Dec. 4, 1962 J. A. DHIMOS 3,067,411

APPROACH LIGHT MONITOR

Filed May 4, 1959

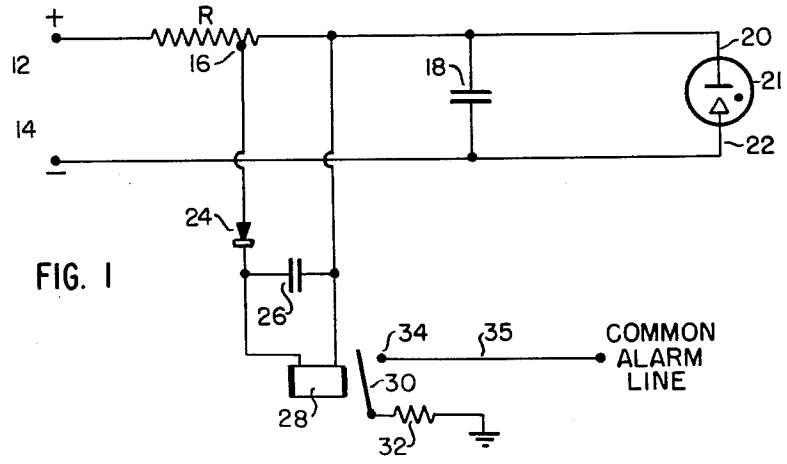


FIG. 1

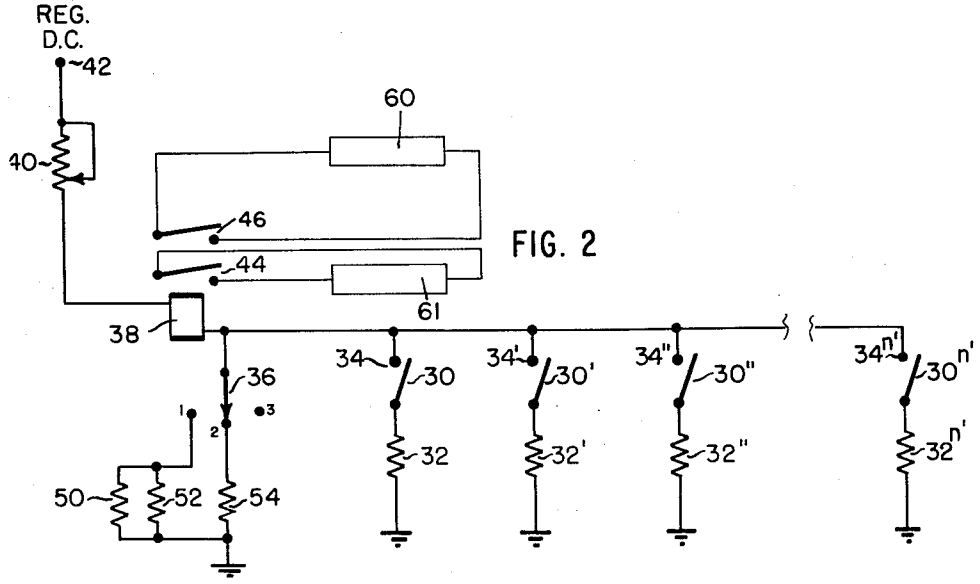


FIG. 2

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United States Patent Office 3,067,411 Patented Dec. 4, 1962

3,067,411

APPROACH LIGHT MONITOR

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Filed May 4, 1959, Ser. No. 810,729
5 Claims. (Cl. 340—251)

This invention relates in general to airport approach lighting systems and in particular to the monitoring of such systems.

In U.S. Patent No. 2,794,657 to Coggins et al., entitled Airport Approach Lighting, a system typical of those to which this invention applies is disclosed. Both the cited patent and this application are assigned to Sylvania Electric Products Co. The system disclosed in the patent is variously known as an electronic flash approach system, commonly abbreviated EFAS, or condenser-discharge sequenced flashing light system.

The latter appellation is quite descriptive of the system. As is explained in greater detail in the patent noted above, a series of lights are placed along the outer approach to an airport runway. These are so connected and arranged that they flash one after another, commencing with the light furthest from the runway and continuing through the series until the last or inner light is flashed. This sequence of flashes is repeated periodically, usually every thirty seconds, and gives the impression of lightning flashes directed toward the end of the runway where the plane is to land. The flash is of such short duration and tremendous intensity that it attracts the pilot's attention even under conditions of very poor visibility without undesired side effects such as blinding glare or possible misinterpretation of direction or meaning of the flash.

Although the sequenced flashed lights have met with general acceptance and are generally considered to be a great aid in the landing of aircraft, certain difficulties have been encountered. In a large installation as many as 28 or more individual lights are used. Smaller airports or installations often use a correspondingly smaller number of lights. In either case, failure of one or more of the lights may well go unnoticed by tower operating personnel. Clearly, it would be desirable to call the failure of any of the lights to the attention of the airport personnel as soon as possible to expedite repair or replacement.

However, the failure of as many as two or three of the lights in a large installation which may have 28 or more separate lights is not necessarily a fatal system defect. In fact, excellent results are obtained despite the absence of light from two or three of the units. On the other hand, in a smaller installation which may have as few as 10 or 12 individual lights, the lack of light from two or three of the units would constitute an intolerable defect. Therefore, any monitoring system, to be uniformly acceptable in installations of various sizes, would preferably provide indications of failure of one or more units, the number to be pre-selected by the operating personnel.

It is, therefore, a primary object of the present invention to monitor the operation of sequenced flashed approach lighting systems.

It is a further object of the invention to provide a monitoring system which indicates failure of one or any other pre-selected number of lights in a sequenced flashing light system.

It is another object of the invention to improve efficiency and safety in the use of sequenced flashing light systems.

In general, the present invention is organized about a particular circuit and the arrangement for sampling voltages at each unit to obtain monitor relay voltage for alarm actuation.

Monitor relay voltage in each unit is actually developed by sampling and rectifying pulses of voltages which occur as condensers are charged to provide the flashing voltage for the units. The rectifier voltage is filtered and applied to the monitor relay, and it is sufficient to keep that relay energized as long as the unit is flashing normally. Should a unit become inoperative, the normal charge-discharge cycle ceases, and the pulse voltage is absent. There is no longer enough voltage to maintain the monitor relay energized under these conditions. When this occurs, a common alarm line is grounded through the contacts of the monitor relay and a monitor resistor of the malfunctioning unit.

The common alarm line is connected in series with an alarm relay coil and a rheostat to a source of regulated D.C. voltage. A switch is also incorporated in the circuit with its movable or common contact connected to the junction of the common alarm line and the alarm relay coil.

The fixed contacts of the switch are arranged to present either no branch circuit in parallel with the units or branch circuits of certain fixed resistance values depending upon the position of the movable switch contact. The values of the resistors in the branch circuits are chosen with reference to the monitor resistors of the units and to the value of applied voltage from the D.C. source to provide alarm relay actuation upon failure of a unit or a number of units as determined by the switch setting.

Closing of the alarm relay contacts provides audible and visual warnings which may be in the form of buzzers and flashing lights or other suitable signals. For a better understanding of the invention together with other and further objects, features and advantages, reference should be made to the following description of a preferred embodiment thereof which should be read in connection with the appended drawing, in which:

FIG. 1 is a simplified schematic diagram of the circuit of a single flashing unit, and

FIG. 2 is a simplified schematic diagram of the alarm system and the actuating circuitry.

In FIG. 1, a typical unit of the sequenced flashing light system is illustrated. D.C. voltage is applied between the terminals **12** and **14**, terminal **12** being of positive polarity and terminal **14** being of negative polarity. Connected to the positive terminal **12** is a sampling resistor **16** which is provided with a tap at some point along its length. The other side of the resistor **16** is connected to the junction of one side of a condenser **18** and the anode **20** of a flashing light unit **21**. The negative terminal **14** is connected to the other side of the condenser **18** and to the cathode **22** of the flashing light **21**. The tap on resistor **16** is connected to a rectifier **24** which in turn is connected to one terminal of a relay condenser **26** and one end of a relay coil **28**. The other end of the condenser **26** and the relay coil **28** are connected in common and returned to the junction of the resistor **16** and the condenser **18**. Associated with the relay coil **28** is a swinging contact **30** which is returned to a reference voltage point or to ground through a monitor resistor **32**. A normally open contact **34** is provided in the relay structure, and it is connected to a common alarm line **35**.

The operation of the invention as a whole may be better understood by first considering the operation of those components shown in FIG. 1. Assuming that the illustrated unit is operating properly, the condenser **18** is charged through the resistor **16** from the voltage applied across the terminals **12** and **14**. Normally, this charge takes place twice a second, and operation of the flashing light **21** also occurs twice a second as the condenser **18** discharges through that unit. During the charge cycle, an exponentially increasing current passes through the

resistor 16, and the voltage developed between the tap on the resistor 16 and its junction with the condenser 18 also builds up exponentially twice each second. The voltage pulses from the tapped portion of the resistor 16 are rectified by the rectifier 24 and are filtered by the condenser 26 to provide a pulsating direct current through the relay coil 28. This current is sufficient to maintain the relay coil 28 energized and the swinging contact 30 remains in its illustrated normally closed position.

However, should the unit 21 become inoperative, the pulsating current ceases to flow through the resistor 16 and insufficient voltage is developed to energize the relay coil 28. Upon de-energization of the relay coil 28, the swinging contact 30 closes with the fixed contact 34 which grounds the common alarm line 35 through the resistor 32.

The actuation of the alarm system which is then obtainable may best be understood by considering FIG. 2. The details of the flashing units have been eliminated from FIG. 2. Only the monitor relay systems, of which 30, 32 and 34 are typical, are illustrated for each unit. These are numbered in accordance with the convention adopted in FIG. 1, and successive units are legended 30', 32', 34', etc.

The common alarm line 35 is connected to the relay contacts 34, 34' etc. and is also connected to the movable contact of a switch 36. The movable contact of the switch 36 is also connected to an alarm relay coil 38, the other end of which is in series with a rehostat 40 and a source of regulated D.C. voltage 42. The alarm relay contacts 44 and 46 are incorporated in a circuit which actuates the audible and visual indications 60, 61, at the substation and control tower respectively.

Three positions are provided on the illustrated switch 36, the first of these positions being grounded through two parallel resistors 50 and 52, which are of equal value, and are also each equal in value to the resistors 32, 32', etc. The second switch position is grounded through a single resistor 54 of the same value as resistor 50, resistor 52, and resistors 32, 32', etc. The third switch position is blank and provides no branch lines in parallel with the common alarm line. Should the requirements of a given installation be such that more than three inoperative lights could be tolerated, additional switch positions may be provided. Such positions would be grounded through parallel resistor networks in which additional resistors would be incorporated.

Assuming the installation to be one wherein an alarm is desired upon the failure of three lights, the switch would be set at the third or floating position. No current would then normally flow from the regulated D.C. source 42 and through the alarm relay coil 38. Each of the relay contacts 34, 34', etc. would present an open circuit to the common alarm line as would the third position of the switch 36. However, upon failure of one unit, current would flow from the D.C. source 42 through one of the monitor resistors such as 32. This would place in circuit a resistance which might be of the order of 22,000 ohms in a typical installation. The rheostat 40 would be so adjusted that the flow of current would not be sufficient to actuate the relay coil 38. Thus, with the switch in the third position, a single unit failure causes no warning to be given.

Similarly, if only two of the units were to fail, two of the relay contacts 30, 30', etc. would close. This would place the parallel combination of two 22,000-ohm resistors in series with the voltage source and the alarm relay coil. The combined resistance of the combination would be 11,000 ohms. The setting of the rheostat is such that there would still be insufficient current flow through the 11,000-ohm resistance to cause actuation of the alarm relay 38.

When, however, three units fail, three of the relays 34, 34' and so forth are actuated, and a resistance of only 7,000 ohms is placed in series with the alarm relay circuit. Proper adjustment of the rheostat 40 assures that the increased current flow and the increasingly greater voltage drop across the coil of relay 38 would cause actuation of the alarm relay contacts. The difference of 4,000 ohms in a typical circuit such as described above between alarm actuation and no alarm actuation gives ample range for proper rheostat adjustment.

In a situation where an alarm is desired upon the failure of two of the units, the same reasoning applies. If the setting of the rheostat 40 be assumed as in the case above to be such that a resistance considerably less than 11,000 ohms is needed to actuate the alarm relay, the operation of the alarm is identical to that described above. With the movable switch contact at position 2, a single 22,000-ohm resistor 54 grounds the alarm relay coil through the switch. Therefore, only two additional parallel monitor resistors of the same value, such as are present in the light units, are needed to actuate the alarm. Finally, when an alarm is desired upon failure of a single unit, two of the required three parallel resistors are provided in the switch circuit, namely resistors 50 and 52. These, of course, return the common alarm line to ground through the first switch position. Thus, only one resistor of an inoperative lighting unit need be in circuit to provide actuating voltage to the alarm relay coil 38.

Although the invention has been described in connection with a specific embodiment and application thereof, various changes and modifications may be made without departing from the inventive concepts. Therefore, the invention should be limited only by the spirit and scope of the appended claims.

What is claimed is:

1. Monitoring apparatus for indicating failure of a preselected number of lights in a sequenced flashing light system comprising a source of regulated D.C. voltage, a rheostat, an alarm relay coil and a multiple position switch connected in series circuit relationship, a pair of resistors of equal predetermined values connected in parallel relationship from a reference voltage point to one position of said switch, a single resistor also of said predetermined value connected from said reference voltage point to a second position on said switch, a third open position being provided on said switch, a common alarm line, said common alarm line and one end of said alarm relay coil being connected to the movable contact of said switch, each said flashing light being connected to and energized by a circuit which includes a discharge condenser and a voltage source and resistor for periodically charging said condenser, a monitor relay circuit at each of said flashing lights, each said monitor relay circuit being connected across at least a portion of said resistor and including a rectifier and parallel combination of filter condenser and monitor relay coil in series with said portion of said resistor, relay contacts operable in response to and normally maintained open by current flow through said monitor relay coil and a monitor resistor also of said predetermined value connected in series from said common alarm line to said voltage reference point, alarm relay contacts adjacent said alarm relay coil, said alarm relay contacts being normally open and responsive in closing to the flow of current of a predetermined magnitude through said alarm relay coil, whereby failure of any of said lights to operate discontinues the flow of current through the resistor of the charging circuit of said light to interrupt the flow of current through said monitor relay coil to connect said common alarm line to ground through said monitor resistor, actuation of said alarm relay contacts taking place upon failure of a number of said lights determined by the position of said movable contact of said switch.

2. In a sequenced flashing light system, the combination of a plurality of light units, energizing circuits for

each of said light units, each said energizing circuit including a condenser, a resistor, means for charging said condenser through said resistor, means for discharging said condenser periodically through said light unit associated therewith, means for sampling the voltage developed in said resistor during the charge of said condenser therethrough, said means including a rectifier and filter connected to at least a portion of said resistor, a relay coil connected to said filter and normally energized by the voltage derived therefrom, a common alarm line, a monitor resistor and contacts associated with said relay coil being connected in series to ground, said relay coil having contacts held open by said relay coil during the presence of voltage thereon and closing upon the absence of voltage thereon to connect said alarm line to ground through said monitor resistor.

3. Apparatus as defined in claim 2 including a source of voltage, a rheostat and an alarm relay coil connected through said common alarm line in series circuit relationship with each of said monitor resistors separately and manually selectable resistors, each of said selectable resistors having one of its ends connected to said common alarm line and being in parallel circuit relationship with said monitor resistors.

4. In a sequenced flashing light system having a number of light units, an alarm system for providing a warning upon the failure of any selectable number of said light units comprising a plurality of monitor resistances of predetermined value, a like plurality of failure-sensing devices, each one of said failure-sensing devices being actuated by a different one of said light units to interpose one of said monitor resistances in series with an alarm relay upon the failure of the light unit by which it is actuated, a plurality of resistance networks, each resistance network having a resistance different from the others and switching means for connecting any of said networks in series with said alarm relay and in parallel circuit relationship with said monitor resistance.

5. Monitoring apparatus for indicating failure of a selectable number of lights of a sequenced flashing light system comprising a plurality of circuits for sensing the failure of any of said lights, a common alarm line connected to one terminal of each of said failure-sensing circuits, the other terminals of each of said failure sensing circuits also being connected together, a voltage source and an alarm relay in series with said common alarm line, said alarm relay being operable in response to the flow of a current of predetermined magnitude, a plurality of networks each having a resistance such that the current through the alarm relay will reach said predetermined magnitude only upon failure of a fixed number of lights, and switch means for interposing one or more of said networks in parallel with said common alarm line and said other terminals of each of said failure-sensing circuits and in series circuit relationship with said alarm relay to determine said fixed number of lights.

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