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Marshall

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[54] **FIRE CONTROL APPARATUS AIR POLLUTION PRODUCT ABATEMENT**

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy,** Washington, D.C.

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[52] **U.S. Cl.**.....**169/2 R,** 116/147, 239/71, 250/205

[51] **Int. Cl.**.....**B06b 3/00**

[58] **Field of Search**.....169/2 R, 5, 23; 239/71, 550, 102; 116/147; 250/200, 201, 205

[56] **References Cited**

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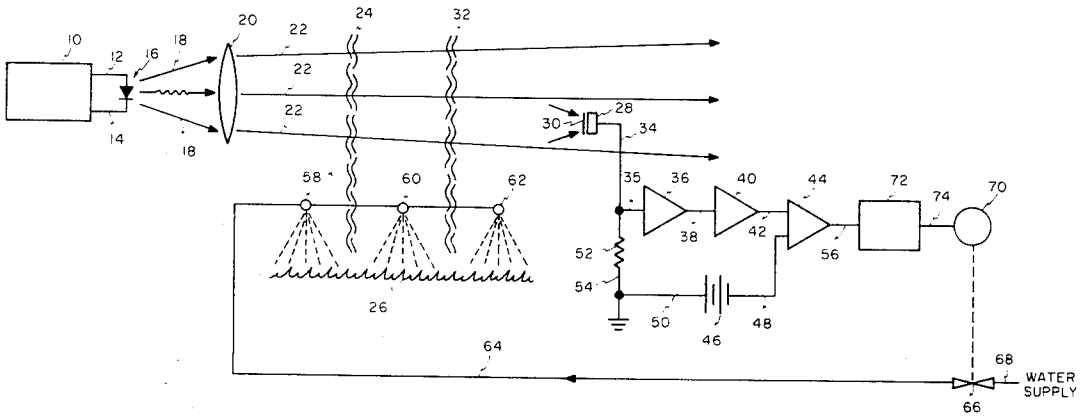
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Assistant Examiner—Michael Mar
Attorney—Richard S. Sciascia et al.

[57] **ABSTRACT**

A light source such as a gallium arsenide laser is positioned in relation to light detector means to produce an electrical signal modulated by the pollution product of an oil fire and applied to a control valve responsive to said modulated electrical signal to control the operation of water spray equipment directed on said fire to thereby minimize air pollution product of said fire.

10 Claims, 4 Drawing Figures



2 Sheets-Sheet 1

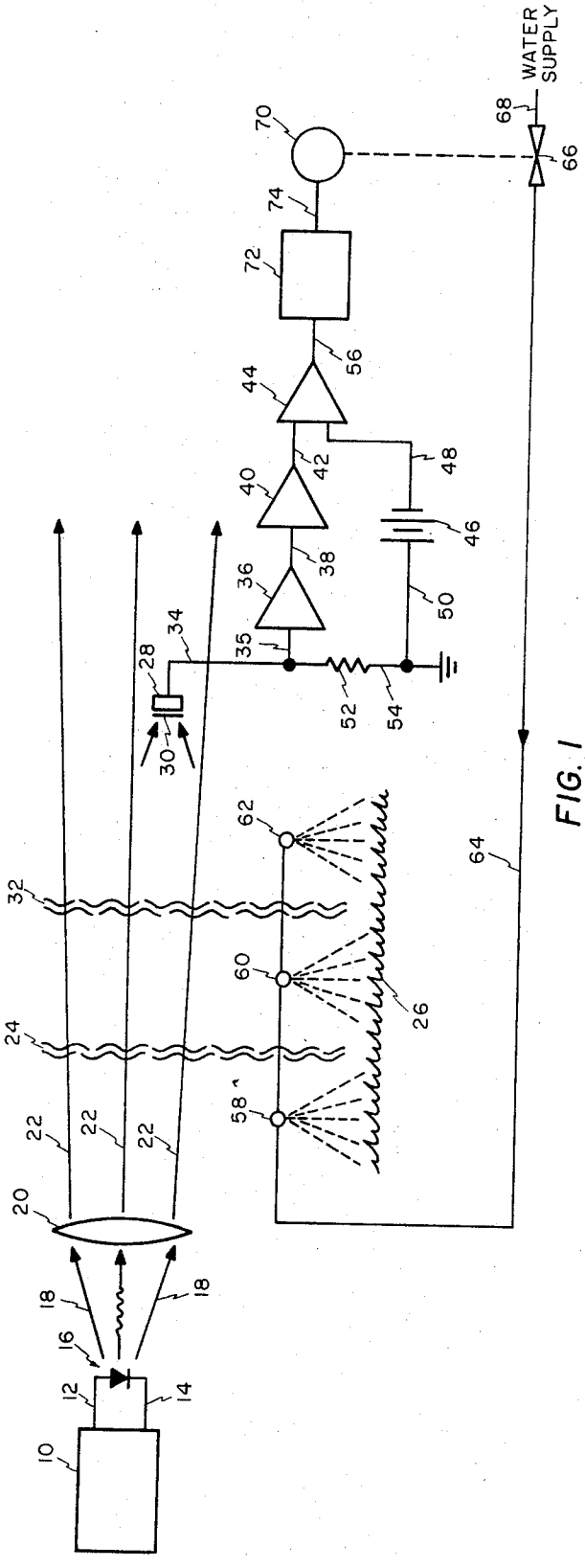


FIG. 1

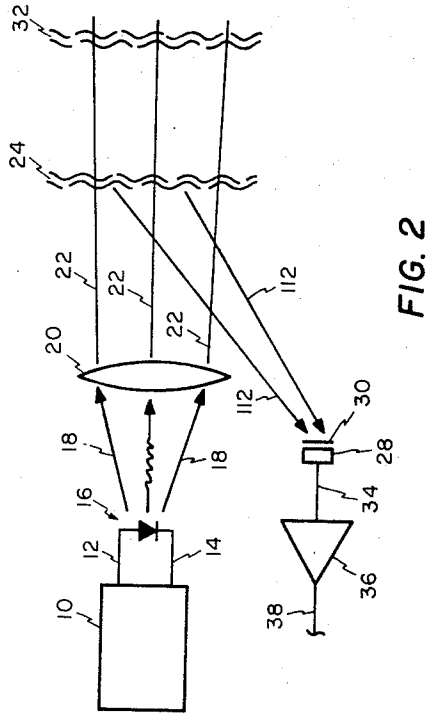


FIG. 2

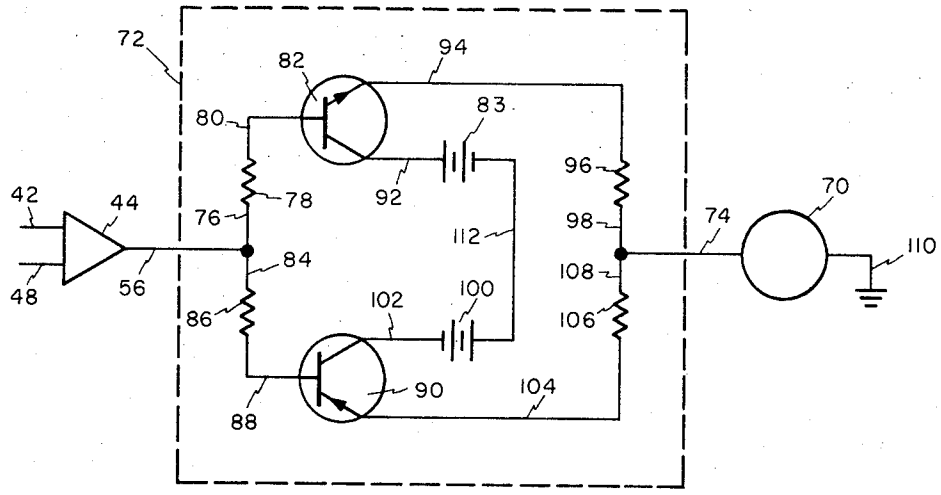

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FIG. 3

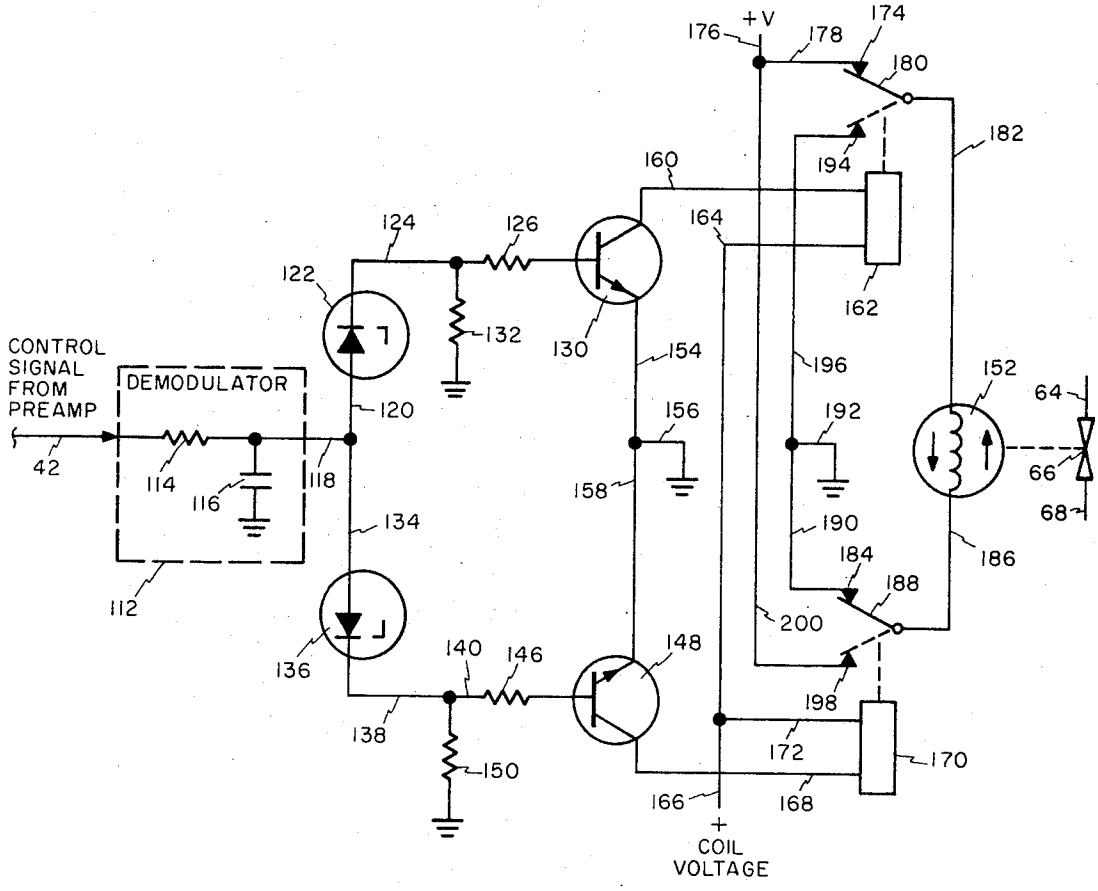

+V
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CONTROL SIGNAL FROM PREAMP
DEMODULATOR
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192
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114
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66
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134
190
184
186
188
112
200
136
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146
148
198
138
172
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150
166
168
+
COIL VOLTAGE

FIG. 4

FIRE CONTROL APPARATUS AIR POLLUTION PRODUCT ABATEMENT

BACKGROUND OF THE INVENTION

The invention relates to the field of training simulations and more particularly to the problem of minimizing air pollution product in the training of personnel in the extinguishment of oil fires.

Diesel oil fires are currently used to train personnel in the techniques of fire fighting. To avoid the production of air pollution product of black or white smoke, it has been a practice to inject into an area near the surface of the fire a fine spray of atomized water. This results in the reduction of black smoke (carbon particles) in the resulting gases, the black particles contributing to air pollution. However, if too much water is sprayed near the surface of the fire, a white smoke or steam will result. At the present, to avoid each of the above conditions, the water sprayed on the fire is controlled by an observer. However, the amount of water sprayed and the timing thereof must be carefully controlled by a skilled observer. If too much water is sprayed, the fire will be extinguished before any training exercise in the extinguishment of the fire can be accomplished. If the volume of water spray is excessive but not sufficient to inadvertently extinguish the fire, there is still the problem of producing vast quantities of steam or white smoke. On the other hand, too small a volume of water spray will result in the production of undesirable quantities of black smoke and carbon particles.

SUMMARY OF THE INVENTION

The subject invention is directed to automatic means for automatic control of the water sprayed on the fire by developing an electrical control signal modulated by the actual air pollution product condition of the fire and utilizing this electrical signal to automatically control the volume of water spray applied to the fire to maintain a condition of minimum air pollution product. In accordance with the invention, in a preferred embodiment a gallium arsenide laser light source and collimating lens is arranged to direct a light ray through the pollution product and a silicon photodiode and a detector pre-amplifier are positioned to respond to the light ray as modulated by the pollution product and develop a modulated electrical control signal. This signal is then applied to electrical signal responsive control means for a valve controlling the volume of water sprayed upon the fire, the control valve being set to provide a volume of water providing minimum pollution product. The fire is thus regulated to provide the necessary actual fire for a realistic training situation in the extinguishment of a fire, while at the same time automatically maintaining at a minimum carbon particles and other air pollutants.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of fire control system apparatus incorporating the invention,

FIG. 2 is a schematic view of a modified fire control system also incorporating the invention,

FIG. 3 is a detailed drawing of one suitable control circuit for a servo motor control circuit shown in block form in FIG. 1, and

FIG. 4 is a detailed drawing of a second suitable control circuit for application to the system shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, FIG. 1 illustrates one preferred embodiment of the invention in which a laser pulsing circuit 10 supplies power on lines 12 and 14 to a gallium arsenide laser diode 16, thereby constituting a light source which produces a laser beam indicated by arrows 18. The laser beam is collimated by a collimating lens 20 to provide a collimated laser light ray indicated by the arrows 22. The collimated laser light ray 22 is directed through a black smoke column 24 rising from an oil fed fire indicated at 26 or through a column of white smoke or steam 32, depending upon the condition of water spray on the fire.

In accordance with one preferred form of the invention there is provided and positioned on the opposite side of the fire 26 a light detector means, in the example shown a silicon photodiode detector 28, so positioned in order to intercept the laser light ray 22 after it has passed through the black smoke column 24 or, alternatively, the white smoke column 32. An interference filter 30 is provided and positioned before the photodiode detector 28 to limit background, i.e., ambient, light radiation when such radiation is a factor, as for example when the fire is located outdoors. The need to use the filter depends upon the ambient light ray situation.

The output electrical signal of the detector 28, modulated by the pollution product, i.e., the black smoke 24 or in the alternative the white smoke or steam 32, is passed on lines 34 and 35 to a preamplifier 36, and thence via a line 38, and amplifier 40 and a line 42 as an input to one side of a differential amplifier 44. A negative input to the differential amplifier 44 is provided from a battery 46 via line 48, the positive side of the battery 46 being connected to ground (indicated) by a line 50. Line 34 is also connected to ground (indicated) via resistor 52 and line 54. The differential amplifier thus provides for an output signal on a line 56 dependent upon the relative polarity values of its inputs on lines 42 and 48.

Water spray nozzles 58, 60, and 62 are connected via line 64, control valve 66 and a line 68 to a water supply source (indicated) to adjustably control the volume of atomized water sprayed on the fire 26. Control of the valve 66 is accomplished by suitable means such as a servo motor 70 connected as indicated to the valve 66. Servo motor 70 is bi-directional in rotation to increase and decrease flow of water through the valve 66.

To rotate the servo motor in each of its two directions responsive to the positive or negative output from the differential transformer 44, any suitable control circuit 72 may be used connected to the differential amplifier output by line 56 and to the servo 70 by a line 74. One suitable circuit for control circuit 72 is shown in FIG. 3. As shown in FIG. 3, the output of differential amplifier 44 is passed on line 56 via a line 76, resistor 78 and a line 80 to the base of an NPN transistor 82 and via a line 84, resistor 86 and a line 88 to the base of a PNP transistor 90. Positive d.c. current is supplied to the collector of transistor 82 from a d.c.

power source 83 via a line 92, the emitter of the transistor 82 being connected to the servo motor 70 via a line 94, resistor 96, a line 98 and line 74. Negative d.c. current is supplied to the collector of transistor 90 from a second d.c. power source 100 via a line 102, the emitter of the transistor 90 being connected to the servo motor 70 via a line 104, a resistor 106, a line 108 and line 74. The servo motor 70 is connected to ground (indicated) by a line 110 and the positive side of d.c. source 100 is connected to the negative side of d.c. source 82 by a line 112. The resistors 78 and 86 may be selected in value to provide a desired degree of dwell point on operation of the servo motor 70 such that continuous hunting of the servo motor is avoided.

In the operation of circuit 72, a positive signal (of value dependent upon the selected values of resistors 78 and 88) on the output line 56 of differential transformer 44 biases transistor 90 to off condition and transistor 82 to on condition. Transistor 82 in on condition passes positive d.c. current to servo motor 70 and turns the motor in a direction to decrease water flow through valve 66 (FIG. 1). The condition of positive output on line 56 would result from a white smoke or steam condition of the fire pollution product, since this condition provides more light on the light detector 28 which in turn provides a sufficiently large output to the positive input line 42 of differential transformer 44 to overcome the fixed negative bias on the negative input line 48 of differential transformer 44.

Under the reverse condition (see FIG. 1) of black smoke over the fire the detector 28 receives less light. The output of detector 28 is less than is required to overcome the fixed negative bias on differential transformer 44 and the output signal on line 56 is negative. Under a condition of negative voltage on line 56 (see FIG. 3) the transistor 82 is biased to off condition and transistor 90 is biased to on condition. Negative current is then passed from power source 100 as an input to servo motor 70 and the motor rotates in a direction to increase the flow of water through valve 66 (FIG. 1). When there is no pollution product or minimum pollution product, the light on the light detector 28 is such as to produce a positive electrical output which when amplified and fed to the differential amplifier 44 equals or substantially equals the negative bias input and the output of the differential amplifier is zero or a value not sufficient to activate either transistor 82 or 90. The servo motor 70 is then supplied with no power and remains stationary, holding the valve 66 in the position for proper water flow to eliminate or minimize pollution product.

It is to be understood that the output signal from the detector 28 is decreased when the pollution product is black smoke because the black smoke absorbs the light ray. The output signal from detector 28 is increased by pollution product of white smoke or steam because of the forward scattering of the ray.

Referring to FIG. 2, the same numerals are used as for FIG. 1, FIG. 2 being provided to show that the detector 28 need not be positioned on the opposite side of the fire from the light ray source to provide an operative device. Thus, in FIG. 2, the detector 28 is positioned adjacent the collimating lens 20 and the detector 28 monitors back scatter rays indicated at 112 from the pollution product. The same phenomenon occurs, in that black smoke absorbs the light rays and reduces the strength of the back scatter rays, thereby reducing the output of the detector 28. On the other hand, white smoke or steam condition increases the light rays and thereby increases the value of back scatter rays, thereby increasing the output of the detector 28. The remaining portions of the system are the same as described for FIG. 1 and operate in the same manner.

Another suitable circuit for control of the servo motor 70 from the output of amplifier 40 is shown in FIG. 4. This circuit would replace in FIG. 1 the differential amplifier and its negative power source as well as the circuit 72, and provides zener diode means for selectively adjusting the dwell band at which the servo motor is inactive. Referring to FIG. 4, the control signal on line 42 (corresponding to line 42 of FIG. 1) is passed through a demodulation circuit 112 including a resistor 114 and grounded capacitor 116 and passed on output line 118 via a line 120, zener diode 122, line 124, and resistor 126 to the base of an NPN transistor 130. A resistor 132 is connected from line 124 to ground indicated to form with the resistor 126 a biasing network. Line 118 is connected via a line 134, a zener 136, a line 138, a line 140 and a resistor 146 to the base of another NPN transistor 148. A resistor 150 is connected between line 140 and ground indicated to form with resistor 146 a biasing network for transistor 148. The purpose of the zener diodes is to establish a dwell band wherein the servo motor indicated by numeral 152 will remain inactive for voltages between the voltage ratings of the diodes. This will become evident as the remaining portions of the circuit are described.

The emitters of transistors 130 and 148 are connected to a common ground indicated by lines 154 and 156 and lines 158 and 156. The collector of transistor 130 is connected to a source of positive potential indicated via a line 160, a relay 162, a line 164 and a line 166. The collector of transistor 148 is connected to the same source of positive potential via a line 168, a relay 170, a line 172 and line 166. Relay 162 has a normally closed contact 174 through which current is passed to one side of the motor 152 via a line 176, a line 178, contact 174, relay bar 180 and a line 182. Relay 170 has a normally closed contact 184 through which current is passed from the other side of motor 152 to ground indicated via a line 186, relay bar 188, contact 184, line 190 and line 192. A normally open contact 194 of relay 162 is connected to ground indicated via a line 196 and line 192. A normally open contact 198 of relay 170 is connected to the positive source of voltage indicated for the motor via a line 200 and line 176.

Considering the operation of the circuit of FIG. 4, each of the transistors 130 and 148 are in inactive state until a positive bias is applied to its base. Until transistor 130 is actuated the motor 152 remains connected to a source of positive voltage and to ground because of the normally closed contacts 174 and 184. The motor which is connected to the valve 66 operates to increase the supply of water to the spray nozzles 58, 60, and 62 (FIG. 1). This corresponds to a condition of pollution product of black smoke where the output of the detector 28 is low and the resultant amplified and demodulated voltage on line 118 (FIG. 4) is insufficient to pass through either of the zener diodes 122 or 136.

As previously indicated, the values of the zener diodes are selected to provide for rotation of motor **152** in one direction responsive to black smoke, to remain inactive for an intermediate condition of minimum pollution product, and to rotate the motor in the opposite direction for white smoke or steam condition. With the above in mind, assume that zener diode **122** is selected for 4 volts and zener diode **136** is selected for 5 volts. Then until the black smoke is sufficiently reduced to provide an output of 4 volts at line **118** (FIG. **4**), motor **152** continues to move in a direction to increase the volume of water spray. When a value of 4 volts input on line **118** is attained and until a voltage of 5 volts is attained, we have a dwell period during which motor **152** is inactive and no adjustment is being made in water spray volume. This is accomplished by the application of bias to the base of transistor **130** which, when activated, energizes relay **162** to open contact **174** and close contact **194**. Opening contact **174** interrupts the supply of positive voltage to the motor **152**.

Should a condition of white smoke or steam develop such that the voltage at line **118** exceeds 5 volts then bias is applied to the base of transistor **148** and its activation opens contact **184** and closes contact **198** of relay **170**. On relay **162**, which is still activated, contact **174** is open and contact **194** is closed. Under this condition the current has been reversed in motor **152**, i.e., the one side of the motor is connected to ground via line **182**, bar **180**, contact **194**, line **196** and line **192**. The opposite side of the motor (originally connected to ground indicated) is now connected to positive voltage via line **186**, bar **188** of relay **170**, contact **198**, line **200** and line **176**. The direction of rotation of the motor is thereby reversed to operate on the valve **66** to decrease the flow of water until the white smoke or steam is eliminated and the input voltage on line **118** drops to the dwell value between **4** and **5** volts, whereupon the motor will then remain inactive as long as the input voltage remains in the dwell range.

It is apparent then that in each of the two examples of suitable control circuits the system can be made completely automatic to provide and maintain a desired minimum pollution product condition of the fire.

What is claimed is:

1. Apparatus for automatically controlling an oil fire to minimize air pollution product caused by the fire comprising:

a. light source means for producing a ray of light,

b. collimating lens means for directing said ray across said oil fire through said pollution product,

c. water spray equipment for directing a fine spray of water on said fire to reduce black smoke air pollutant product and when used to excess to ultimately create white smoke or steam pollutant,

d. light detection means positioned to respond in control output electrical signal amplitude to the intensity of light received upon said detector directly and also as modulated by said pollution product and white smoke or steam,

e. amplifier means for amplifying said control output signal,

f. valve means for adjusting the volume of said water spray, and

g. valve control means responsive to said control amplifier output signal amplitude to increase and decrease the volume of water spray respectively responsive to conditions of black smoke and white smoke or steam, and in the absence of either pollutant to maintain the spray constant, thereby to minimize said pollution product.

2. Apparatus according to claim **1**,

a. said light detection means being positioned adjacent said light source means and directed toward said oil fire to monitor back scatter from black smoke and white smoke or steam produced by said oil fire.

3. Apparatus according to claim **1**,

a. said light detector being positioned opposite said light source to receive said directed ray through said pollution product.

4. Apparatus according to claim **1**, including

a. an interference filter positioned in front of said light detector and selected to eliminate the effects of ambient background light radiation conditions.

5. Apparatus according to claim **1**, said valve control means comprising:

a. a servo motor connected to said valve,

b. a pair of transistor elements connected to said servo motor and respectively to positive and negative d.c. power sources for selectively rotating said servo motor in opposite directions in accordance with the voltage bias condition applied to said transistors,

c. a differential amplifier connected to receive a variable positive d.c. control voltage from said amplifier means and a fixed negative d.c. signal from a source of negative d.c. voltage to provide a variable positive and negative output signal or zero output signal dependent upon the relation of said input voltages to said differential amplifier,

d. a bias resistor for each of said transistors, the output of said differential amplifier being connected through each of said bias resistors to the base of its associated transistor, the value of said resistors being selected to provide a dwell band conditioning said transistors to off condition and hence inactivating said servo motor for a selected intermediate range of control signal from said amplifier corresponding to a desired condition of minimum pollution product.

6. Apparatus according to claim **1**, said valve control means comprising:

a. a servo motor connected to said valve,

b. a pair of relays connected to said servo motor and to a source of d.c. voltage, said relays having normally closed contacts for rotation of said servo motor in a direction to increase water spray volume, one of said relays having a normally open contact which when closed interrupts power supply to said motor, and the other of said relays having normally open contacts which when activated reverse the rotation of said motor to reduce water spray volume,

c. a pair of transistor elements connected to respectively actuate said relays, one of said transistors in on condition closing said normally open contact of said one relay, the other of said transistors closing the normally open contact of said other relay,

d. a pair of zener diodes connected respectively to apply a bias voltage to said transistors to control the on - off condition of said transistors in accordance with the value of control voltage signal applied to said zener diodes from said amplifier means,

e. the value of said zener diodes being selected of related different values to prevent application of bias voltage to said transistors for low voltage control signal from said amplifier to maintain said motor in condition for increasing water spray, to pass bias voltage to one of said transistors for an intermediate range control signal value and to pass bias voltage to the other of said transistors to reverse the rotation of said servo motor for control voltage values above said intermediate voltage range.

7. Apparatus according to claim 2,

a. said light source means including a laser pulser and laser diode,

b. said light detector including a photo-diode detector.

8. Apparatus according to claim 3,

a. said light source means including a laser pulser and laser diode,

b. said light detector including a photo-diode detector.

9. Apparatus according to claim 2,

a. said light source means including a laser pulser and gallium arsenide laser diode,

b. said light detector including a silicon photo-diode.

10. Apparatus according to claim 3,

a. said light source means including a laser pulser and gallium arsenide laser diode,

b. said light detector including a silicon photo-diode.

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