be seen that the connection illustrated will have substantially the same effect.

To further stabilize the operation of the transistor circuit, a voltage regulating element is preferably connected between the emitter electrodes 18*a* and 18*b* of the transistors and the point 43 to which the bottom ends of the base electrode resistors 24*a'* and 24*b'* are connected. This voltage regulating device is shown as a semiconductor diode 45, which may be, for example, a silicon diode which maintains a substantially constant voltage (e.g. .5–.7 volt) for wide variations in current. Voltage regulating diode 45 is obviously polarized to pass normal current which would flow through the transistor devices 10*a* and 10*b*.

In order to operate the annunicator circuit shown in FIG. 4 with normally-closed field contacts identified by reference numeral 30', the common path 15' has been further modified so that the normally-closed contacts control a gating circuit 47. The gating circuit 47 is shown as comprising a PNP transistor 49 which may be the same transistor (2N235) as the transistors 10*a* and 10*b* and having a base or control electrode 51 an emitter and collector electrodes 53 and 55, respectively. The collector electrode 55 is connected to the bottom of the voltage regulating diode 45 in the common path 15', and the emitter electrode 53 is preferably connected to one terminal of a suitable biasing means which, in the embodiment illustrated, is a semi-conductor diode 57, such as a silicon rectifier. This diode is obviously polarized to pass current in the normal direction through the transistors 10*a* and 10*b*. The other terminal of the diode 57 is connected to the H bus. As will appear, diode 57 is utilized to provide a suitable stabilized voltage for normally biasing the gating transistor 49 to a non-conductive state. To this end, the uper terminal of the diode 57 is connected to the N bus through a suitably sized resistor 59 (e.g. 2000 ohms). The voltage drop across the rectifier 57 may be in the neighborhood of six-tenths of a volt, as is the voltage drop across the previously mentioned diode 45.

The base electrode 51 of the gating transistor 49 is connected to the H bus through a resistor 61 and is connected to the N bus through a pair of resistors 63 and 65 and a pair of terminals 67—67' shunted by a jumper 69. Terminals 67—67' enable the operation of the circuit of FIG. 4 with normally-open field contacts by the simple expedient of connecting a set of normally-open contacts between the terminals 67—67' after the jumper 69 has been removed and omitting the normally-closed contacts 30' from the circuit. The normally-closed field contacts 30' are connected preferably between the juncture of resistors 63 and 65 and the H bus. When the variable being monitored is normal, and the normally-closed field contacts 30' are being utilized, the latter decouple the negative voltage of the N bus from the base electrode 51. As above explained with a PNP type of transistor, a negative voltage on the base electrode relative to the emitter electrode will effect conduction whereas a positive voltage will effect a non-conductive state thereof. It can be seen that the voltage drop across the diode 57 will, therefore, provide a bias which will tend to keep the transistor 49 in a non-conductive state when the normally-closed field contacts 30' are closed. As soon as the variable becomes abnormal and the normally-closed field contacts 30' open, a negative voltage will be applied to the base electrode 51 across resistor 61 which will start the transistor 49 conducting, thereby opening the gating circuit 47, to allow conduction through the common path 15'. As above explained, the left hand transistor 10*a* will then initially become conductive thereby energizing the alarm lamp L1 which will flash on and off at a visible rate. Operation of the acknowledgement switch 2 will trigger the bistable flip-flop circuit into an opposite state of conduction to de-energize the alarm lamp L1 and energize the alarm lamp L2.

From the description of the circuit just given, it is apparent that connection of a normally-open set of field contacts across terminals 67—67' in place of the jumper 69 and omission of the normally-closed field contacts 30' will effect identical operation of the alarm lamps L1 and L2 and of the audible alarm means for successive closure of the field contacts and operation of the acknowledgement switch 2.

In the two annunicator circuits just described, PNP type transistors have been utilized and connected in the manner described. In accordance with the broader aspect of the present invention, the PNP type transistors can be connected in a manner such that the emitter electrode becomes the control terminal of the transistor and the output of load terminals thereof are comprised by the collector and base electrodes. Also, NPN type transistors of proper current capacity may be utilized, although, presently, such transistors do not commonly carry sufficient current to light brightly the usual filament-type alarm lamps.

The use of the gating circuit 47 in the common path 15 instead of connecting the field contacts directly therein results in substantial circuit flexibility, permitting selective initial lock-in and/or reset operation where desired, by the addition of a few elements to the bistable circuit. In these types of circuit operation, the circuit maintains an alarm state of operation even though the variable becomes abnormal only momentarily. During initial lock-in operation, lock-in of the circuit ends with operation of the acknowledgement switch 2, whereas in reset operation lock-in continues until operation of a reset switch following acknowledgement. To effect lock-in and/or reset operation, conduction of the gating circuit 47 is maintained by an auxiliary control device to be described. Accordingly, reference should now be made to the box diagram of FIG. 5 which shows what might be referred to as a universal annunicator circuit which, using the base circuit shown in FIG. 4 with the addition of a few other elements, provides a wide variety of visual sequences with either normally-open or normally-closed field contacts. The corresponding elements in FIGS. 4 and 5 have been given similar reference characters, it being understood, however, that in the case of the control devices 10*a*, 10*b* and 49, in accordance with the broader aspects of the present invention, static control elements other than transistors could be substituted therefor and other changes made as well.

A typical annunciator system comprises a large number of points or variables to be monitored by separate annunciator circuits connected in parallel across common busses and using a common acknowledgement switch and audible alarm device. FIG. 5 is drawn to illustrate application of the present invention to such a typical system, the components exclusive to a particular variable

are there shown enclosed by dotted lines A1 and A2. In describing FIG. 5, only one of the annunciator circuits A1 will be described, it being understood that the annunciator circuit A2 and others which could be used may be identical to and operate in the same manner as the circuit to be described.

To provide for initial lock-in or reset operation, a holding circuit, generally indicated by reference numeral 72, is provided which will maintain the main gating control device 49 in the common path 15' of the bistable flip-flop circuit in a highly conductive state after it is initially set into this state by the particular field contacts utilized. This holding circuit includes a lock-in control gate device 74 which may be a transistor device as will be described, although it may be comprised of another type of control device, preferably a static control device. The gate 74 has one load terminal 74*c* connected through a resistor 76 to the control terminal 74*b* of the main gating control device 49 and another load terminal 74*c* connected through a resistor 77 to a pair of parallel or alternate current paths 78 and 80. The current path 78 includes a lock-in select on-off switch 82 which is a lock-in control switch which may selectively open or close the path 78. The switch 82 is connected through an isolating diode 84 preferably to the load terminal 16*b* of the right hand bistable control device 10*b* nearest the alarm lamp L2. The alternate path 80 includes a reset select on-off switch 86 for selectively opening and closing the alternate path 80. The switch 86 extends through an isolating diode 87*b* to a reset bus K. A normally-closed pushbutton switch 89 is connected between the reset bus K and the N bus. The lock-in control gate device 74 has a control terminal 74*a* preferably connected through a resistor 88 to some point in the common path 15' which will trigger the lock-in control device 74 into a highly conductive state when current conduction begins in the common path, provided that one of the alternate paths 78 or 80 is closed. Conduction of the lock-in control device causes current to flow through the load terminals 74*c*—74*b*, resistor 77 and either path 78 or 80. The resultant voltage drop across resistor 61 will maintain conduction of the main gating control device 49 even though the field contracts, which initially started conduction of the gating control device 49, return to a normal position.

Assuming that only initial lock-in operation is desired, switch 82 in path 78 would be closed and switch 86 in path 78 would be open. If the variable involved went abnormal momentarily, the main gate control device 49 would be held in a conducting state by the biasing current generated by the negative voltage applied to the upper end of path 78 from bus N through lamp L2. This biasing current is too small to light the latter lamp but sufficiently high to produce a bias across resistor 61 which keeps the gate control device 49 conducting. The negative voltage applied to the upper end of path 78 remains as long as the right hand control device 10*b* of the bistable circuit remains non-conductive. As soon as the circuit is acknowledged, however, the control device 10*b* is rendered conductive which effectively shunts the load circuit of the clock-in gate control device 74 to terminate the biasing current which maintained conduction of the gate control device 49. The latter device will therefore become non-conductive if the field contacts have returned to their normal position.

The circuit for acknowledging the annunciator circuit in FIG. 5 is somewhat different than shown in FIG. 4 in that the acknowledgement bus C is connected to the control terminal 20*b* of the right hand control device 10*b* rather than the control terminal 20*a* of the left hand control device 10*a*, and, accordingly, the normally-open acknowledgement pushbutton switch 2 connected to the C bus is connected to the N bus instead of the H bus. An isolating diode 32 and a resistor 90 are connected in the line between the C bus and the control terminal 20*b*. With this arrangement, momentary depression of acknowledgement switch 2 will connect a negative potential to the control terminal 20*b* of the right hand current control device 10*b* which will start the conduction thereof and hence flip the bistable trigger circuit into a condition where the left-hand control device 10*a* is non-conductive and the right hand control device 10*b* is conductive.

In the circuit shown, a set of normally-closed contacts 30' are connected into the circuit as illustrated in FIG. 4 so that opening of the contacts will establish a connection of the control terminal 51 of the gating control device 49 to the N bus. However, the path to the N bus in FIG. 5 is somewhat different than the corresponding circuit in FIG. 4 due to the addition of an LN bus and associated components to be described which provide what will be referred to as "lock-out" operation, which enables the first of a series of abnormal variables to be identified. Connection of the control terminal 51 to the LN bus is made through resistors 63 and 65, terminal 67—67' electrically joined by the "NC" position of a single-pole, single-throw field contact select switch 91 connected to the LN bus. The LN bus is connected to the N bus through a lock-out select, on-off switch 93, which is closed when lock-out operation is "off." The switch 91 is closed when the circuit is to be operated with normally-closed field contacts and is open when the circuit is to be operated with normally-open field contacts. In the latter case, the normally-closed field contacts 30' are disconnected from a pair of terminals 95—95 and a set of normally-open field contacts are connected across the terminals 67—67'.

If manual reset operation is desired, the initial alarm condition of alarm lamp L1 is locked-in before acknowledgement and the acknowledged alarm condition of the alarm lamp L2 is locked-in after acknowledgement until operation of the reset switch 89. When manual reset operation is desired, both the reset select switch 86 in path 80 and the lock-in select switch 82 are closed. In such case, it should be noted that, following initiation of conduction in the common path 15' of the bistable circuit, both paths 78 and 80 are active in coupling the operating N bus voltage to the lock-in control device 74 to provide the proper bias voltage for the gating control device 49. The purpose for using path 78 in addition to path 80 for initial lock-in purposes is to prevent the cancelling of the lock-in operation by inadvertent depression of the reset switch 89 instead of the acknowledgement switch 2 when acknowledgement is desired. Thus, assuming that the variable involved became momentarily abnormal, the alarm lamp L1 would be locked-in by the holding circuit 72. Then, in the absence of a closed path 78, inadvertent depression of the reset switch 89 instead of the acknowledgement switch 2 would break the holding circuit and therefore close the main control gate 47, thereby de-energizing alarm lamp L1 and also maintaining the alarm lamp L2 de-energized. The presence of alternate paths 78 and 80 with their select switches 82 and 86 have the additional advantages of providing a selection of either or both initial lock-in and manual reset operation or neither. Thus, opening both of these switches will disable the holding circuit 72 so that automatic reset both before and after acknowledgement would be present. That is, return of the variable to normal would cancel any existing indication on alarm lamps L1 and L2. The main control gate device 49 and the lock-in control device 74 are interconnected to form a bistable control circuit. In the transistor embodiment of the invention illustrated in FIG. 8*a*, these two devices form a bistable circuit having one state where the devices are simultaneously highly conductive and another state where the devices are simultaneously relatively nonconductive.

FIG. 6 is a table which illustrates the operation of the alarm lamps L1 and L2 and the bistable control devices 10*a* and 10*b* during manual reset operation.

The circuit of FIG. 5 also enables the ready selection of either a flashing or a non-flashing operation of any of the alarm lamps L1. As in the embodiment of FIG. 4, the upper terminal of the left hand alarm lamp L1 is connected to the F bus. The F bus connects with the N bus through either the flasher 37 or a flasher select on-off switch 96. Closure of the switch 96 bypasses the flasher 37 so that a steady bright indication will appear on the left hand alarm lamp L1 when the associated variables become abnormal and until acknowledgement. Opening of the select switch 96 will enable the flasher 37 to produce a flashing indication on these alarm lamps until the circuit is acknowledged. The flasher 37 may be driven by a driver 37' controlled from the R bus which is active during an initial alarm condition of any of the annunciator circuits A1, A2, etc. The details of an exemplary driver and flasher will be described later on in connection with the schematic diagram of FIG. 8*a*.

As previously indicated, the circuit of FIG. 5 enables selection of still another type of light sequence, which may be referred to as a visual sequence. In a situation where a number of variables are related so that the abnormality of any one of a number of variables will cause other variables to become abnormal, it is often important to be able to identify the variable which first went abnormal, so that the source of trouble can be easily located. To this end, when the lock-out select switch 93 is opened, the LN bus associated with the field contact control circuit is connected through the load circuit of a lock-out gate control device 97 to the N bus. Lock-out operation also requires that the lock-in circuit 72 be operative to provide at least initial lock-in operation. During lock-out operation, the lock-out gate control device 97 is normally opened or conducting until a variable becomes abnormal, whereupon the resultant positive voltage appearing on the R bus is fed, via a line 98, to the control terminal of the lock-out gate control device to close the same so as to prevent operation of the bistable circuits of all of the annunciator circuits which become abnormal subsequent to the first variable, until the acknowledgement switch 2 is operated which removes the positive voltage from the R bus. The bistable circuit associated with the variable which first went abnormal operates independently of the circuit including the LN bus because of its lock-in circuit 72. After acknowledgement, the gate control device 97 opens allowing all of the bistable circuits associated with still abnormal variables to operate by displaying steady-on lighted alarm lamps L2 only. The table of FIG. 7 summarizes this lock-out operation.

The details of an exemplary lock-out control circuit including the lock-out control device 97 will be hereinafter described in connection with the schematic diagram of FIG. 8*a*.

Reference should now be made to FIGS. 8*a* and 8*b* which illustrate a complete schematic diagram of the annunciator system shown, and just described in connection with FIG. 5. Most of the components associated with the individual annunciator circuits A1 and A2 are shown incorporated in respective plug-in units designated by the dotted boxes A1' and A2', the double arrows appearing at the margins thereof representing, respectively, the male plug-in terminals of the plug-in units and respective socket terminals carried by a chassis carrying the common components, such as the busses. The alarm lamps L1 and L2, the field contacts 30 or 30' and their associated terminals and the field contact select switches are shown mounted externally of the plug-in units. Some of the busses and circuit paths have been re-arranged from that shown in FIG. 5.

The lock-in control gates 74 of each annunciator circuit A1, A2, etc. is shown as comprising an NPN type transistor having emitter, base and collector electrodes 74*a*, 74*b* and 74*c* corresponding to the similarly identified terminals in the box diagram of FIG. 5. Thus, the base electrode is connected via a resistor 88 to the common path 15', the emitter electrode 74*b* is connected to a resistor 77 connected to the alternate paths 78 and 80, and the collector electrode 74*c* is connected to a resistor 76 leading to the control or base electrode 51 of the main gate transistor device 49.

As previously indicated, where a transistor is used as a control element, it is possible that the transistor which is normally non-conductive can trigger itself into conduction. To prevent this result, a resistor 100 is connected between each emitter electrode 74*a* and the positive or H bus, to provide a bias voltage which inhibits conduction of each transistor 74 except under circuit conditions requiring this conduction, that is, when the base electrode 74*b* of the transistor 74 receives a positive voltage from the common path 15'. Then, as explained in connection with box diagram of FIG. 5, the transistor control device 74 begins to conduct heavily, thereby locking-in the conductive condition of the gating transistor 49.

Transistor 74 may be a type 2N169 NPN transistor and the values of the various resistors associated therewith may be as follows with a bus voltage of 24 volts and the other circuit constants shown in or described in connection with the corresponding components in FIG. 4:

	Ohms
76	560
77	68
88	1000
100	2200

These values, it should be understood, are exemplary only, and are not to be considered as limitations on the scope of the present invention.

In FIG. 8*a*, lock-out control device 97 is shown as comprising a PNP type of transistor whose base or control electrode 97*b* is connected through a resistor 101 to the N bus and through a resistor 102 and line 98 to the R bus. The emitter electrode 97*a* of the transistor 97 is connected to the LN bus and the collector electrode 97*c* thereof is connected through a diode 103 to the N bus. The lock-out switch 93 shunts the load terminals, namely the emitter and collector electrodes 97*a* and 97*c* of the transistor 97. Now, the R bus is isolated from the positive H bus when the left hand transistor devices 10*a* of all of the bistable circuits are non-conductive, and, in such case, the transistor 97 will be in a low impedance output state and will conduct heavily when the field contacts involved are in their abnormal indication position. FIG. 5 illustrates the use of normally-open contacts 30 and closure thereof completes a circuit extending from the H bus, and through resistors 61, 63 and 65, the field contacts 30, bus LN, emitter and collector electrodes 97*a* and 97*c* of transistor 97 and diode 103 leading to the N bus. Conduction of this circuit generates a voltage at the base electrode 51 of gating transistor 49 which enables the latter to conduct. As above explained, as soon as this occurs, the left hand transistor 10*a* conducts causing a positive voltage to appear on bus R. This voltage is fed to the base electrode 97*b* of the lock-out transistor 97 which renders the latter transistor non-conductive to uncouple the LN bus from the N bus and so prevents operation of all annunciator circuits associated with variables which became abnormal after the variable which first became abnormal, until the acknowledgement switch 2 is depressed. When the acknowledgement pushbutton is depressed momentarily, the conductive states of the transistor of the then operating bistable circuit reverses, removing the voltage from bus R which kept the lock-out transistor 97 non-conducting. Transistor 97 immediately resumes conduction so the bistable circuits associated with variables which are still abnormal immediately become operative in an acknowledged state with the right hand transistors conducting and lights L2 steady-on.

The circuit of FIG. 8*a* includes, in addition to those

corresponding elements found in FIG. 5, a test circuit which enables the triggering of all the bistable circuits into an initial alarm condition to test the proper operation thereof and of the associated lamps L1 and L2. To this end, a T bus is connected to each of the various annunciator circuits A1, A2, etc. through an isolating diode 105 and a resistor 106 to the base or control electrode 51 of the main gating transistor 49 in the common path 15'. The T bus is connected through a normally-open test pushbutton switch 104 to the N bus. When the test switch 104 is depressed, this applies the negative potential of the N bus to the base electrodes of all of the gating control transistors 49 to simulate an abnormal condition of all of the variables, to initiate conduction of all of the left hand transistors 10*a* of the bistable circuits, which energizes all of the left hand alarm lamps L1 if the lamps are operating properly. If the lock-in circuit 72 is operative, the latter condition of the circuit will remain until the acknowledgement switch 2 is depressed, which as above explained, will reverse the states of conduction of the transistors 10*a* and 10*b* to light all of the right hand alarm lamps L2 if they are operating properly.

In order to provide a remote light indication where desired which indicates that at least one of the variables in the system is abnormal, a common bus A is provided which is coupled through a diode 107 to the collector electrodes 55 of all of the gating transistors 49, so that, when any of the bistable circuits is operating, a positive voltage will be applied to the A bus. A remote light 109 may be connected between the A bus and the N bus which will be energized when the common path 15' of any of the bistable circuits is operating. Also, if the control line 98 associated with lock-out transistor 97 is disconnected from bus R and connected to bus A (as represented by dotted connection 98'), the lock-out circuit will prevent operation of all annunciator circuits except the circuit associated with the first-to-become abnormal variable, even after acknowledgement, until the last mentioned variable returns to normal and the associated bistable circuit becomes non-conductive. The voltage on bus A could be used to operate shut-down control means 106 controlling apparatus whose variables are being monitored by the various annunciator circuits. In such case, when one variable becomes abnormal, all the monitored apparatuses are shut down until such variable returns to normal.

FIG. 8*a* also illustrates a circuit diagram for the flasher 37 and the driver 37', therefore, which comprises a single plug-in unit. Flasher 37 is shown as comprising a PNP type transistor 109 having its emitter electrole 109*a* connected to the F bus, its collector electrode 109*c* connected to the N bus and its base electrode 109*b* to the driver circuit 37'. The driver circuit includes a NPN type transistor 111 whose emitter electrode 111*a* is connected through a resistor 112 to the N bus and through a resistor 114 and a thermistor 114' to the H bus, whose collector electrode 111*c* is connected through a resistor 113 to the H bus, and whose base electrode 111*b* is connected to the juncture of a pair of resistors 115 and 116, respectively. The upper resistor 115 is connected to the R bus and the lower resistor 116 is connected to the N bus. A series circuit comprising a resistor 118 and a capacitor 119 is connected between the juncture of resistors 115 and 116 and the base electrode 109*b* of the flasher transistor 109. Also associated with the base electrode 109*b* of the flasher transistor 109 is a PNP type transistor 120 having an emitter electrode 120*a* connected through a biasing diode 122 to the H bus, a collector electrode 120*c* connected to the base electrode 109*b* of the flasher transistor 109, and a base electrode 120*b* connected to the end of resistor 113 connected to the electrode 111*c* of the transistor 111. A resistor 124 is connected between the emitter electrode 120*a* of the transistor 120 and the N bus.

Exemplary values of the circuit elements making up the flasher and driver circuit are given in FIG. 8*a* when the transistor 109 is a 2N277 transistor, transistor 111 is a 2N169 transistor and transistor 120 is a 2N291 transistor.

The operation of the flasher and driver circuit is as follows: When all of the variables are abnormal, the R bus is effectively isolated from the H and N busses so that the base electrode 111*b* has the full negative potential of the N bus applied thereto through resistor 116 which renders the NPN type transistor 111 non-conductive. The bias voltage developed across the diode 122 keeps the transistor 120 nonconductive. As soon as one of the variables become abnormal, however, and the left hand transistor 10*a* of the associated bistable circuit is rendered conductive, the positive potential of the H bus is coupled to the R bus through the latter transistor and, this potential is coupled to the base electrode 111*b* of the transistor 111 to initiate conduction thereof. As soon as conduction of transistor 111 begins, the resultant current flow through the resistor 113 produces a negative bias on the base electrode of PNP type transistor 120 which overcomes the effect of the bias voltage across diode 122 and initiates conduction thereof. This couples the positive potential of the H bus to the base electrode 109*b* of the flasher transistor 109 which keeps the transistor 109 non-conductive. The right hand end of capacitor 118 is then near the potential of the H bus and the capacitor then charges to a potential determined by the normal voltage division between resistors 115 and 116. The potential developed by the charging current keeps the transistor 111 conducting until the capacitor is substantially fully charged. When this occurs, the normal potential developed across the resistor 116 will be sufficient to render the transistor 111 non-conductive which, due to the consequent cessation of current flow through resistor 113, will render transistor 120 non-conductive. Capacitor 118 then begins to discharge through a circuit including resistor 115, resistor 117, capacitor 118, and resistor 123 and the resultant voltage biases the flasher transistor 109 to a conductive state, thereby for the moment energizing the left hand alarm lamp L1 of the bistable circuit involved. As the capacitor 118 discharges the voltage developed in the discharge circuit maintains the non-conductive state of the transistor 111, but when the capacitor 121 becomes substantially fully discharged, the transistor 111 then again becomes conductive and the above mentioned process is repeated. Since the conductibility of transistor 111 will be obviously affect the flashing rate, and ambient temperature changes will normally affect the conductibility of this transistor, the negative resistance characteristics of thermistor 114' subjected to the same ambient temperature changes will vary the bias conditions on transistor 111 in a direction to neutralize the effect of this temperature change on transistor 111. The time constant of the capacitor charge and discharge circuit is such that the flasher transistor 109 will be alternately rendered conductive and non-conductive at a visible rate. When an initial alarm condition is acknowledged, as above explained, the positive potential disappears from the R bus which renders the flasher circuit inoperative.

For a description of the audible alarm or horn circuit 4, reference should now be made to FIG. 8*b*. This circuit includes a suitable horn device 4' and a driver circuit therefor including an NPN transistor 126 having an emitter electrode 126*a* connected to the juncture of a pair of resistors 128 and 130. Resistor 128 is connected to the N bus and the resistor 130 is connected to the H bus. The base electrode 126*b* of the transistor 126 is connected through a resistor 132 to the R bus and through a resistor 134 to the N bus. The collector electrode 126*c* of the transistor 126 is connected through a resistor 136 to the H bus.

The driver circuit also includes a PNP transistor 138

having an emitter electrode 138*a* connected through a biasing diode 140 to the H bus and through a resistor 142 to the N bus. Diode 140 and resistor 142 provide a bias which normally keeps the transistor 138 in a non-conductive state. The base electrode 138*b* of the transistor 138 is connected to the terminal of the resistor 136 connected to the collector electrode 126*c* of the transistor 126. The collector electrode 138*c* of the transistor 138 is connected to a suitable electrical horn 4' which, in turn, is connected to the N bus.

The operation of the horn circuit is as follows: When all of the variables are normal, as above explained, the R bus is isolated from various busses of the system and the negative voltage of the N bus is accordingly applied to the base electrode 126*b* of the transistor 126, thereby rendering the transistor non-conductive. No current flows through the resistor 136 and the biasing circuit comprising the diode 140 and the resistor 142 biases the transistor 138 into a non-conductive state, thereby insuring the de-energization of the horn device 4'. As soon as the variable becomes abnormal the R bus becomes positive and the base electrode 126*b* of the transistor 126 is driven to a positive potential thereby starting the conduction of the transistor 126. As soon as the transistor 126 begins to conduct, the resultant current flow through the resistor 136 creates a potential on the base electrode 138*b* of the transistor 138 which starts the transistor 138 conducting, thereby sounding the electric horn 4'. As soon as the bistable circuit involved is acknowledged, the positive potential on the R bus is removed, thereby effecting the non-conduction of the transistors 126 and 138, which de-energizes the horn device 4'.

It should be understood that numerous modifications may be made of the most preferred forms 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. An annunciator circuit comprising first normally de-energized visual alarm means, a second normally de-energized visual alarm means, control means for controlling the operation of both of said visual alarm means and comprised of a bistable circuit formed by a pair of static control means arranged to have opposite mutually maintained states of operation at any given time and to reverse their respective states of operation when either is momentarily triggered into an opposite state of operation, said first visual alarm means being controlled by one of said control means and the other being controlled by the other of said control means and being arranged to be energized when the associated control means are in corresponding states of operation, condition responsive means for controlling the operation of said static control means and having a normal condition when the variable to be monitored is normal and an abnormal condition when the variable is abnormal, means for rendering both of said control means inoperative upon said first and second control means normally to de-energize both of said visual alarm means which said condition responsive means is in said normal condition, and for rendering said control means operative to energize said first visual alarm means when said condition responsive means is initially operated to its abnormal indicating condition, and acknowledgement means for triggering said static control means into the state of operation which de-energizes the first visual alarm means and energizes said second visual alarm means.

2. An annunciator circuit comprising: first visual alarm means for providing at least a normal and an alarm visual indication, second visual alarm means for providing at least a normal and an alarm visual indication, variable responsive means having a normal condition when the variable is normal and an abnormal condition at least when the variable is initially abnormal, a bistable flip-flop control circuit including first and second static, current control devices arranged in respective main current paths and interconnected so that a relatively high conductive state of either device will maintain the other device in a relatively low conductive state and vice versa, and momentary reversal of the conductive condition of either device will reverse the then existing states of both devices, means respectively connecting said first and second visual alarm means in the main current paths of said first and second static current control devices, said visual alarm means displaying said normal indications when the associated current control devices are in their relatively low conductive states and displaying said alarm indications when their associated current control devices are in their relatively high conductive states, means for ensuring initial operation of said first static current control device in a relatively high conducting state when conduction of said control devices is permitted, means connecting said variable responsive means in circuit with said bistable flip-flop control devices so as to prevent conduction of both of said current control devices while said variable responsive means is initially in said normal condition and to allow conduction of said current control devices when said variable responsive means is initially operated to its abnormal condition, and manually operable acknowledgement means for reversing the initial states of conduction of said current control devices.

3. An annunciator circuit comprising: first visual alarm means for providing at least a normal and an alarm visual indication, second visual alarm means for providing at least a normal and an alarm visual indication, variable responsive means having a normal condition when the variable is normal and an abnormal condition at least when the variable is initially abnormal, a bistable flip-flop control circuit including first and second static, current control devices arranged in respective main current paths and interconnected so that a relatively high conductive state of either device will maintain the other device in a relatively low conductive state and vice versa, and momentary reversal of the conductive condition of either device will reverse the then existing states of both devices, means respectively connecting said first and second visual alarm means in the main current paths of said first and second static current control devices, said visual alarm means normally displaying said normal indications when the associated current control devices are in their relatively low conductive states and displaying said alarm indications when the associated current control devices are in their relatively high conductive states, means for ensuring initial operation of said first static current control device in a relatively high conducting state when conduction of said control devices is permitted, means connecting said variable responsive means in circuit with said bistable flip-flop control device so as to prevent conduction of both of said current control devices while said variable responsive means is initially in said normal condition and to allow condition of said current control devices when said variable responsive means is initially operated to its abnormal condition, manually operable acknowledgement means for reversing the initial states of conduction of said current control devices, and lock-in means responsive to the operation of said variable responsive means to said abnormal condition for preventing discontinuance of the conduction of said current control devices by the return of said variable responsive means to its normal condition.

4. The annunciator circuit of claim 3 wherein said lock-in means includes means for disabling said lock-in circuit when the initial states of conduction of said control devices is reversed by said acknowledgement means.

5. An annunciator circuit including visual alarm means providing an alert indication when energized and a normal indication when de-energized, normally-closed variable responsive switch means which is closed when the variable is normal and is open when the variable is abnormal, and means responsive to said switch means for

controlling said visual alarm and comprising: a bistable flip-flop circuit including a first and a second current control device located in distinct current paths, said visual alarm means being in the current path of said first control device, said bistable circuit including a common path for the flow of current in said distinct current paths, means interconnecting said control devices wherein a relatively high-conductive state of either control device maintains a relatively low conductive state of the other device and momentary reversal of the existing conductive states of either device will reverse the stable states of both devices, means for unbalancing said bistable circuit to favor said first control device for initial high-conduction, normally-closed gating means in said common path for preventing current flow through said control devices when closed and allowing current flow therethrough when open, means for connecting said normally-closed variable-responsive switch means to said gating means to open the same when the related variable becomes abnormal, means connecting a normally-open variable-responsive switch means to said gating means to open the same when the related variable becomes abnormal, and manually operable acknowledgement means connected to said bistable circuit for reversing the initial states of conduction of said control devices and initiating conduction of said second control device to de-energize said visual alarm means.

6. In an annunciator circuit including visual alarm means providing an alert indication when energized and a normal indication when de-energized, primary variable responsive means responsive directly to the variable and having a normal condition when the variable is normal and an abnormal condition when the variable is abnormal, and manually operable acknowledgement means for acknowledging an initial alert condition of said visual alarm means, the improvement comprising control circuit means responsive to said primary responsive means and said acknowledgement means for controlling said visual alarm means and comprising: a bistable flip-flop control circuit including a first and a second current control device located in distinct current paths, said visual alarm means being in the current path of said first control device, means interconnecting said control devices so that a relatively high conductive state of either control device maintains a relatively low conductive state in the other device and momentary reversal of the conductive state of either device will reverse the existing stable states of conduction of both devices, means for unbalancing said bistable circuit to favor said first control device for initial high conduction, gating means for preventing current flow through said control devices when closed and allowing current to flow therethrough when open, said gating means being initially controlled by said primary variable responsive means and being opened to allow current flow in said control devices when said primary variable responsive means is operated to its abnormal condition, gate control means responsive to the conduction of said first control device for maintaining said gating means open independently of said primary variable responsive means until said second control device starts conducting, and means connecting said manually operable acknowledgement means to said bistable circuit for reversing the stable states of conduction of said control devices to initiate high conduction in said second control device and to terminate the high conduction of said first control device to de-energize said visual alarm means in the current path thereof.

7. In an annunciator circuit including first and second visual alarm means each providing an alert indication when energized and a normal indication when de-energized, primary variable responsive means responsive directly to the condition of a variable and having a normal condition when the variable is normal and an abnormal condition when the variable is abnormal, and manually operable acknowledgement means for acknowledging an initial alert condition of the visual alarm means, the improvement comprising control circuit means responsive to said variable responsive means and acknowledgement means for controlling said visual alarm means and comprising: a bistable flip-flop circuit including a first and a second control device located in distinct current paths respectively including said first and second visual alarm means, said bistable circuit including means interconnecting said control devices so that a relatively high conductive state of either control device will energize the associated visual alarm means and maintain a relatively low conductive state in the other device and momentary reversal of the conductive states of either device will reverse the existing stable states of conduction of both devices, means for unbalancing said bistable circuit to favor said first control device for initial high conduction, normally-closed gating means for preventing current flow through said control devices when closed and allowing current flow therethrough when open, said gating means being responsive initially to the operation of said primary variable responsive means to its abnormal condition for opening the gating means whereby to start said first control device in a high-conductive state to energize said first visual alarm means, gate holding means including a first initial lock-in circuit portion responsive to the conduction of said first control device for maintaining said gating means open independently of said primary variable responsive means until said second control device starts conducting, means connecting said manually operable acknowledgement means to said bistable circuit to reverse the initial stable states of conduction of said control devices to de-energize said first visual alarm means and to initiate high conduction of said second control device and energization of said second visual alarm means, manually operable reset means, and said gate holding control means including a second alternate lock-in circuit portion including said reset means for maintaining said gating means open independently of said primary variable responsive means and said first initial lock-in circuit portion until operation of said reset means.

8. In combination, a bistable flip-flop control circuit including a first and a second control device each having a pair of load terminals and a control terminal, a source of unidirectional voltage having a first output terminal providing a first voltage of polarity which, when applied to the control terminal of either of said control devices, can effect a relatively high conductive condition thereof, and a second output terminal providing a voltage of opposite polarity to said first polarity, said load terminals of said control devices being in said separate current paths and the load and control terminals thereof being interconnected so that a high conductive state of one of the control devices will maintain a relatively low conductive state in the other device and momentary reversal of the states of conduction of either of the devices will reverse the stable states of conduction of both devices, visual alarm means in the current path of said first control device and adapted to provide an alarm indication when said first control device is in a high conductive state, means favoring initial conduction of said first control device, visual alarm means connected in the current path of the load terminals of said first control device and adapted to provide a normal indication when the latter control device is in a relatively low conductive state and an alarm indication when the device is in a relatively high conductive state, and a common path for flow of current through said load terminals of said control devices including a third, normally-non-conductive, control device having control and load terminals and normally preventing conduction of said first and second control devices, the load terminals of said third control device being in said common path, a control circuit associated with the control terminal of said third control device for rendering the same conductive and including circuit means for holding the conductive state of said third control device when conduction in said common path begins comprising a fourth control device having load and control terminals,

means connecting the control terminal of said fourth control device to said bistable flip-flop circuit for initial conduction thereof when conduction begins in said common path, means connected between two load terminals of said fourth control device and the control terminal of said third control device for biasing the third control device into a high conductive state when the fourth control device is in a high conductive state independently of the condition of said field switch means, means responsive to initiation of the conduction of said second control device and connected in circuit with the load terminals of said fourth control device for reducing the current through said load terminals to a value which will not sustain high current conduction of said third control device independently of said field switch means, and acknowledgment switch means for reversing the initial states of conduction of said first and second control devices to trigger said first control device to a relatively low conductive state to de-energize said visual alarm means.

9. In an annunciator circuit including first visual alarm means providing an alert indication when energized and a normal indication when de-energized, varialbe responsive gating means which is closed when the variable is normal and open when the variable initially becomes abnormal, and manually operable acknowledgement switch means for acknowledging an initial alert condition of the visual alarm means, the improvement comprising control circuit means responsive to said variable responsive means and acknowledgement means for controlling said visual alarm means and comprising: a bistable flip-flop control circuit including a first and a second transistor control device each having a pair of load terminals and a control terminal, a source of substantially constant unidirectional voltage having a first output terminal providing a voltage of a polarity and magnitude which, if applied to the control terminal of either of said transistor control devices, can effect conduction thereof, and a second output terminal providing a voltage of opposite polarity to said first polarity, means connecting a first pair of corresponding load terminals of said first and second transistor control devices to said first voltage source terminal through separate current paths, the path associated with said first transistor control device including said first visual alarm means, means connecting the other pair of output terminals of said transistor control devices to said second voltage source terminal through said variable responsive gating means so that the transistor control devices are both substantially non-conductive when the variable is normal and conduction thereof is permitted when the variable initially becomes abnormal, first resistance means connected between each terminal of said first pair of load terminals of said transistor control devices and the control terminal of the other control device for providing a bistable flip-flop circuit where a high conductive state of one of the control devices maintains a relatively low conductive state of the other control device and momentary reversal of the conductive states of either device will reverse the stable states of conduction of both devices, second resistance means connected between the control terminal of each of said transistors and the same point on the side of said variable responsive switch means remote from said second voltage source terminal, said first resistance means being of substantially the same value and said second resistance means being of substantially the same value, the latter being substantially smaller than the former, and means effectively shunting sudden voltage changes from said first resistance means of said first control device, thus creating an initial unbalance in the bias conditions of control devices to favor said first control device for initial high conduction, wherein opening of said variable responsive gating means will result in the initial high conduction of said first control device and the consequent energization of said first visual alarm means, and means coupling said acknowledgment switch means between said voltage source and said bistable circuit for reversing the initial conductive states of said control devices to trigger said first control device into a low conductive state and said second control device to a high conductive state.

10. In combination, a bistable flip-flop control circuit comprising a first and a second transistor control device of the same type each having an emitter, collector and base electrode, a source of unidirectional voltage having a first terminal providing a voltage adapted to provide a relatively high conductive state when applied to the base electrode of either of said control devices, and a second terminal providing a voltage adapted to provide a relatively low conductive state when applied to the base electrode of either of said control devices, means connecting the collector electrode of said control devices through separate current paths to said first voltage source terminal, a common path for flow of current in said separate current paths comprising a third transistor control device of the same type as said first and second transistor control devices and having a collector electrode connected to the emitter electrodes of said first and second transistor control devices and an emitter electrode connected to said second voltage source terminal, biasing means normally biasing said third transistor control device to a low conductive state normally to inhibit high current conduction of said first and second control devices, means interconnecting the collector electrode of each of said first and second control devices to the base electrode of the other of same to form a flip-flop bistable circuit where a high conductive state of one device maintains a low conductive state of the other device and momentary reversal of the conductive states of one of the devices will reverse the stable states of conduction of both devices, first control means including field switch means for effecting a high conductive state of said third control device when a variable becomes abnormal, and first visual alarm means in said current path between the collector electrode of said first control device and said first voltage source terminal, manually operable acknowledgment switch means for reversing the initial stable states of conduction of said first and second control devices, a holding circuit for maintaining a high conductive state of said third control devices after the latter initially becomes highly conductive comprising a transistor control device of an opposite type to said first, second and third transistor control devices and having base, emitter and collector electrodes, means coupling the base electrode of said fourth transistor control devices to a point in said common path on the collector side of said third transistor control device for initiating a highly conductive state of said fourth control device when the third control device starts to conduct heavily, first means coupling the emitter electrode of said fourth control device to the collector electrode of said second transistor control devices, means connecting the collector electrode of said fourth transistor control device to the base electrode of said third transistor control device and said second voltage source terminal for biasing said third control device to a highly conductive state when the fourth control device is in a high conductive state, and means associated with said first means for terminating the high conductive state of said fourth control device to disable the holding circuit.

11. In an annunciator circuit including first visual alarm means providing an alert indication when energized and a normal indication when de-energized, variable responsive means and manually operable acknowledgment means for acknowledging an initial alert condition of the visual alarm means, the improvement comprising control circuit means responsive to said variable responsive means and acknowledgment means for controlling said visual alarm means and comprising: a bistable flip-flop control circuit including a first and a second current control device each having a pair of load terminals and a control terminal, a source of unidirectional voltage hav-

ing a first output terminal providing a voltage of a first polarity which, if applied to the control terminal of either of said control devices, can effect conduction thereof, and a second output terminal providing a voltage of opposite polarity to said first polarity, flasher means, means connecting one of the corresponding load terminals of said first and second control devices to said first voltage source terminal through separate current paths, the path associated with said first control device including said first visual alarm means and said flasher means which flashes said first visual alarm means at a visible rate when said first control device is in a state of relatively high conduction, circuit means connected between the other load terminals of said control devices and said second voltage source terminal and which includes said variable responsive means, said variable responsive switch means preventing substantial conduction of said control devices when the variable is normal and allowing conduction therethrough when the variable is abnormal, control circuit means associated with said control terminals of said control devices and including means connected between each of said one load terminals of each control device and the control terminal of the other control device to form a bistable flip-flop circuit where a relatively high conductive state of either control device maintains the other control device in a relatively low conductive state and momentary reversal of the conductive states of either control device reverses the stable states of conduction of both devices, said control circuit means also including means favoring said first control device for initial high conduction, and means coupling said acknowledgment switch means between one of said voltage source terminals and the control terminal of one of said control devices to reverse the initial states of conduction thereof.

12. In an annunciator circuit including first visual alarm means providing an alert indication when energized and a normal indication when de-energized, variable responsive means and manually operable acknowledgement means for acknowledging an initial alert condition of the visual alarm means, the improvement comprising control circuit means responsive to said variable responsive means and acknowledgement means for controlling said visual alarm means and comprising: a bistable flip-flop control circuit including a first and a second current control device each having a pair of load terminals and a control terminal, a source of unidirectional voltage of a first polarity which, if applied to the control terminal of either of said control devices, can effect conduction thereof, and a second output terminal providing a voltage of opposite polarity to said first polarity, flasher means, means connecting one of the corresponding load terminals of said first and second control devices to said first voltage source terminal through separate current paths, the path associated with said first control device including said first visual alarm means and said flasher means which flashes said first visual alarm means at a visible rate when said first control device is in a state of relatively high conduction, means including a resistance connected directly between the said one load terminal of said first control device and said first voltage source terminal to stabilize the voltage at said load terminal, circuit means connected between the other load terminals of said control devices and said second voltage source terminal and which includes said variable responsive means, said variable responsive switch means preventing substantial conduction of said control devices when the variable is normal and allowing conduction therethrough when the variable is abnormal, control circuit means associated with said control terminals of said control devices and including means connected between each of said one load terminal of each control device and the control terminal of the other control device to form a bistable flip-flop circuit where a relatively high conductive state of either control device maintains the other control device in a relatively low conductive state and momentary reversal of the conductive states of either control device reverses the stable states of conduction of both devices, said control circuit means also including means favoring said first control device for initial high conduction, and means coupling said acknowledgement switch means between one of said voltage source terminals and the control terminal of one of said control devices to reverse the initial states of conduction thereof.

13. In an annunciator circuit including first visual alarm means providing an alert indication when energized and a normal indication when de-energized, variable responsive means and manually operable acknowledgement means for acknowledging an initial alert condition of the visual alarm means, the improvement comprising control circuit means responsive to said variable responsive means and acknowledgement means for controlling said visual alarm means and comprising: a bistable flip-flop control circuit including a first and a second transistor current control device each having a pair of load terminals and a control terminal, a source of unidirectional voltage having a first output terminal providing a voltage of a first polarity which, if applied to the control terminal of either of said transistor control devices, can effect conduction thereof, and a second output terminal providing a voltage of opposite polarity to said first polarity, means connecting one of the corresponding load terminals of said first and second transistor control devices to said first voltage source terminal through separate current paths, the path associated with said first control device including said first visual alarm means, said bistable circuit including a common path comprising a series circuit of a voltage stabilizing impedance means and said variable responsive means, means connecting one end of said common path to said second voltage source terminal and the other end thereof to the other load terminals of said control device, said variable responsive switch means preventing substantial conduction of said control devices when the variable is normal and allowing conduction therethrough when the variable is abnormal, control circuit means associated with said control terminals of said control devices and including means connected between each of said one load terminals of each control device and the control terminal of the other control device to form a bistable flip-flop circuit where a relatively high conductive state of either control device maintains the other control device in a relatively low conductive state and momentary reversal of the conductive states of either control device reverses the stable states of conduction of both devices, said control circuit means also including means favoring said first control device for initial high conduction, and means coupling said acknowledgement switch means between one of said voltage source terminals and the control terminal of one of said control devices to reverse the initial states of conduction thereof.

14. In an annunciator circuit including respective visual alarm means for indicating the conditions of respective variables to be monitored and each providing an alert indication when energized and a normal indication when de-energized, primary variable responsive means associated with each variable to be monitored and having a normal condition when the associated variable is normal and an abnormal condition when the associated variable is abnormal, the improvement comprising respective control circuits responsive to said respective variable responsive means for energizing the associated visual alarm means when in a given state of operation, said control circuits each comprising a bistable flip-flop circuit including a first and a second static element current control device located in distinct current paths, means interconnecting said control devices for providing a flip-flop action wherein a relatively high conductive state of either control device will maintain a relatively low conductive state in the other device and momentary reversal of the conductive states of either device will reverse the existing

stable states of conduction of both devices, and means favoring the associated first control device for initial high conduction, first normally-closed gating means for preventing current flow through said associated control devices thereof when closed and allowing current flow therethrough when open, a common lock-out bus to which all of said variable responsive means are connected, a source of potential for the bistable circuits to which said current paths are connected, second normally-closed gating means connected between said lock-out bus and said potential source, means connecting each of the variable responsive means to said associated first gating means for opening the latter when the associated variable responsive means is in its abnormal condition and said second gating means is closed, to couple said potential source to said first gating means, a control circuit for closing said second gating means as a first control device of any of said bistable circuits initially becomes conductive, said conduction of said first control device constituting said given condition which operates the associated visual alarm means to prevent the opening of the first gating means and hence the operation of any bistable circuit associated with a variable which becomes abnormal following a first-to-become abnormal variable, and each of said bistable circuits further including gate holding means for maintaining the associated first gating means open independently of the condition of the associated variable responsive means once the associated first control device starts conducting.

15. An annunciator including: visual alarm means, condition responsive means having a normal variable indicating state and an abnormal variable indicating state, manually operable acknowledgement means, and control circuit means responsive to said condition responsive means and said manually operable acknowledgement means to provide different alarm indications on said visual alarm means comprising: a static element bistable circuit having two operating states where relatively large current is drawn and a non-operating state where relatively no current is drawn, means for setting said bistable circuit into one of its operating states when said condition responsive means is in its abnormal variable-indicating state, means for operating said visual alarm means to provide said initial alarm indication in response to operation of said bistable circuit into said one operating state, means for setting said bistable circuit into its other operating state when said manually operable acknowledgement means is momentarily operated, means for changing said initial alarm indication on said visual alarm means to an acknowledged alarm indication when said bistable circuit is in its other operating state, said bistable circuit being rendered inoperative to cancel said alarm indication on said visual alarm means after said condition responsive switch means returns to its normal variable indicating state.

16. In an annunciator circuit including visual alarm means, and condition responsive means having a normal variable indicating state and an abnormal variable indicating state, control circuit means interposed between said condition responsive means and said visual alarm means to provide an alarm indication on said visual alarm means and comprising: a source of current, a pair of static current control devices connected to said current source and interconnected with one another to form a bistable control circuit having at least two states, one of which is a state wherein both of said static current control devices are simultaneously in a non-conductive condition and another state wherein at least one of said static current control devices is in a conductive condition, means connecting said condition responsive means into operative relation with said bistable control circuit for operating the same in said one state wherein the associated static current control devices are both in their non-conductive conditions, and for operating the same into its other state wherein at least one current control device is in a conductive condition, and means coupling said visual alarm means to said bistable control circuit for de-energizing said visual alarm means when said bistable control circuit is in said one operating state and for energizing the same when said bistable control circuit is in said other state.

17. In an annunciator system for monitoring a number of variables, visual alarm means for each variable, condition responsive means for each variable having a normal variable indicating state and an abnormal variable indicating state, manually operable acknowledgement means, manually operable reset means, and control circuit means for each variable responsive to said condition responsive means, and said acknowledgement and reset means, each of said control circuit means comprising: a first and a second static element bistable circuit each having two operating states, means for operating said first bistable circuit to one of its operating states when said condition responsive means is changed from its normal to its abnormal variable indicating state, means for operating said visual alarm means to provide an initial alarm indication following operation of said first bistable circuit into said one operating state, means for setting said second bistable circuit into one of its operating states when said manually operable acknowledgement means is operated, means for changing said initial alarm indication on said visual alarm means to an acknowledged alarm indication when said second bistable circuit is triggered to said one operating state by said acknowledgement means, and means for setting said first bistable circuit into its other operating state upon operation of said manually operable reset means provided said condition responsive means is in its normal variable indicating state, said visual alarm means being rendered inoperative upon operation of said first bistable circuit to said other operating state by said manually operable reset means.

18. In an annunciator system for monitoring a number of variables: variable responsive means for each variable responsive directly to the variable and having a normal condition when the variable is normal and an abnormal condition when the variable is abnormal, manually operable acknowledgement switch means, visual alarm means for each variable, and a control circuit for each variable responsive to said variable responsive means and said acknowledgement switch means for providing an initial visual alarm indication on said visual alarm means when the variable responsive means is operated to its abnormal condition by the associated variable and a different acknowledged visual alarm indication thereon when said acknowledgement switch means is operated, each of said control circuits comprising a first and a second pair of static current control devices and related means interconnected to form respective circuits each having a first and a second state of operation, means coupling said variable responsive means to the circuit formed by said first pair of static current control devices for effecting the triggering of the circuit formed thereby from its first to its second state of operation when said variable responsive means is operated to said abnormal condition and to then maintain this state of operation at least until said variable responsive means is returned to its normal condition, means coupling said acknowledgement switch means to the circuit formed by said second pair of current control devices for effecting the triggering of the circuit formed thereby from its first to its second state of operation upon momentary operation of said latter switch means, means interconnecting the circuit formed by said first and second pair of current control devices which effect the triggering of the circuit formed by said second pair of current control devices into its first state of operation when the circuit formed by said first pair of current control devices is triggered into one of its states of operation, and means coupling said visual alarm means to said control circuit to provide an initial visual alarm indication when the circuit formed by said first pair of

current control devices is in its second state of operation and the circuit formed by said second pair of current control devices is in its first state of operation and to provide said acknowledged visual alarm indication when the circuit formed by said first pair of current control devices is in its second state of operation and the circuit formed by said second pair of current control devices is in its second state of operation.

19. In an annunciator system for monitoring a number of variables: variable responsive means for each variable responsive directly to the variable and having a normal condition when the variable is normal and an abnormal condition when the variable is abnormal, manually operable acknowledgement switch means, manually operable reset switch means, visual alarm means for each variable, and a control circuit for each variable responsive to said variable responsive means and said acknowledgement and reset switch means for providing an initial visual alarm indication on said visual alarm means when the variable responsive means is operated to its abnormal condition by the associated variable and a different acknowledged visual alarm indication thereon when said acknowledgement switch is operated, each of said control circuits comprising a first and a second pair of static current control devices and related means interconnected to form respective circuits each having a first and a second state of operation, means coupling said variable responsive means to the circuit formed by said first pair of static current control devices for effecting the triggering of the circuit formed thereby from its first to its second state of operation when said variable responsive means is operated to said abnormal condition and to then maintain this state of operation at least until said variable responsive means is returned to its normal condition, means coupling said acknowledgement switch means to the circuit formed by said second pair of current control devices for effecting the triggering of the circuit formed thereby from its first to its second state of operation upon momentary operation of said latter switch means, means interconnecting the circuit formed by said first and second pair of current control devices which effect the triggering of the circuit formed by said second pair of current control devices into its first state of operation when the circuit formed by said first pair of current control devices is triggered into one of its states of operation, and means coupling said visual alarm means to said control circuit to provide an initial visual alarm indication when the circuit formed by said first pair of current control devices is in its first state of operation and the circuit formed by said second pair of current control devices is in its first state of operation and to provide said acknowledged visual alarm indication when the circuit formed by said first pair of current control devices is in its second state of operation and the circuit formed by said second pair of current control devices is in its second state of operation, and means coupling said reset switch means to the circuit formed by said first pair of current control devices for effecting the triggering of the circuit formed thereby from its second to its first state of operation upon momentary operation of said latter switch means provided said variable responsive means has returned to its normal condition.

20. In an annunciator circuit including visual alarm means, condition responsive means having a normal variable indicating state and an abnormal variable indicating state, and manually operable acknowledgement switch means, control circuit means interposed between said condition responsive means, said manually operable acknowledgement means and said visual alarm means to provide different alarm indications on said visual alarm means respectively in response to operation of said condition responsive means and said acknowledgement switch means, said control circuit comprising a first and a second pair of static current control devices each arranged to form a bistable circuit having at least two states, one of the states being a normal one in which both static current control devices are in a nonconductive condition and another state wherein at least one of said static current control devices is in a conductive condition, means connecting said condition responsive means to one of said bistable control circuits for operating the same into said one state, where both said static current control devices are in their nonconductive condition, when the condition responsive means is in its normal variable indicating state, and for operating the same into said other state when the condition responsive means is in its abnormal variable indicating state, means coupling said acknowledgment means to the other bistable control circuit for operating the same from said one normal state, where both static current control devices thereof are in their non-conductive states, into said other state, and means coupling said visual alarm means to said bistable control circuits for providing an initial visual alarm indication when said one bistable control circuit is first triggered by initial operation of said condition responsive means and for providing a different visual alarm indication when said other bistable control circuit is triggered by said acknowledgment switch means.

21. In an annunciator circuit including respective visual alarm means for indicating the conditions of respective variables to be monitored and each providing an alert indication when energized and a normal indication when de-energized, and primary variable responsive means associated with each variable to be monitored and having a normal condition when the associated variable is normal and an abnormal condition when the associated variable is abnormal, the improvement comprising respective control circuits responsive to said respective variable responsive means for energizing the associated visual alarm means when in a given state of operation, said control circuits each comprising: a static element bistable flip-flop circuit having two operating states, means for triggering said bistable circuit into one of its operating states when the associated variable responsive means is operated to its abnormal condition, means coupling each visual alarm means to the associated bistable circuit for operating the same to provide said alert indication when the associated bistable circuit is triggered into said one operating state, holding means for maintaining said bistable circuit in said one operating state independently of the condition of the associated variable responsive means, and lock-out means immediately responsive to the triggering of any of said bistable circuits into said one operating state for preventing similar operation of the other bistable circuits.

22. In an annunciator circuit including respective visual alarm means for indicating the conditions of respective variables to be monitored and each providing an alert indication when energized and a normal indication when de-energized, and primary variable responsive means associated with each variable to be monitored and having a normal condition when the associated variable is normal and an abnormal condition when the associated variable is abnormal, the improvement comprising respective control circuits responsive to said respective variable responsive means for energizing the associated visual alarm means when in a given state of operation, said control circuits each comprising: a static element bistable flip-flop circuit having two operating states, means for triggering said bistable circuit into one of its operating states when the associated variable responsive means is operated to its abnormal condition, means coupling each visual alarm means to the associated bistable circuit for operating the same to provide said alert indication when the associated bistable circuit is triggered into said one operating state, and lock-out means immediately responsive to the triggering of any of said bistable circuits into said one operating state for preventing similar operation of the other bistable circuits.

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