Sept. 17, 1957 W. G. ROWELL 2,807,008

FAIL-SAFE SYSTEM AND TECHNIQUE

Filed May 8, 1956 2 Sheets-Sheet 1

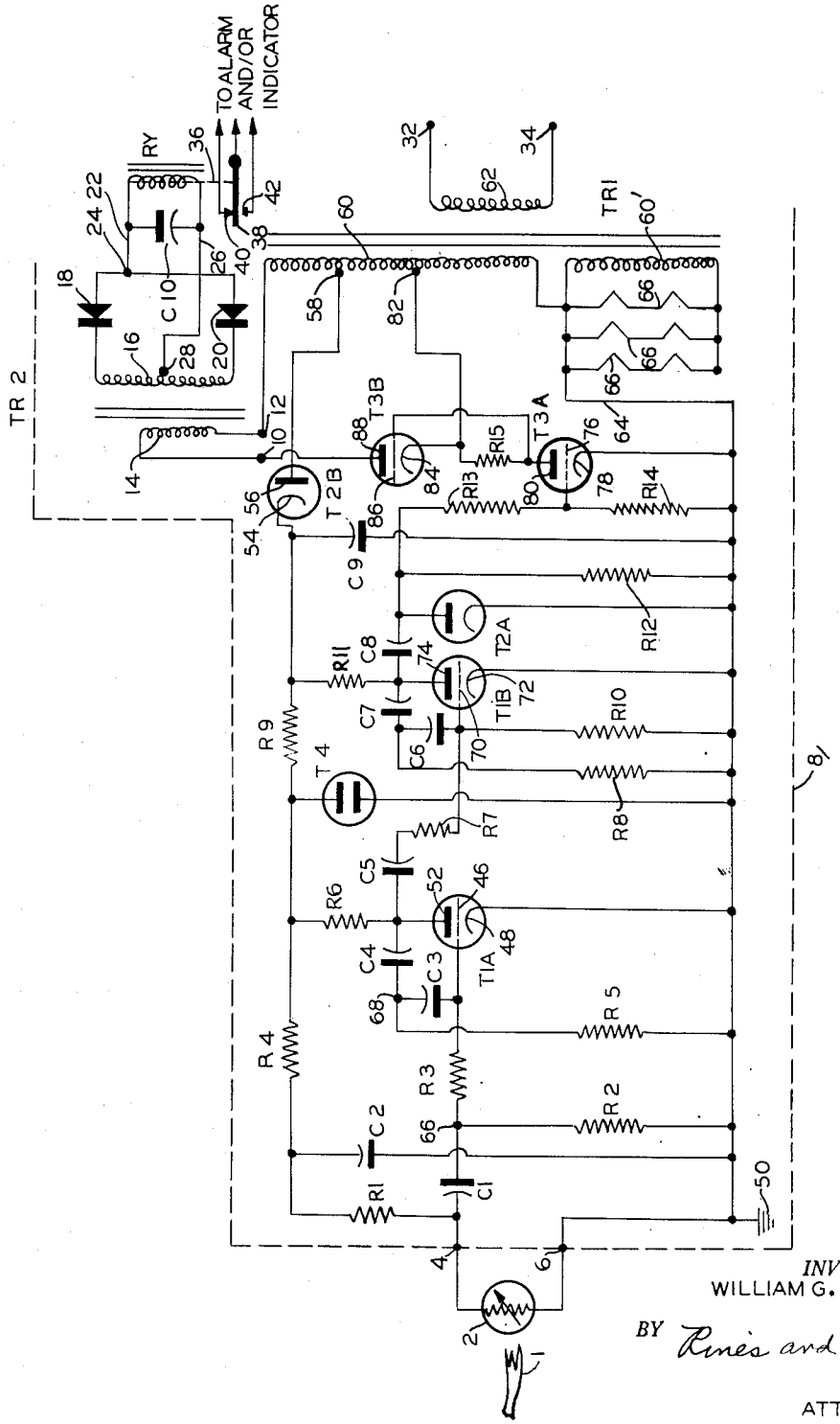

FIG. 1

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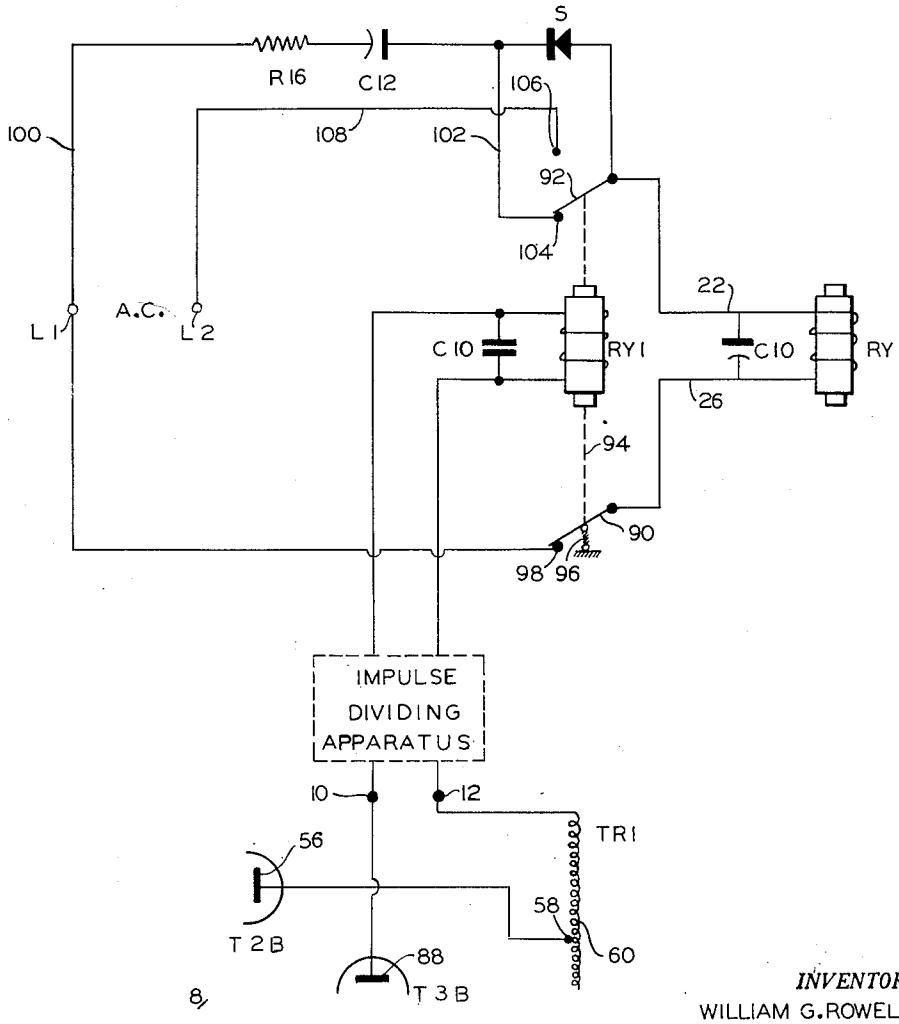

FIG. 2

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2,807,008

FAIL-SAFE SYSTEM AND TECHNIQUE

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Application May 8, 1956, Serial No. 583,571

23 Claims. (Cl. 340—213)

The present invention relates to fail-safe systems and techniques and, more particularly, to systems for and techniques for monitoring events that are accompanied by a characteristic fluctuating or perturbating condition or phenomenon.

As is disclosed in my copending applications, Serial Nos. 375,224, now Patent No. 2,798,213, and 425,296, now Patent No. 2,798,214, filed on or about August 19, 1953, and April 23, 1954, respectively, and in an article entitled "Fail-safe gets new meaning" by William G. Rowell and A. B. Van Rennes, appearing on pages 79 through 81, Control Engineering, March 1956, and in a further article by William G. Rowell, entitled "Fail-safe monitor," appearing on pages 28 through 31 of Electronic Design, March 1, 1956, monitoring or other systems of a wide variety of electrical, electronic, mechanical or electro-mechanical types, may now be rendered completely fail-safe. The term "fail-safe" is intended to connote that the system is incapable of producing a false indication of the presence of an event-to-be-detected or producing an indication that the system is operative when, in fact, one or more components of the system has or have failed. The importance of such a safeguard for the protection of life and property, or, at the very least, for providing economical operation, is stressed in the said applications and articles.

While the systems and techniques discussed in the said applications and articles are entirely satisfactory and have been found to work admirably well in practice, they may be somewhat simplified in the case of the monitoring of events that of themselves are inherently accompanied by characteristic fluctuations. Included in events of this character are flames such as, for example, those produced by oil or gas burners and the like. Flames may be monitored by sensing the visible-light condition accompanying some flames, the infra-red or heat condition accompanying some flames, or the sounds of combustion accompanying the production of a flame. As discussed in the said applications, flames are known to have inherently associated with them fluctuating light, heat and sound characteristics of definite predetermined frequency bands. The range of the rates of fluctuation of the infra-red or heat characteristics generated by gas flames and the like, for example, is from about 5 to about 25 cycles per second. The range of sound-frequency fluctuations for the flames of oil burners and the like, as another illustration, includes frequencies of the order of 100 cycles and higher.

Underlying the technique disclosed in application Serial No. 375,224, as explained, also, in the said articles, is the accompanying of a principal signal by a checking or modifying signal of predetermined characteristics. In accordance with the present invention, the event-to-be-detected, provides its own checking-signal or modifying-signal fluctuation modification of the principal signal, permitting the employment of less apparatus. When so simplified by means of the present invention, however, the systems and methods still operate in accordance with

the principles and modes of operation disclosed in the said applications, but they do so with the aid of less equipment.

An object of the present invention, accordingly, is to provide a new, improved and simplified fail-safe system and technique of the character described. In summary, the present invention contemplates the employment of means responsive to a characteristic of an event-to-be-detected, which event inherently has fluctuations of a rate or rates lying within a predetermined range of rates the longest period of which is less than a predetermined time interval. The responsive means produces a signal indication of the presence of such a characteristic modified with fluctuations corresponding to the said fluctuations of the event. The fluctuation-modified signal is applied to the input of the monitoring system and is transmitted through the system to the output thereof. Means is provided for recovering or reproducing the fluctuations from the fluctuation-modified signal in the output of the system, as is means for indicating the failure so to recover or reproduce fthe fluctuations for a time substantially equal to the said predetermined time interval. Preferred constructional details are hereinafter presented.

A further object is to provide such a system and technique that are particularly adapted for the monitoring of flames and the like.

Other and further objects will be explained hereinafter and will be more particularly pointed out in the appended claims.

The invention will now be described in connection with the accompanying drawings Fig. 1 of which is a circuit diagram of a preferred embodiment of the invention; and

Fig. 2 is a similar diagram of a modification.

While, for purposes of illustration, the invention will hereinafter be described in connection with an electronic flame-monitor system, it is to be understood that the invention is by no means limited thereto and that it may equally well be applied to many different kinds of electrical, electronic, mechanical and electro-mechanical systems, as discussed in the said applications and articles.

In Fig. 1, a radiation monitor sensor or detector device is shown at **2**, responsive to radiations from a flame **1**, such as, for example, a gas or oil burner flame and the like. While the sensor **2** could be a microphone for responding to specific-frequency sound fluctuations characteristically accompanying the production of the flame **1**, as before explained, or a photocell for receiving the visible light characteristic, ultra-violet or other conditions of the flame **1**, it is preferred to employ a photocell **2** of the lead-sulphide variety and the like, which will respond to the infra-red- or heat-fluctuation characteristics of the flame **1**, occurring within the said 5 to 25 cycle-per-second range. The photocell infra-red or heat sensor or detector **2** is connected to the input terminals **4**, **6** of a high input-impedance electronic flame-monitor amplifier system **8**. The system **8** is shown as a conventional commercial type embodying a pair of alternating-current amplifier stages comprising electron or vacuum tubes T1A and T1B and a pair of further amplifier tubes T3A and T3B of the direct-current type. In the output of the system **8**, represented at the terminals **10**, **12**, shown disposed above the amplifier T3B, a transformer TR2 is provided, having a primary winding **14** electromagnetically coupled to a step-up secondary winding **16**. The secondary winding **16** is, in turn, shunted betwen its upper and lower terminals by similarly polarized rectifiers **18** and **20**. An ultimate direct-current load relay RY is connected by a conductor **22** to the junction **24** of the rectifiers **18** and **20**, and by a conductor **26** to an intermediate tap **28** of the secondary winding **16**.

The transformer TR2 is tuned, as by appropriate well-

known design of the mass of the magnetic core material associated therewith, to provide a low-impedance substantially maximum response to electrical fluctuations fed thereto of rate or rates within the said 5 to 25 cycle-per-second range or any band within that range. The transformer TR2 will then present a high-impedance low-level or negligible response to all other fluctuation rates of frequencies lying outside the said range such as, for example, the sixty-cycle frequency available at the alternating-current mains terminals 32, 34.

The load relay RY, as before stated, is illustrated as a direct-current type of relay that may control, through an armature 36, a switch 38 that cooperates with either of a pair of contacts 40, 42 in order to operate an alarm, indicator, control or other device, as explained in the said applications and articles. The relay RY is provided with a holding capacitor C10, shunting the same, to provide slow-release-response characteristics. By adjusting the value of the capacitor C10 and the impedance of the relay winding, the relay RY, after being energized, will de-energize only after the elapse of an interval of time corresponding to the before-mentioned predetermined time interval greater than the longest period in the said 5 to 25 cycle-per-second range. Other types of delayed or slow-response indicators, alarms or controls may, of course, also be employed, as discussed in the said applications and articles.

Unlike prior-art monitor circuits of the type illustrated in Fig. 1, the fluctuation-modified electrical signal fed into the input terminals 4, 6 of the system 8 and amplified in the pair of alternating-current amplifiers T1A, T1B is not integrated, smoothed-out or rectified to remove the fluctuations before application to the output terminals 10, 12. To the contrary, the fluctuation-modified signal is passed through the further pair of amplifiers T3A, T3B and to the output terminals 10, 12, whence the fluctuations are stepped-up or increased in amplitude by the transformer TR2, and then rectified to hold the relay RY energized. So long as the repetitive fluctuations within the said range of rates that were passed from the input terminals 4, 6 through the system 8 to the output terminals 10, 12 are recovered or reproduced in the transformer TR2 from the amplified fluctuation-modified electrical signal, accordingly, the load relay RY will remain energized. Upon failure so to recover or reproduce the fluctuations for a time substantially equal to the said predetermined time interval, the relay RY will become deenergized and operate the alarm, indicator, control or other apparatus. The complete monitor from the sensor 2 to the rectifiers 18, 20, and including all of the electrical and electronic components of the system 8, is thus completely fail safe.

The details of the system 8 may now be explained. The input terminal 4 is connected through a coupling capacitor C1 and a grid resistor R3 to the control-grid electrode 46 of the amplifier tube T1A. The amplifier T1A is shown as of the normally conductive triode variety having its cathode 48 directly connected to the ground or chassis terminal 50, and its plate or anode 52 connected by a plate load resistor R6 and a current-limiting resistor R9 to a plate voltage rectifier T2B. The resistor R9 actually connects to the cathode 54 of the rectifier T2B, the anode or plate 56 of which is connected to an intermediate tap 58 of the secondary winding 60 of a power transformer TR1. The primary winding 62 of the power transformer TR1 is energized from the mains terminals 32, 34. The upper end of the secondary winding 60 is connected to the output terminal 12 and, through the primary winding 14 of the step-up transformer TR2, to the output terminal 10. The lower end of the secondary winding 60 is connected by conductor 64 to the ground terminal 50. Heater windings 66 for the amplifier tubes T1A, T1B, T2A, T2B and T3A and T3B are energized by the further secondary winding 60' of the power transformer TR1, also provided by the conductor 64.

Associated with the first alternating-current amplifier stage is a type filter network tuned or adjusted to pass the desired range or band of fluctuation frequencies, such as the before-mentioned 5 to 25 cycle-per-second range or any desired band within that range. The filter network is shown comprising a shunt-connected resistor R2 connected from a point 66 between the condenser or capacitor C1 and the resistor R3 to the ground terminal 50, the resistor R3, and a further capacitor C3 connected from the control grid 46 of the tube T1A through a resistor R5 to the ground terminal 50. A direct-current blocking capacitor C4 is connected from the plate or anode 52 of the tube T1A to the junction 68 between the capacitor C3 and the resistor R5. A plate-voltage supply filter-smoothing capacitor C2 is connected between the ground terminal 50 and the left-hand terminal of a current-limiting resistor R4. The right-hand terminal of the resistor R4 connects with the before-mentioned limiting resistor R9. A similar smoothing capacitor C9 is connected from the cathode 54 of the plate-supply voltage rectifier T2B to ground. A voltage-regulator gaseous-discharge diode T4 is disposed between the said right-hand terminal of the current-limiting resistor R4 and the ground terminal 50. Still an additional current-limiting resistor R1 is connected between the input terminal 4 of the system 8 and the upper terminal of the capacitor C2.

The output of the normally conducting alternating-current amplifier stage T1A is coupled by the capacitor C5 and resistor R7 to the control-grid electrode 70 of the next successive amplifier stage T1B. The cathode 72 of the tube T1B is connected to the ground terminal 50 and its plate or anode 74 is connected through a plate-load resistor R11 to the cathode 54 of the plate-supply voltage rectifier T2B. The amplifier stages T1A and T1B may be disposed in a single envelope, such as the type 12SL7GT double triode, or they may comprise separate tubes. Similar remarks apply in connection with the amplifier stages T3A, T3B, which may be of the type 12SN7GT, and the diode T2B and a further diode T2A, which, in turn, may be a type 12H6 double diode. A π-type filter network R8, C6, R10, corresponding to the network R2, R3, C3, R5, previously discussed in connection with the amplifier stage T1A, is connected in the input circuit of the second amplifier stage T1B between the control-grid electrode 70 thereof and the cathode 72. A direct-current blocking capacitor C7 is connected between the plate or anode 74 of the tube T1B and the upper terminal of the filter capacitor C6.

The output of the amplifier T1B is coupled by capacitor C8 and resistor R13 to the control-grid electrode 76 of the third amplifier stage T3A of the direct-current type. The resistor R13 serves with the resistor R14, the latter of which is connected between the control-grid electrode 76 and the grounded cathode 78 of the tube T3A, as grid-bias resistors. They are shunted by a further resistor R12 that serves with the capacitor C8 as a filter network and serves, also, as the plate-load resistor for the previously mentioned further diode T2A. That diode T2A, in turn, is connected between the coupling capacitor C8 and the ground terminal 50 and furnishes direct-current grid-bias voltage for the amplifier T3A. The amplifier T3A, like the amplifiers T1A and A1B is normally conducting and its plate or anode 80 is connected through a plate-load resistor R15 to a further intermediate terminal 82 of the secondary winding 60 of the power transformer TR1. The resistor R15 also serves as a grid-bias resistor for the last amplifier stage T3B in view of its connection between the cathode 84 and the control-grid electrode 86 thereof. The plate or anode 88 of the tube T3B is, in turn, connected to the output terminal 10.

The fluctuation-modified electrical signal applied to the input 4, 6 of the system 8 is thus fed to the normally

conducting amplifier T1A, producing amplified fluctuations at the plate 52 that are, in turn, amplified by the second amplifier T1B. The corresponding negatively-going fluctuating voltages appearing at the capacitor C8 repetitively cut-off or reduce the conduction of the amplifier T3A. Since the grid 86 of the tube T3B is normally maintained at a negative potential, the cut-off of the tube T3A will reduce this negative potential so that the tube T3B will conduct. Repetitive conduction of the amplifier T3B will result in the reproducing or recovering of the fluctuations in the transformer TR2.

As is explained in the said applications and articles, other types of output devices besides the transformer TR2 may be employed. In Fig. 2, which may be preferred in view of its simplicity and readily obtainable conventional components, accordingly, the terminals 10 and 12 of Fig. 1 are shown connected to an electromagnetic relay RY1 shunted by a holding capacitor represented by the same nomenclature C10 as the holding capacitor of the relay RY and adapted to respond to fluctuations within the said range or band. The relay RY1, moreover, should have sufficiently high alternating-current impedance to prevent its operation at the power or mains frequency, as discussed in connection with the transformer TR2 of Fig. 1. A suppression circuit for maintaining the ultimate load relay or other device RY energized so long as the fluctuations are recovered and reproduced by synchronous energization and deenergization of the relay RY1, is shown as comprising a capacitor C12 for alternately storing direct-current energy and feeding the same to the slow-release load RY in synchronism with the recovery of the fluctuations in the output of the stystem 8. This result is effected by the switching members 90 and 92 that are pivotable between alternate positions in response to the upward movement of the armature 94 of the relay RY1 upon energization of the same, and the downward movement in response to the restoring power of the spring 96 upon de-energization of the relay RY1. With the relay RY1 de-energized, the switch 90, which is permanently connected by the conductor 26 to the lower terminals of the load relay RY and its shunt capacitor C10, engages the contact 98 and establishes an electrical-circuit connection by a conductor 100 to a resistor R16. The resistor R16 is connected to the left-hand terminal of the storing capacitor C12. The right-hand terminal of the storing capacitor C12 is connected by the conductor 102 to a contact 104 and thence through the switch member 92 to the conductor 22 that feeds the upper terminals of the load relay RY. In the illustrated position, therefore, the capacitor C12 feeds out its stored energy to the load relay RY. It should be noted, moreover, that the hereinafter described rectifier S is at this time shunted by the low-impedance path of the switching member 92. When the relay RY1 is in its energized condition, however, the switch members 90 and 92 are moved to their upper positions, breaking the connection with contact 98 and making connection with contact 106, respectively. In such position, the capacitor C12 charges or stores direct-current potential in an electric circuit traceable from the terminal L1 of a source of alternating-current energy A. C., which may be the same source as at the terminals 32, 34 of Fig. 1, by way of the conductor 100, the charging impedance R16, the capacitor C12, the rectifier S, the switch member 92, the contact 106, a further conductor 108 and the other terminal L2 of the source. The continual recovery of the desired range of fluctuations in the relay RY1 will therefore maintain the switching means repetitively alternating between its upper and lower positions, thus keeping the load RY energized. Upon failure to recover the fluctuations for a period greater than the before-mentioned predetermined time interval, the relay RY will thereupon provide an appropriate indication.

In all cases, however, all the numerous unsafe failure possibilities that exist in conventional prior-art monitor circuits 8 of the type illustrated in Fig. 1 are eliminated by the present invention. Included in such possibilities are the following conditions which have been observed in practice: an opening in the winding or in a connection in the lower portion of the winding 60 of the transformer TR1; an open-circuit or defective power filter capacitor C2 or C9; a short-circuited plate-supply rectifier T2B; a short-circuit in the grid-to-cathode circuit of the tube T3B or the wiring thereto; or an anode-to-cathode short in the tube T3B, to mention but a few.

If desired, the fluctuation impulses may be counted down or divided so that the relay RY1 of Fig. 2, or the load RY of Figs. 1 and 2, receives energization once for every group of so-many fluctuations. In such a case, the period of the count-down will be less than the previously discussed predetermined time interval. For purposes of illustration, this result is indicated as effected in Fig. 2 by the dotted block labelled "Impulse-Dividing Apparatus," which may assume the form of any well-known cut-down apparatus, such as a multivibrator circuit or a condenser-step charger, and the like. Instead of having irregular fluctuation rates, moreover, the fluctuations may be fed to multivibrator and similar-type circuits for regularizing the fluctuations into a constant rate, as is well known.

In summary, therefore, the perturbations caused by the event to be detected are, in addition to meeting the amplifying and other conditions of the system, also expressly uitilized as a checking signal for determining the operability of the sensor 2, the amplifying system 8, and the output thereof to the coil of relay RY.

As before explained, moreover, other types of sensors may be employed as may other types of monitor, detecting or receiving systems. Resistance, reactance or bridge-type sensors or detectors, as further illustrations, may be employed, as may oscillator circuits and the like. Other types of suppression circuits or impulse-responsive devices, including those disclosed in the said applications and articles, may also be utilized.

Further modifications will occur to those skilled in the art and all such are considered to fall within the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A system for monitoring an event having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, means responsive to a characteristic of the event for producing an electrical signal indicative of the presence of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the event, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means for recovering the fluctuations from the fluctuation-modified signal in the output of the system, and means operable in the event of failure so to recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

2. A system for monitoring an event having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than predetermined time interval, the system having, in combination, an input, an output, means responsive to a characteristic of the event for producing an electrical signal indicative of the presence of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the event, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means selectively responsive to electrical

fluctuations of rate lying within the said predetermined range of rates for recovering the fluctuations from the fluctuation-modified signal in the output of the system, and means operable in the event of failure so to recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

3. A system for monitoring an event having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, means responsive to a characteristic of the event for producing an electrical signal indicative of the presence of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the event, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means comprising a relay of low impedance to electrical fluctuations of rate lying within the said predetermined range of rates and of high impedance to fluctuations of rate outside the said predetermined range of rates for recovering the fluctuations from the fluctuation-modified signal in the output of the system, and means operable in the event of failure so to recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

4. A system for monitoring an event having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, means responsive to a characteristic of the event for producing an electrical signal indicative of the presence of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the event, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means comprising a stepup transformer selectively responsive to electrical fluctuations of rate lying within the said predetermined range of rates for recovering the fluctuations from the fluctuation-modified signal in the output of the system, and means operable in the event of failure so to recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

5. A system for monitoring an event having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, means responsive to a characteristic of the event for producing an electrical signal indicative of the presence of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the event, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, switching means responsive to the recovering of the fluctuations from the fluctuation-modified signal in the output and adapted to occupy alternate positions at the said fluctuation rate or rates, means for supplying alternating-current potential of a rate outside the said predetermined range of rates, rectifying means, direct-current potential-storing means, an electric circuit operative when the switching means occupies one of its positions for connecting the supplying means to the storing means through the rectifying means in order to store direct-current potential in the storing means, a slow-response direct-current load adapted to respond in a period of time substantially equal to the said predetermined time interval, and a further electric circuit operative when the switching means occupies its alternate position to connect the storing means to the load.

6. A system for monitoring an event having inherent

fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, means responsive to a characteristic of the event for producing an electrical signal indicative of the presence of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the event, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, relay-controlled switching means responsive to the recovering of the fluctuations from the fluctuation-modified signal in the output and adapted to occupy alternate positions at the said fluctuation rate or rates, means for supplying alternating-current potential of a rate outside the said predetermined range of rates, rectifying means, capacitor means, an electric circuit operative when the switching means occupies one of its positions for connecting the supplying means to the capacitor means through the rectifying means in order to store direct-current potential in the capacitor means, a slow-response direct-current capacitor-shunted load relay adapted, after being energized, to release in a period of time substantially equal to the said predetermined time interval, and a further electric circuit operative when the switching means occupies its alternate position to connect the first-named capacitor to the load relay in order to maintain the same energized.

7. A system for monitoring an event having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, means responsive to a characteristic of the event for producing an electrical signal indicative of the presence of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the event, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means for recovering the fluctuations from the fluctuation-modified signal in the output of the system and for producing further electrical impulses, one corresponding to a group of the said fluctuations and of period less than the said predetermined time interval, and means operable in the event of failure to receive the said impulses for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

8. A system for monitoring an event having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, means responsive to a characteristic of the event for producing an electrical signal indicative of the presence of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the event, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means for recovering the fluctuations from the fluctuation-modified signal in the output of the system, a slow-response load adapted, after being energized, to de-energize in a period of time equal to the said predetermined time interval, and means for alternately storing energy and delivering the stored energy to the load synchronously with the recovering of the said fluctuations.

9. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, a detector responsive to a characteristic of the flame for producing an electrical signal indicative of the detection of such characteristic and modified with electrical fluctu-

ations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means for recovering the fluctuations from the fluctuation-modified signal in the output of the system, and means operable in the event of failure so to recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

10. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, a detector responsive to the infrared or heat characteristic of the flame for producing an electrical signal indicative of the detection of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means for recovering the fluctuations from the fluctuaion-modified signal in the output of the system, and means operable in the event of failure so to recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

11. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, a detector responsive to the infra-red or heat characteristic of the flame for producing an electrical signal indicative of the detection of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means selectively responsive to electrical fluctuations of rate lying within the said predetermined range of rates for recovering the fluctuations from the fluctuation-modified signal in the output of the system, and means operable in the event of failure so to recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

12. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, a detector responsive to the infra-red or heat characteristic of the flame for producing an electrical signal indicative of the detection of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means comprising a relay of low impedance to electrical fluctuations of rate lying within the said predetermined range of rates and of high impedance to fluctuations of rate outside the said predetermined range of rates for recovering the fluctuations from the fluctuation-modified signal in the output of the system, and means operable in the event of failure so to recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

13. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, a detector responsive to the infra-red or heat characteristic of the flame for producing an electrical signal indicative of the detection of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the ouput thereof, means comprising a step-up transformer selectively responsive to electrical fluctuations of rate lying within the said predetermined range of rates for recovering the fluctuations from the fluctuation-modified signal in the output of the system, and means operable in the event of failure so to recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

14. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, a detector responsive to the infra-red or heat characteristic of the flame for producing an electrical signal indicative of the detection of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to he ouput thereof, switching means responsive to the recovering of the fluctuations from the fluctuation-modified signal in the output and adapted to occupy alternate positions at the said flucuation rate or rates, means for supplying alternating-current potential of a rate outside the said predetermined range of rates, rectifying means, direct-current potential-storing means, an electric circuit operative when the switching means occupies one of its positions for connecting the supplying means to the storing means through the rectifying means in order to store direct-current potential in the storing means, a slow-response direct-current load adapted to respond in a period of time substantially equal to the said predetermined time interval, and a further electric circuit operative when the switching means occupies its alternate position to connect the storing means to the load.

15. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, a detector responsive to the infrared or heat characteristic of the flame for producing an electrical signal indicative of the detection of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, relay-controlled switching means responsive to the recovering of the fluctuations from the fluctuation-modified signal in the output and adapted to occupy alternate positions at the said fluctuation rate or rates, means for supplying alternating-current potential of a rate outside the said predetermined range of rates, rectifying means, capacitor means, an electric circuit operative when the switching means occupies one of its positions for connecting the supply means to the capacitor means through the rectifying means in order to store direct-current potential in the capacitor means, a slow-response direct-current capacitor-shunted load relay adapted, after being energized, to release in a period of time substantially equal to the said predetermined time interval, and a further electric circuit operative when the switching means occupies its alternate position to connect the first-named capacitor to the load relay in order to maintain the same energized.

16. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, a

detector responsive to the infrared or heat characteristic of the flame for producing an electrical signal indicative of the detection of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means for recovering the fluctuations from the fluctuation-modified signal in the output of the system and for producing further electrical impulses, one corresponding to a group of the said fluctuations and of period less than the said predetermined time interval, and means operable in the event of failure to receive the said impulses for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

17. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, a detector responsive to the infrared or heat characteristic of the flame for producing an electrical signal indicative of the detection of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means for recovering the fluctuations from the fluctuation-modified signal in the output of the system, a slow-response load adapted, after being energized, to de-energize in a period of time equal to the said predetermined time interval, and means for alternately storing energy and delivering the stored engery to the load synchronously with the recovering of the said fluctuations.

18. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, amplifier means connected between the input and the output and adapted selectively to respond to electrical fluctuations lying within the said predetermined range of rates, a detector responsive to the infra-red or heat characteristic of the flame for producing an eelctrical signal indicative of the detection of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the amplifier means to the output of the system, means for recovering the fluctuations from the fluctuation-modified signal in the output of the system, and means operable in the event of failure so to recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

19. A flame-monitor system for monitoring a flame having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, a pair of successively connected alternating-current amplifier stages and a pair of successively connected amplifier stages of the direct-current type connected between the input and the output of the system, the first stage of each of the pair of stages being normally conductive and the alternating-current amplifier stages having means selectively responsive to fluctuations within the said predetermined range of rates, a detector responsive to the infra-red or heat characteristic of the flame for producing an electric signal indicative of the detection of such characteristic and modified with electrical fluctuations corresponding to the said fluctuations of the flame, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the pairs of amplifier stages to the output of the system, means for recovering the fluctuations from the fluctuation-modified signal in the output of the system, a slow-response load adapted, after being energized, to de-energize in a period of time equal to the said predetermined time interval, and means for alternately storing energy and delivering the stored energy to the load synchronously with the recovering of the said fluctuations.

20. A system for monitoring an event having inherent fluctuations of a rate or rates lying within a predetermined range of rates the longest corresponding period of which is less than a predetermined time interval, the system having, in combination, an input, an output, means responsive to a characteristic of the event for producing a signal indicative of the presence of such characteristic and modified with fluctuations corresponding to the said fluctuations of the event, means for applying the fluctuation-modified signal to the input of the system to transmit the same through the system to the output thereof, means for recovering the fluctuations from the fluctuation-modified signal in the output of the system, and means operable in the event of failure so so recover the fluctuations for a time substantially equal to the said predetermined time interval, for thereupon indicating such failure.

21. A signal-detection system adapted to prevent a false indication from being given when a characteristically fluctuating event-to-be-detected is not present or when any system component has failed, the system having, in combination, a sensor device adapted to detect the fluctuating condition characteristically produced by the event-to-be-detected and arranged, when influenced by the said condition, to produce a corresponding fluctuating electrical signal, an amplifier connected to the sensor to amplify the said fluctuating electrical signal, electromagnetic means associated with the said amplifier and adapted to be recurrently energized by the amplified fluctuating electrical signal, the electromagnetic means providing maximum response to fluctuating electrical signals of a band of frequencies corresponding to the frequencies of fluctuation of the event, and indicating means responsive to the said electromagnetic means and adapted to give a steady indication during the time that the said electromagnetic means is being recurrently energized.

22. A signal-detection system adapted to prevent a false indication from being given when a characteristically fluctuating event-to-be-detected is not present or when any system component has failed, the system having, in combination, a sensor device adapted to detect the fluctuating condition characteristically produced by the event-to-be-detected and arranged, when influenced by the said condition, to produce a corresponding fluctuating electrical signal, an amplifier connected to the sensor to amplify the said fluctuating electrical signal, electromagnetic means associated with the said amplifier and adapted to be recurrently energized by the amplified fluctuating electrical signal, the electromagnetic means providing maximum response to fluctuating electrical signals of a band of frequencies corresponding to the frequencies of fluctuation of the event, and indicating means responsive to the said electromagnetic means and adapted to give a steady indication during the time that the said electromagnetic means is being recurrently energized, and for a predetermined time greater than the period of the minimum frequency of the said band after the electromagnetic means has ceased to become recurrently energized.

23. A flame-detector system adapted to prevent a false flame signal from being given when a flame is not present or when any component of the system has failed, the system having, in combination, a flame-sensor device adapted to detect a fluctuating condition characteristically produced by flames and arranged, when influenced by the said condition, to produce corresponding fluctuating electrical signals, means for applying the said fluctuating electrical signals to an electrical amplifier for amplifying the same, electromagnetic means associated with the said amplifier and adapted to be selectively recurrently energized by am-

plified fluctuating signals of a band of frequencies corresponding to the frequencies of fluctuation of the flame, and control means responsive to the said electromagnetic means adapted to give a steady indication during the time that the said electromagnetic means is being recurrently energized to indicate that a flame condition is being sensed by the sensor device.

References Cited in the file of this patent

UNITED STATES PATENTS

2,643,370	Lawrence	June 23, 1953
2,736,882	Sorensen	Feb. 28, 1956