United States Patent

[11] **3,573,788**

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[21] Appl. No. **758,378**
[22] Filed **Sept. 9, 1968**
Division of Ser. No. 535,745, Mar. 21, 1966, Pat. No. 3,440,637
[45] Patented **Apr. 6, 1971**
[73] Assignee **The Bendix Corporation**

[54] **MEANS TO VARY THE INTENSITY OF ILLUMINATION OF ELECTROLUMINESCENT DISPLAY SEGMENTS**
5 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **340/324,** 315/169, 340/335
[51] **Int. Cl.** **G01d 7/00,** G09b 9/32
[50] **Field of Search** 340/324, 335, 334, 339, 336; 313/108; 315/163, 164, 169, 170, 176

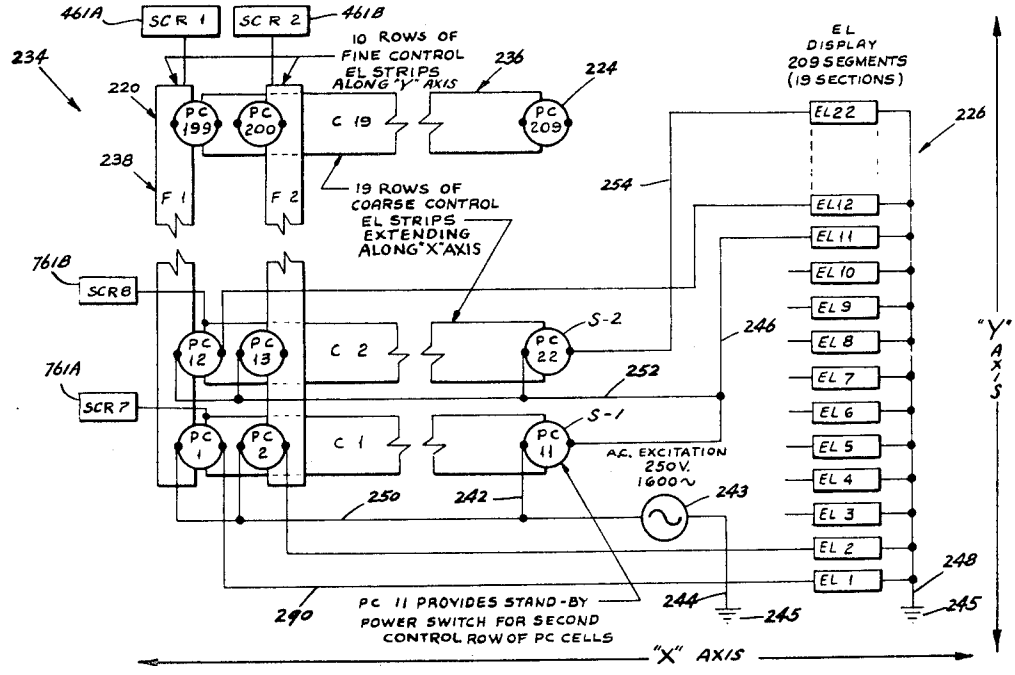
[56] **References Cited**

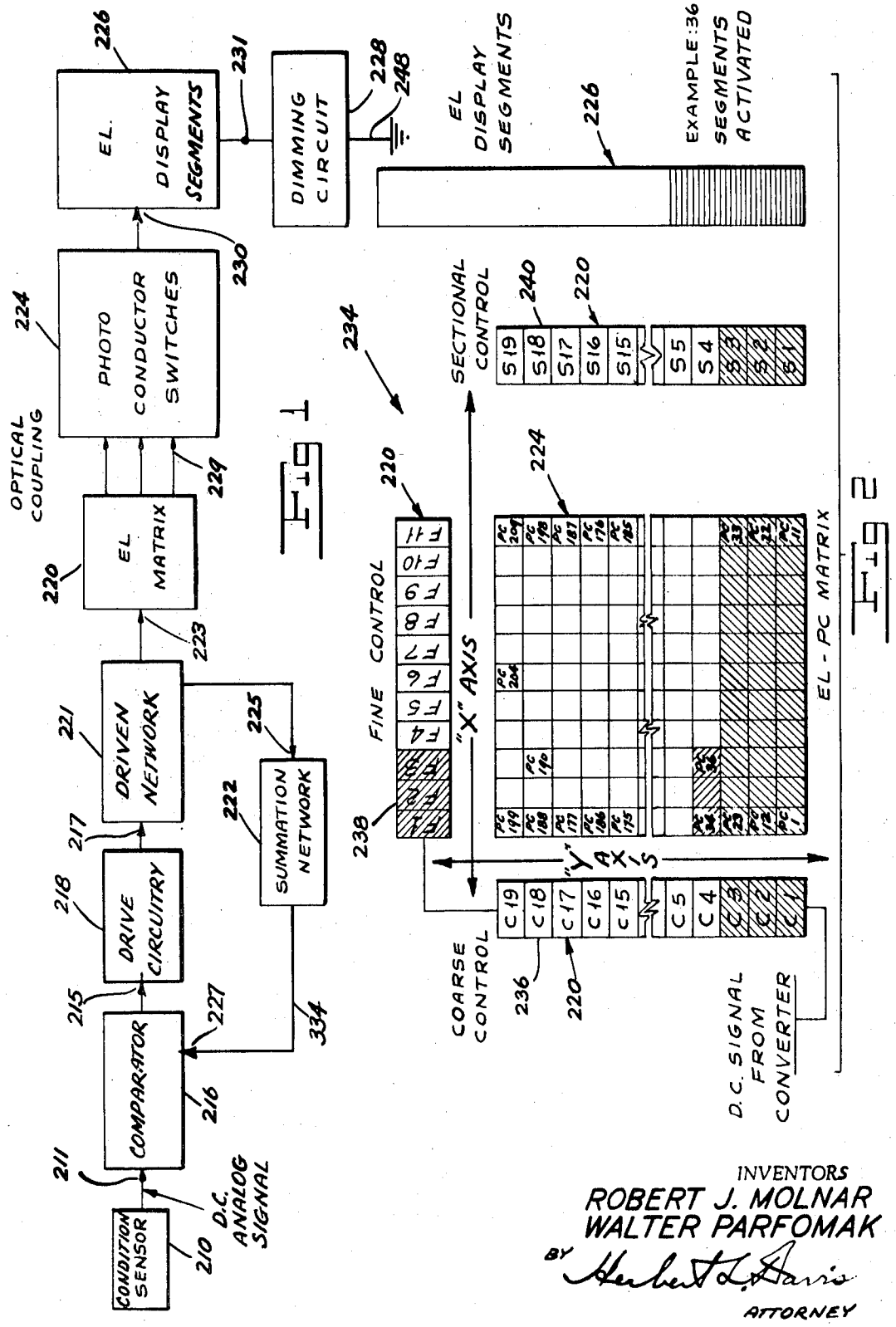
UNITED STATES PATENTS

2,961,579	11/1960	Roney et al.	315/170
3,098,214	7/1963	Windes et al.	307/257
3,366,804	1/1968	Heaviside	307/257
3,423,602	1/1969	Louis	307/257
3,440,488	4/1969	Skirvin	340/335

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ABSTRACT: Means for controlling an alternating current selectively applied to energize a plurality of electroluminescent segments so as to vary the intensity of illumination of the selectively energized electroluminescent display segments.





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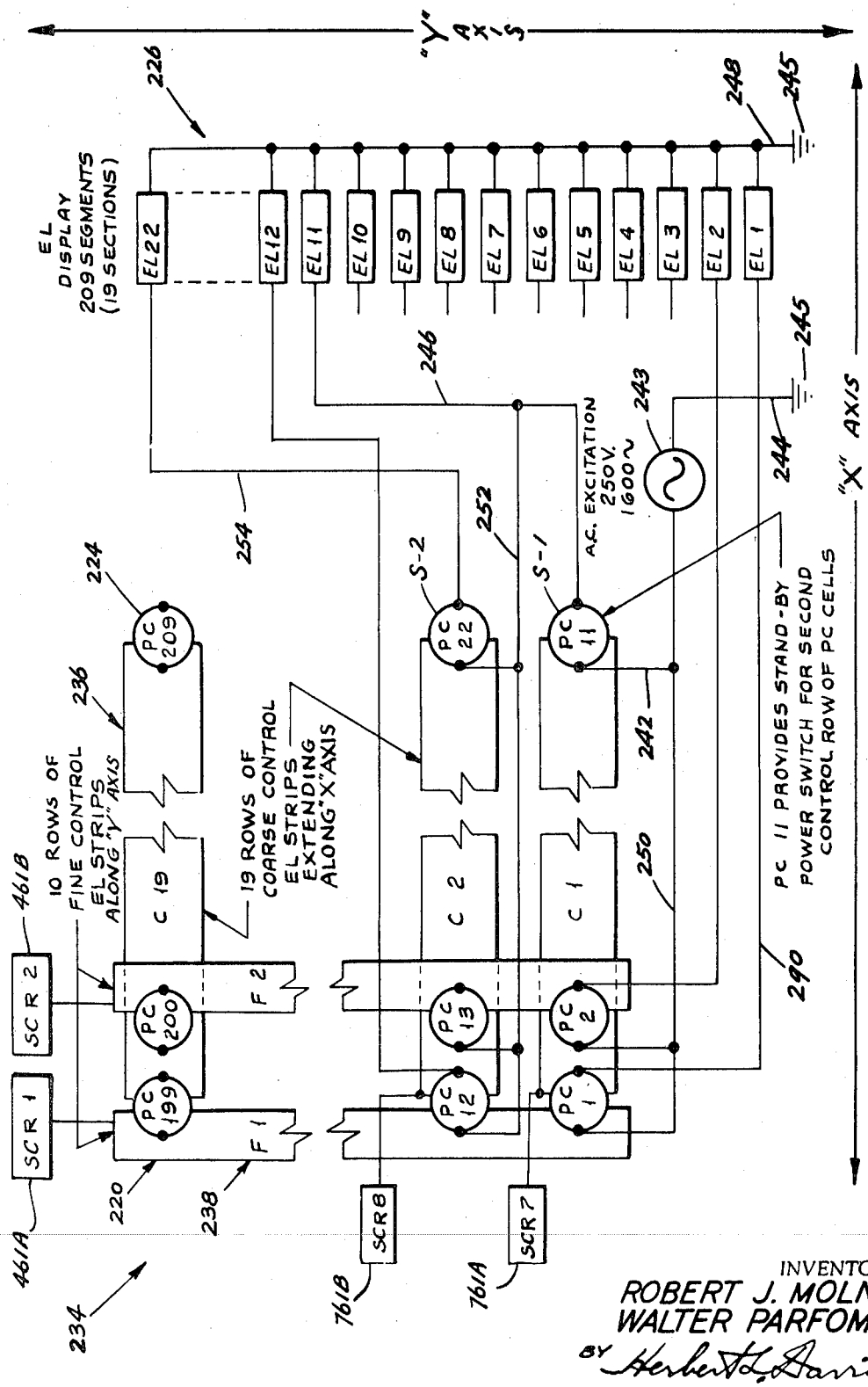


FIG 3

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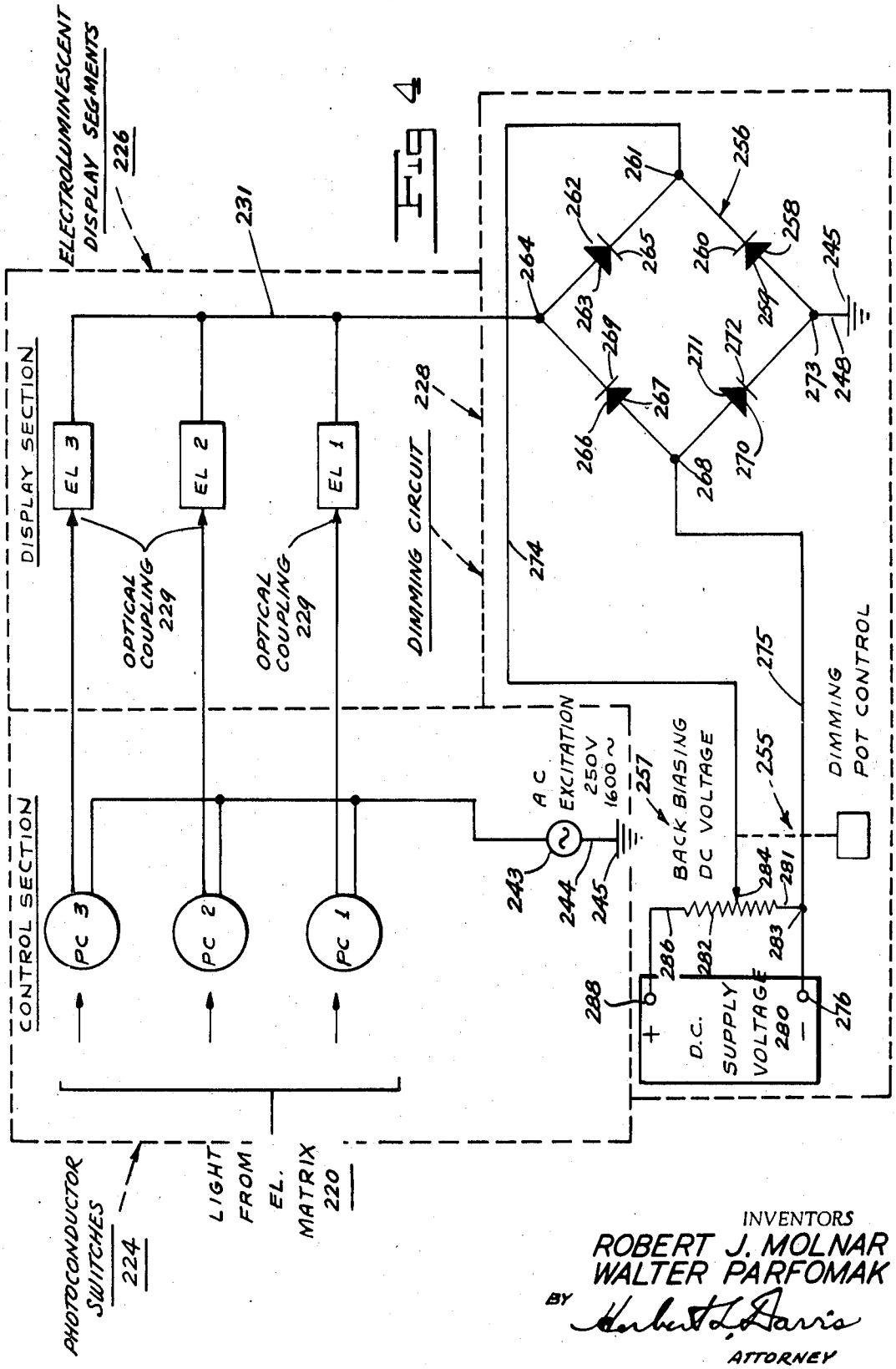


Fig 4

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MEANS TO VARY THE INTENSITY OF ILLUMINATION OF ELECTROLUMINESCENT DISPLAY SEGMENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a division of a copending U.S. application Ser. No. 535,745, filed Mar. 21, 1966, and now U.S. Pat. No. 3,440,637 granted Apr. 22, 1969 to Robert J. Molnar and Walter Parfomak for a Solid State Display with Electronic Drive Circuitry.

The present invention is directed to a means to vary the intensitive of illumination of a plurality of selectively illuminated electroluminescent display segments as described and claimed herein with reference to the dimming control of FIG. 4. The pulse responsive control network described herein is the subject matter of a U.S. application Ser. No. 758,946 filed Sept. 11, 1968 by Robert J. Molnar and Walter Parfomak as another division of the U.S. application Ser. No. 535,745 filed Mar. 21, 1966, and which last mentioned application was in turn filed as a continuation-in-part as to all common subject matter of a now abandoned U.S. application Ser. No. 467,391, filed Jun. 28, 1965 by Robert J. Molnar and Walter Parfomak for a Solid State Display with Electronic Drive Circuitry.

The solid state display system to which the present invention may be applied may include a condition sensor, comparator, drive circuitry, driven step integrator network and feedback summation network for driving a plurality of electroluminescent display segments.

In such a display system the condition sensor may, for example, include: (1) a thermocouple of a type arranged to provide an analog direct current signal corresponding to a sensed temperature condition; or (2) the condition sensor may be of a fuel flow synchro sensing type which may necessitate the use of a converter such as described and claimed in a U.S. Pat. No. 3,375,508, granted Mar. 26, 1968, to Robert J. Molnar and Walter Parfomak, the inventors of the present invention.

Further, the comparator provided in the system may be of a type described and claimed in a U.S. Pat. No. 3,363,112 granted Jan. 9, 1968, to Robert J. Molnar and Walter Parfomak, the inventors of the present invention.

Moreover, the electronic drive circuitry utilized in the system may be of a type described and claimed in a U.S. Pat. No. 3,333,114 granted Jul. 25, 1967, to Robert J. Molnar and Walter Parfomak, the inventors of the present invention.

Furthermore, there may be provided in the drive circuitry a control circuit and electronic step integrator of a type described and claimed in a U.S. Pat. No. 3,427,609 granted Feb. 11, 1969 on a copending U.S. application Ser. No. 411,803, filed Nov. 17, 1964 by Robert J. Molnar and Walter Parfomak, the inventors of the present invention. All of the foregoing applications and patents have been assigned to The Bendix Corporation, the assignee of the present invention.

As distinguished from the foregoing features, the present invention is directed to a means for adjusting an alternating current for energizing the plurality of electroluminescent display segments so as to vary the intensity of illumination of the display segments as more specifically described and claimed herein with reference to FIG. 4.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is in the field of solid state display with electronic drive circuitry and, more particularly, to an improved control network including means for adjusting an alternating current for energizing a plurality of selectively illuminated electroluminescent display segments so as to vary the intensity of illumination thereof.

2. Description of the Prior Art

Heretofore, solid state display systems have been provided including means for controlling the illumination of a stack of electroluminescent segments which may be of a type similar to that of the electroluminescent segments disclosed in a U.S. Reissue Pat. No. 26,207, granted May 23, 1967 to Frederick Blancke Sylvander and assigned to The Bendix Corporation, assignee of the present invention.

In the display system of the U.S. Reissue Pat. No. 26,207, and in the arrangement of the present invention, the electroluminescent segments are of a type having thin films of phosphor material sandwiched or positioned immediately between two electrical conductive layers one or both of which may be transparent. In such an arrangement, each electroluminescent layer is essentially a capacitor which is so arranged that upon the application of an alternating current voltage across the outer conductive layers, the phosphor material will emit light, as heretofore explained in the aforenoted U.S. Reissue Pat. No. 26,207, while upon a direct current voltage being applied thereto, the capacitor effect of the electroluminescent segment serves to block the passage of the direct current therethrough so that no light is emitted from such electroluminescent segment.

In the present invention, the specific control network for the stack of electroluminescent display segments is quite different from that disclosed in the U.S. Reissue Pat. No. 26,207, in that in addition to the provision of a means responsive to an output signal proportional to a sensed condition to selectively operate a control network so as to connect a source of alternating current to said display segments to effectively illuminate said segments so as to provide a variable length luminous display column indicative of the sensed condition, there is further provided in the present invention an operator-operative means, as shown fails detail by FIG. 4, for adjusting the alternating current from said source so as to vary the intensity of the illumination of the electroluminescent display segments and thereby enable the operator to better distinguish the variable length display column under different operating conditions of ambient illumination. The prior art fails to suggest the simplified control network of the present invention for adjusting the alternating current so as to vary the intensity of the illumination of the plurality of electroluminescent display segments selectively connected thereto through the control network.

SUMMARY OF THE INVENTION

The invention contemplates an improved network from controlling the intensity of illumination of a stack of electroluminescent display segments selectively energized from a source of alternating current.

Another object of the invention is to provide a means for controlling the illumination of a stack of electroluminescent display segments including a back biased diode bridge network in series with a source of alternating current, and means for effecting selective energization of the segments, together with a variable direct current supply voltage to back bias the diode bridge so as to control the effective alternating current applied across opposite conductive layers of the stack of electroluminescent segments to in turn vary the intensity of illumination of a luminous display column.

Another object of the invention is to provide a diode bridge network arranged to limit the passage of alternating current therethrough so as to effect illumination of the electroluminescent display segments with only that portion of the alternating current of a voltage greater than a back biasing direct current voltage, set by adjustment of an operator-operative potentiometer, so as to provide a precise control of the intensity of illumination of the electroluminescent display column regardless of the number of electroluminescent segments that may be selectively activated.

A further object of the invention is to provide a stack of electroluminescent segments connected in series with a blocking diode bridge network, a source of alternating current, and means to connect the source of alternating current through the blocking diode bridge network so as to selectively illuminate the segments, the blocking diode bridge network including a control potentiometer to vary a back biasing direct current voltage applied to the diodes of the bridge network so that the alternating current supplied across the electroluminescent segments may be varied to reduce or increase the brightness of illumination of the selectively energized electroluminescent display segments.

These and other objects and advantages of the invention are pointed out in the following description in the terms of the embodiment thereof which is shown in the accompanying drawings.

IN THE DRAWINGS

FIG. 1 shows a block diagram of an electroluminescent photoconductor solid state display system embodying the invention.

FIG. 2 is a symbolic representation of the electroluminescent photoconductor matrix in a novel layout arrangement for indicating coarse, fine, and sectional controls in driving the electroluminescent display segments.

FIG. 3 shows an enlarged detailed fragmentary schematic view of the electroluminescent photoconductor matrix shown in FIG. 2, as attached to the electroluminescent display segments for illuminating the same.

FIG. 4 is a detailed circuitry of the dimming circuit shown in FIG. 1.

DESCRIPTION OF THE INVENTION

The electroluminescent photoconductor solid state display system comprises an indicator panel and a driven network utilizing a novel optoelectronic approach. A condition sensor device is provided to obtain from analog signals such as exhaust gas temperature, fuel flow or a tachometer, a direct current analog signal to control a comparator circuit and in turn an electronic drive circuitry to effect a corresponding control of a driven network including electroluminescent segments arranged in an instrument simulating a thermometer type moving display.

More specifically the condition sensor means used may, for example, be: (1) a thermocouple of a type arranged to provide an analog direct current signal corresponding to a sensed temperature condition; or (2) the condition sensor means may be of a fuel flow synchro signal sensing type which may necessitate the use of a converter such as described in U.S. Pat. No. 3,375,508, granted Mar. 26, 1968 to Robert J. Molnar et al., assigned to The Bendix Corporation, the same assignee as the present invention; or (3) the condition sensor means may be tachometer signal sensing means of a type in which tachometer signals are converted to produce one pulse per cycle of a generator speed and in which the amplitude and width of the pulses are controlled so that a filtered output produces a direct current analog signal which is an accurate function of the sensed condition or tachometer speed.

Referring to the drawing of FIG. 1, there is indicated a block diagram of the system. A condition sensor **210** provides a direct current analog signal corresponding to the sensed condition which is directed, as shown by arrow **211**, to an electronic error detector, such as, a comparator **216**, which may be analogous to a differential in an electromechanical system. The comparator **216** may be of the type described and claimed in the aforenoted U.S. Pat. No. 3,363,112, granted Jan. 9, 1968 to Robert J. Molnar and Walter Parfomak for a single transistorized comparator circuit and assigned to The Bendix Corporation, the assignee of the present invention.

An electronic drive circuitry **218** which may be of a type described and claimed in the aforenoted U.S. Pat. No. 3,333,114, granted Jul. 25,1967 to Robert Molnar and Walter Parfomak for an electronic drive circuit and assigned to The Bendix Corporation, may include as shown by FIG. **5**, a control circuit **219** which receives the differential output signal, as shown by arrow **215**, from the comparator **216**. The control circuit **219** in turn controls the operation of the drive circuit **218** in applying driving pulses, as shown by arrow **217** of FIG. **1**, to a driven network **221**.

The driven network **221**, under control of the driving pulses applies electrical pulses, as indicated by the arrow **223** of FIG. **1**, to regulate the operation of the electroluminescent matrix **220**. Further, a summation network **222** receives electrical signal information, as shown by arrow **225**, from the driven network **221** and directs a feedback signal, as indicated by the arrow **227**, to the comparator **218** corresponding to the regulated condition of the matrix **220**.

More specifically, as described and claimed in the aforenoted U.S. Pat. No. 3,440,637, the driven network **221** directs signal information corresponding to the regulated operation of the electroluminescent capacitor strips extending along the X axis and Y axis of the matrix **220**, while the summation network **222** then integrates the information signal until the direct current feedback signal voltage directed to the comparator **216** from the summation network **222**, as shown by an arrow **227** of FIG. **1**, is equal to the direct current analog signal voltage directed to the comparator **216** from the condition sensor **210**, as shown by the arrow **221**. That is, the DC feedback signal voltage acts in opposition to the DC analog signal voltage so that when the resulting differential or error signal voltage is reduced to zero, the integration is accomplished.

Electroluminescent Matrix

It should be also noted at this time that, as described and claimed in the U.S. Pat. No. 3,440,637, the multisegment switching of the electroluminescent display portion of the invention requires three orders of control including a fine control, a coarse control, and a third order of control achieved by photoconductor switches **224** being arranged to receive light from the electroluminescent capacitor strips F1 to F10 of the electroluminescent matrix **220**, as shown by arrows **229** of FIG. 1.

A last row of Y axis extending photocells are provided to control the excitation of each succeeding row of X axis extending photocells in which the first row of X axis extending photocells does not require such control since it is excited continuously.

The electroluminescent matrix **220** of FIG. **1** is shown symbolically in FIG. **2**, partially in schematic form in FIG. **3** and in detail in the U.S. Pat. No. 3,440,637.

In addition, the photoconductor switches **224**, shown in the block diagram of FIG. **1**, are also shown symbolically in FIG. **2**, partially in FIGS. **3** and **4**, and in detail in the U.S. Pat. No. 3,440,637.

An electroluminescent display column made up of a series of electroluminescent display segments **226**, shown in FIG. **1**, is connected to be energized by the electroluminescent matrix **220** and the photoconductor switches **224**, as shown by arrows **229** and **230**, respectively. The electroluminescent display segments **226** are shown symbolically in FIG. **2** and partially schematically in FIGS. **3**, and **4**, and in the U.S. Pat. No. 3,440,637. The electroluminescent display segments **226** are described more fully in the aforementioned U.S. Reissue Pat. No. 26,207.

A dimming circuit **228**, providing means for dimming the electroluminescent display **226** by manual control, is shown in FIG. **1** connected to the system by a line **231**. The dimming circuit **228** is more specifically shown in FIG. **4**, as including a back biased diode bridge in series with the ground leg of the electroluminescent display section, as hereinafter more fully described.

As shown symbolically in FIG. **2** and in detail in the U.S. Pat. No. 3,440,637, the electroluminescent matrix **220** is optically coupled to the photoconductor switches **224** to form an electroluminescent photoconductor matrix **234**. The electroluminescent photoconductor matrix **234** may, for example, comprise 209 photoconductor switches indicated by numerals PC1 to PC209, a coarse electroluminescent control **236** including 19 electroluminescent capacitor strips C1 to C19, extending along the X axis, a fine electroluminescent control **238** including 10 electroluminescent capacitor strips F1 to F10, extending along the Y axis with a symbolic F11 to show the last fine control, and a sectional control **240** which includes 19 sectional photoconductor switches S1 to S19, which are rendered conductive upon illumination of the associated coarse control electroluminescent capacitor strips C1 to C19.

The electroluminescent photoconductor matrix **234** symbolically shows, in FIG. **2**, 209 squares representing the 209 photoconductor switches providing driving or switching means for the 209 electroluminescent display segments **226** numbered EL1 to EL**209**. It should be noted that each photoconductor switch PC1 to PC**209** drives its correspondingly numbered electroluminescent segment, and in this sense are correlated one to the other. It should be also noted that FIG. **2** symbolically shows at **226** an example of 36 activated electroluminescent segments which are driven by 36 photoconductor switches PC1 to PC**36**.

The interconnection of the photoconductor switches **224** with their corresponding electroluminescent display segments **226** is shown in more detail in FIG. **3** wherein the electroluminescent segments **226** are controlled by the photoconductor switches **224** through the fine electroluminescent switching means **238** controlled by silicon controlled rectifier switches, as described and claimed in the U.S. Pat. No. 3,440,637, and which control the energization of the 10 electroluminescent strips F1 to F**10**. In addition, the coarse switching means **236** is controlled by other silicon controlled rectifier switches which control the energization of the 19 electroluminescent strips C1 to c**19**, as described and claimed in the U.S. Pat. No. 3,440,637

Therefore, as shown in FIG. **3**, the electroluminescent photoconductor matrix **234** illuminates 209 photoconductor switches PC1 to PC**209** through the electroluminescent strips F1 to F**10** and C1 to C**19** controlled by the silicon controlled rectifier switches which are operatively controlled by the driven network **221**.

It should be noted that FIG. **3** is a fragmentary drawing of the electronic circuitry to show the connection between the silicon controlled rectifier switches energizing the electroluminescent strips and that the U.S. Pat. No. 3,440,637 shows in greater detail the silicon controlled rectifier electronic circuitry utilized in the solid state display circuitry to drive the optoelectric portion of the system. That is the electronic circuitry which operates to energize the 19 electroluminescent coarse control strips C1 to C**19** extending in the X axis and the 10 electroluminescent fine control strips F1 to F**10** extending in the Y axis of the electroluminescent photoconductor matrix **234** to provide thereby two orders of control to illuminate the electroluminescent display segments **226**. However, as hereinbefore described, and as shown in FIGS. **2** and **3**, multisegment switching of the electroluminescent display **226** requires three orders of control. This third order of control is effected by providing photoconductor switches S1 to S**19** of the sectional control **240** each of which sectional control switches corresponds to one of the photoconductors such as the last photoconductor in each row PC**11**, PC**22**, PC**33**, and so on up to the last photoconductor PC**198** located on the next to the last row of photoconductors. These photoconductors, PC**11**, PC**22**, PC**33**, and so on to PC**198** corresponding to the sectional control switches S1 to S**19**, respectively, are the last photoconductors on each of the electroluminescent strips extending on the X axis from C1 to C**18** except for the last electroluminescent strip C**19**. The last photoconductor PC**209** may be utilized as an additional section control switch in the event more than 209 electroluminescent display segments were to be illuminated.

In this system the photoconductors S1 to S**18** of the sectional control **240** are used to control the excitation for the next row of photoconductors extending on the X axis. For example, as shown schematically in FIG. **3**, the photoconductor PC**11** corresponding to the sectional control switch S**1** is used as a stand-by power switch for the second row of photoconductors, PC**12** to PC**22**.

More specifically, as shown in FIG. **3**, photoconductor PC**11** corresponding to sectional control switch S**1** is connected through line conductors **242** and **250** to one terminal of a suitable source of alternating current **243**. The other terminal of the source **243** is connected by a line conductor **244** to a ground **245**. The photoconductor PC**11** is also connected by a line conductor **246** to electroluminescent segment EL**11** and in turn the electroluminescent EL**11** is connected to ground **245** by a common line conductor **248**. In addition, the line conductor **250** connects the row of photoconductors PC1 to PC**11**. When the electroluminescent strip C1 is illuminated, light rays are directed thereby upon the photoconductors PC1 to PC**11** to reduce their electrical resistance and render them conductive of electrical energy, whereupon voltage from the alternating current source **243** will be applied through photoconductor PC**11** corresponding to the sectional control switch S**1** to the photoconductors PC**12** to PC**22** through a line conductor **252**. Thereafter, should the fine control electroluminescent strips F1 to F**10** be illuminated, then the photoconductors PC**11** to PC**21** would be rendered conductive; or, should the coarse control electroluminescent strip C2 be illuminated, then the photoconductors PC**11** to PC**22** would become electrically conductive and current would be directed to the electroluminescent segments EL**12** to EL**22** for illuminating segments of the electroluminescent display **226**. That is, when the photoconductor PC**11** is switched on to illuminate the eleventh electroluminescent segment EL**11** through the line conductor **246**, it is also effective as the sectional control switch S**1** to connect through the line conductor **252** for stand-by the next row of X axis extending photoconductors PC**12** to PC**22**.

Furthermore, the photoconductor PC**22** is connected to the alternating current source **243** through photoconductor PC**11** by the line conductor **252** and should the photoconductor PC**22** have been previously rendered conductive by the illumination of the coarse control strip C**2**, the photoconductor PC**22** then serves to effect the illumination of the electroluminescent segment EL**22** through a line conductor **254**. At the same time photoconductor PC**22** is also effective as sectional control switch S**2** to connect for stand-by the next succeeding row of X axis extending photoconductors PC**23** to PC**33**. The photoconductor PC**33**, upon illumination of the coarse control strip C**3**, is rendered conductive to illuminate the electroluminescent segment EL**33** and is thereupon effective as sectional control switch S**3** to connect for stand-by the next succeeding row of X axis extending photoconductors PC**34** to PC**44**, and so on until photoconductor PC**198**, shown by FIG. **2**, becomes effective upon illumination of the coarse control strip C**18** to connect for stand-by the last row of X axis extending photoconductors PC**199** to PC**209**.

The driven network **221** while utilizing only 16 silicon controlled rectifier switches may be rendered effective to drive 10 Y axis extending fine control electroluminescent strips and 19 X axis extending coarse control electroluminescent strips, for energizing 209 electroluminescent display segments, as explained in the aforenoted U.S. Pat. No. 3,440,637.

As shown schematically in FIG. **3**, the electroluminescent display segments **226** are divided into a column of a number of small segments of a phosphor material. The number needed being determined by the accuracy, resolution, and sensitivity requirements of the display instrument.

Dimming Control

Referring now to the dimming control **228**, a dimming potentiometer control **255** shown in FIG. **4** provides for manual control of the brightness of the energized electroluminescent display segments **226** so that the display may be distinguishable under any condition of ambient illumination.

The dimming circuit **228**, shown in FIG. **4**, comprises a back biasing diode bridge rectifier **256** connected in the common conductor **231** leading from the display segments **226**, shown in FIG. **3**, and interposed between the electroluminescent display segments **226** and the conductor **248** leading to ground **245**. A dimming potentiometer control **255** is provided for the area source lamp to balance the display for darkness operation. The brightness of the electroluminescent segments will be adequate for visibility in normal lighting (approximately 50 foot-candles). The arrangement is such that the diode bridge

rectifier 256 serves to limit the passage of alternating current from the source 243 and through the display segments 226 to a voltage greater than a back biasing direct current voltage 257 set by adjustment of the potentiometer 255. In this manner, there is provided a precise control of the electroluminescent display brightness regardless of the number of electroluminescent segments activated.

Referring particularly to the back biasing diode bridge rectifier 256, it will be seen that a first diode 258 comprises an anode 259 connected to a junction 273 and thereby to the ground 245 by conductor 248 and a cathode 260 connected to a junction 261 to which leads the conductor 274 from the control potentiometer 255. A second diode 262 comprises an anode 263 connected to a junction 264 to which leads the line conductor 231 from the electroluminescent display segments 226 and a cathode 265 connected to the junction 261.

In addition, the bridge rectifier 256 comprises a third diode 266 having an anode 267 connected to a junction 268 from which leads the conductor 275 to the control potentiometer 255 and a cathode 269 connected to the junction 264 to which leads the line conductor 231 from the electroluminescent display segments 226. A fourth diode 270 has an anode 271 connected to the junction 268 and a cathode 272 connected to the junction 273 and thereby through the common line conductor 248 to the ground 245.

In this manner, the back biasing diode bridge 256 is connected to the ground 245 in series with the electroluminescent display segments 226 by its two junctions 264 and 273. The bridge rectifier 256 is also connected to the back biasing direct current voltage 257 at its junctions 261 and 268 through line conductors 274 and 275, respectively. The line conductor 275 is connected to a negative terminal 276 of a direct current supply voltage 280 and to one terminal 281 of a resistor 282 at junction 283. The other line conductor 274 is connected through a movable contact arm 284 to the resistor 282 which resistor is connected at an opposite terminal 286 to a positive terminal 288 of the supply voltage 280. The lighting intensity may be adjusted, as desired, by suitable adjustment of the dimming potentiometer control 255 to set the back biasing DC voltage so as to limit the effective voltage of the energizing alternating current applied through the bridge rectifier 256 to the electroluminescent display segments 226.

The electroluminescent display segments EL1 to EL209 are essentially capacitors and if a direct current voltage is applied across an electroluminescent segment no light would be produced. At the same time, if a portion of the alternate current voltage which is applied across the electroluminescent segment is blocked, it will vary its brightness. Therefore, since the electroluminescent segments 226 are in series with the bridge rectifier 256, an operator may adjust the control potentiometer 255 to vary the back biasing direct current, whereupon the alternating current supplied across the electroluminescent segments 226 will be varied to reduce or increase the brightness of the electroluminescent display lamps.

The alternating current activating circuit for the selectively illuminated electroluminescent display segments 226 may be readily traced from the source of aLternating current 243. Thus upon a positive half wave of alternating current being applied from the source 243 through the conductor 244 leading to the ground 245, the positive half wave of alternating current will be applied through the grounded conductor 248 to the junction 273 of the diode bridge 256 and thereby to the anode 259 of the diode 258 and from the cathode 260 of the diode 258 to the junction 261.

However, only that portion of the positive half wave of the alternating current will pass through the diode 258 to the junction 261 which effectively overcomes the biasing force applied by the direct current source 280 to the cathode 260 of the diode 258. The resultant portion of the positive half wave of the alternating current applied at the junction 261 will then be applied through the conductor 274 and the effective part of the resistor 282 leading to the conductor 281 and through the conductor 275 to the junction 268 of the diode bridge 256. Moreover, from the junction 268, the resultant portion of the alternating current is applied to the anode 267 of the diode 266 and from the cathode 269 of the diode 266 to the junction 264 where the resultant portion of the alternating current is applied through the common conductor 231 to one conductive layer of each of the selectively illuminated electroluminescent segments 226, while the opposite conductive layer of each of the selectively illuminated segments 226 is connected through a control section, as shown by FIG. 4, to the opposite then negative terminal of the source of alternating current 243.

Similarly, upon the reoccurring opposite positive half wave being applied at the previously negative terminal of the source of alternating current 243, this opposite positive half wave will then be applied through the aforementioned control section to one of the conductive layers of each of the selectively illuminated segments 226, while a positive reverse flow of current will be effected from the opposite conductive layers of each of the selectively illuminated segments 226 through the common conductor 231 to the junction 264 of the diode bridge 256 and thereby to the anode 263 of the diode 262 and from the cathode 265 of the diode 262 to the junction 261.

However, only that portion of the positive half wave of the alternating current will pass through the diode 262 to the junction 261 which has effectively overcome the back biasing force applied by the direct current source 280 to the cathode 265 of the diode 262. The resultant portion of the positive half wave of the alternating current applied at the junction 261 will then be applied through the conductor 274 and the effective part of the resistor 282 leading to the conductor 281 and through the conductor 275 to the junction 268 of the diode bridge 256. Moreover, from the junction 268 the resultant portion of the alternating current is applied to the anode 271 of the diode 270 and from the cathode 272 of the diode 270 to the junction 273 where the resultant portion of the alternating current is applied through the conductor 248 to the ground 245 returning thereby through the conductor 244 to the opposite then negative terminal of the source of alternating current 243.

It will be seen then that the resultant portion of the alternating current applied across the opposite conductive layers of the selectively illuminated electroluminescent display segments 226 is effectively controlled by the back biasing direct current voltage applied by the direct current source 280 as set by the adjustment of the operator-operative potentiometer control 255. Thus the intensity of illumination of the selectively illuminated electroluminescent segments 226 may be effectively increased by decreasing the biasing voltage applied by the direct current biasing source 280 while the intensity of illumination may be effectively decreased by increasing the biasing voltage applied by the direct current biasing source 280.

The dimming control 228, as described and claimed herein with reference to FIG. 4, provides the subject matter of the present invention, whereby the intensity of the illumination of the luminous column of the electroluminescent display may be readily adjusted independently of the number of electroluminescent segments 226 that may be selectively illuminated so that the viewer may be able to better distinguish the indicator display column under varying conditions of ambient illumination.

Control System for Display Segments

As herein described with reference to FIG. 1, a direct current analog signal voltage effected by the condition sensor 210 is compared in a comparator 216 with a feedback voltage applied through a summation network 222 by the driven network 221 and any difference or error voltage is fed to the electronic drive circuitry 218 to control the operation of a driven network 221 as more fully described in the U.S. Pat. No. 3,440,637.

Within the electronic circuitry the differential error voltage resulting from the comparison of the direct current analog signal voltage and the feedback voltage is used to control the length of the lighted electroluminescent display column **226**. That is, a lighted condition is caused to progress along the display column of the electroluminescent display segments **226** by the resulting operation of the driven network **221** which causes electroluminescent driving capacitor strips F1 to F10 and C1 to C19 to shine upon the photoconductor switches PC1 to PC209 to excite, in turn, a predetermined number of the 209 electroluminescent display segments EL1 to EL209 corresponding to an indicated value of the condition sensed by the sensor **210**.

Thus, by means of the direct current analog and feedback signals from the electronic circuit, the length of this lighted electroluminescent column of the display segment **226** is continuously compared to the value of the direct current input parameter of the sensor **210**. When the lighted column of the display segments **226** has progressed to the predetermined length indicative of the sensed condition, the switching circuit is operated to stop further movement or illumination of the column of the display segment **226**.

As hereinbefore described with reference to FIGS. **2** and **3**, the various electroluminescent capacitor control strips F1 to F10 and C1 to C19 of the electroluminescent photoconductor drive circuits, internal to the display indicator, are not made in the same geometrical format as the column of the display segments **226**. The display segments **226** may be made, for example, of 44 electroluminescent display segments to the inch, but the electroluminescent capacitor control strips are provided with a series of 10 parallel, spaced electroluminescent fine control strips F1 to F10 extending in Y-axis direction, and the other with a series of 19 parallel spaced electroluminescent coarse control strips C1 to C19 extending perpendicular thereto in an X-axis direction. The electroluminescent strips are then connected to the electronic control circuitry, partly shown in schematic form in FIGS. **3** and **4**, and more fully shown in the U.S. Pat. No. 3,440,637.

The various electroluminescent and photoconductor elements may be arranged on four or more thin cards, as shown in the U.S. Pat. No. 3,440,637. These cards may be stacked and interconnected in the same manner as if they were a single format. In addition, in simplifying the production of these electroluminescent photoconductor elements, this method may be used for troubleshooting and thus allow for change of scale factor in the summation of signals from each card. Reliability theory assigns a great importance to the proper assembly of individual electroluminescent and photoconductor cells.

The electronic drive circuitry and driven network **221** and summation network **222** performs the guiding control for the various coarse and fine electroluminescent strips, the photoconductors and eventually the electroluminescent display segments **226** as best shown and described in the aforenoted U.S. Pat. No. 3,440,637.

The dimming circuit shown in FIG. **4** utilizes the capacitor characteristics of the electroluminescent display segments **226** so that a direct current applied across the opposite plates of the display segments **226** effects no illumination. At the same time, if a portion of the alternating current voltage of the illuminating current is blocked, the brightness of the electroluminescent display segments **226** will be varied thereby. In the bridge circuit of FIG. **4**, there is a direct current supplied in series with the alternating current voltage and with the electroluminescent display segments **226** so that as the direct current is increased in the bridge rectifier **256**, the alternating current across the electroluminescent display segments **226** will be reduced.

In summary therefore, the solid state display circuitry described herein provides for reduction in activating the circuitry by means of a four dimensional control, the use of an electronic servo for greater accuracy, and the use of means to simultaneously switch off all the photoconductors for a faster response within the system. In addition, this system provides for a unique combination of electronic and optoelectronic techniques in a matrix control with a multifunction operation of the coarse and fine control circuitries and a dual function of a transfer circuit. Further, this system provides for a high accuracy produced by a simple summation circuit, a unique circuit arrangement for excitation control and level changes and a unique electronic isolation between control and display sections achieved by means of the electroluminescent and photoconductor components and in addition the present invention provides a unique circuit for dimming the electroluminescent display segments.

While one embodiment of the invention has been illustrated and described, various changes in the form and relative arrangement of the parts, which will now appear to those skilled in the art may be made without departing from the scope of the invention. Reference is, therefore, to be had to the appended claims for a definition of the limits of the invention.

We claim:

1. For use with a condition sensor of a type including means for effecting an output signal proportional to a sensed condition, the combination comprising a plurality of electroluminescent display segments including opposite capacitive-type plates, a first source of alternating current, means response to said output signal to selectively connect said source of alternating current across the opposite capacitive-type plates of said display segments to illuminate said segments so as to provide a variable length luminous display indicative of the sensed condition, a second source of direct current biasing voltage, the means for selectively connecting said source of alternating current across the opposite capacitive-type plates of said display segments including first unidirectional current flow control means connecting one phase of said alternating current in a series opposing relation with said direct current biasing voltage of said second source, and a second unidirectional current flow control means for connecting an opposite phase of said alternating current in an opposite series opposing relation with said direct current biasing voltage of said second source, said second source of direct current biasing voltage being connected in a back biasing relation to said first and second unidirectional current flow control means and in opposition to the first and second phases of said alternating current applied through said first and second unidirectional current flow control means across the opposite capacitive-type plates of said display segments, and operator-operative means for adjusting the direct current biasing voltage of said second source to vary intensity of illumination of the electroluminescent display segments by the alternating current of said first source.

2. The combination defined by claim **1** in which the selective connecting means includes a bridge network, the first and unidirectional current flow control means being arranged in opposite arms of said bridge network, a first pair of input legs being connected between opposite arms of the bridge network, said first input legs being serially connected in the means connecting said source of alternating current across the opposite capacitive-type plates of said display segments, and a second pair of input legs being connected between other opposite arms of the bridge network for connecting the second source of direct current biasing voltage across the first and second unidirectional current flow control means in such a polarity sense as to apply an electromotive force in a back biasing relation to said first and second unidirectional current flow control means and acting in opposing relation to the first source of alternating current, and operator-operative means for adjusting the second source of direct current voltage so as to vary the electromotive force acting in said opposing relation and thereby the intensity of the illumination of the electroluminescent display segments by the first source of alternating current applied through said bridge network and across the opposite capacitive-type plates of said display segments.

3. The combination defined by claim **1** in which the selective connecting means includes a diode bridge means, the first unidirectional current flow control means including a first pair

of diodes connected in opposite arms of said bridge means in one like polarity sense, said second unidirectional current flow control means including a second pair of diodes connected in other opposite arms of said bridge means in another opposite polarity sense from said first pair of diodes, said first and second pairs of diodes being connected in said bridge means in said one and other polarity senses for connecting said one and other phases of said first source of alternating current in said series opposing relation to said second source of direct current voltage and across said opposite capacitive-type plates of said display segments, an adjustable potentiometer connected across said second source of direct current voltage and operatively connected across opposite arms of the diode bridge means to apply the back biasing voltage to the first and second pairs of diodes of the diode bridge means to block passage of a portion of the alternating current applied through the diode bridge means and across the opposite capacitive-type plates of the selectively connected display segments to thereby vary the intensity of illumination of the selectively illuminated electroluminescent display segments.

4. For use with a condition sensor of a type including means for effecting an output signal proportional to a sensed condition, the combination comprising a plurality of electroluminescent display segments, each of said segments including opposite conductive layers, a source of alternating current, means responsive to said output signal to selectively connect said source of alternating current across the opposite conductive layers of said display segments to illuminate said segments so as to provide a variable length luminous display indicative of the sensed condition, a bridge network, a first control junction on the bridge network, the bridge network including a first pair of unidirectional current flow control devices for permitting flow of current from the first control junction of the bridge network to opposite input-output junctions of the bridge network, a second control junction on the bridge network, the bridge network including a second pair of unidirectional current flow control devices for permitting flow of current to the second control junction of the bridge network from the opposite input-output junctions of the bridge network, means serially connecting the opposite input-output junctions of the bridge network between the source of alternating current and the means to selectively connect said source of alternating current across the opposite conductive layers of said display segments, a direct current voltage source, means connecting the direct current voltage source across said first and second control junctions in a polarity sense to back bias the unidirectional current flow control devices in opposite relation to the unidirectional flow of current therethrough by the alternating current source so as to block passage of at least a portion of the alternating current applied by the alternating current source and permit passage through the bridge network of that portion of the alternating current which effectively overcomes the biasing voltage of the direct current voltage source and thereby control intensity of illumination of the selectively illuminated electroluminescent segments.

5. The combination defined by claim 4 including a potentiometer having a resistor element connected across said source of direct current voltage, the means connecting the direct current voltage source across said first and second control junctions of the bridge network including an adjustably positioned control arm cooperatively arranged in relation to said resistor element so as to provide first and second portions of said resistor element, each of said portions of the resistor element being variable relative one to the other by the positioning of the control arm, and an operator-operative control to vary the position of the control arm and the effective resistance of said portions of the resistor element relative one to the other and thereby provide a variable voltage divider permitting a variable biasing voltage to be derived and applied by the direct current voltage source across the first and second control junctions so that the portion of the alternating current which effectively overcomes the derived biasing voltage applied by the direct current voltage source may effect a flow of current through the second pair of unidirectional current flow control devices to the second control junction of the bridge network and through at least one of said portions of the resistor element of the potentiometer to the first control junction of the bridge network and selectively through the first pair of unidirectional current flow control devices to the output of alternating input-output junctions of the bridge network.