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[54] **EMERGENCY TRAFFIC LIGHT CONTROL**
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307/64, 66; 320/2

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ABSTRACT: Automatic changeover apparatus for operating a traffic light under DC power through an inverter upon a failure of a primary power source. A battery charger is incorporated into the apparatus to maintain the battery providing the DC power at peak voltage.

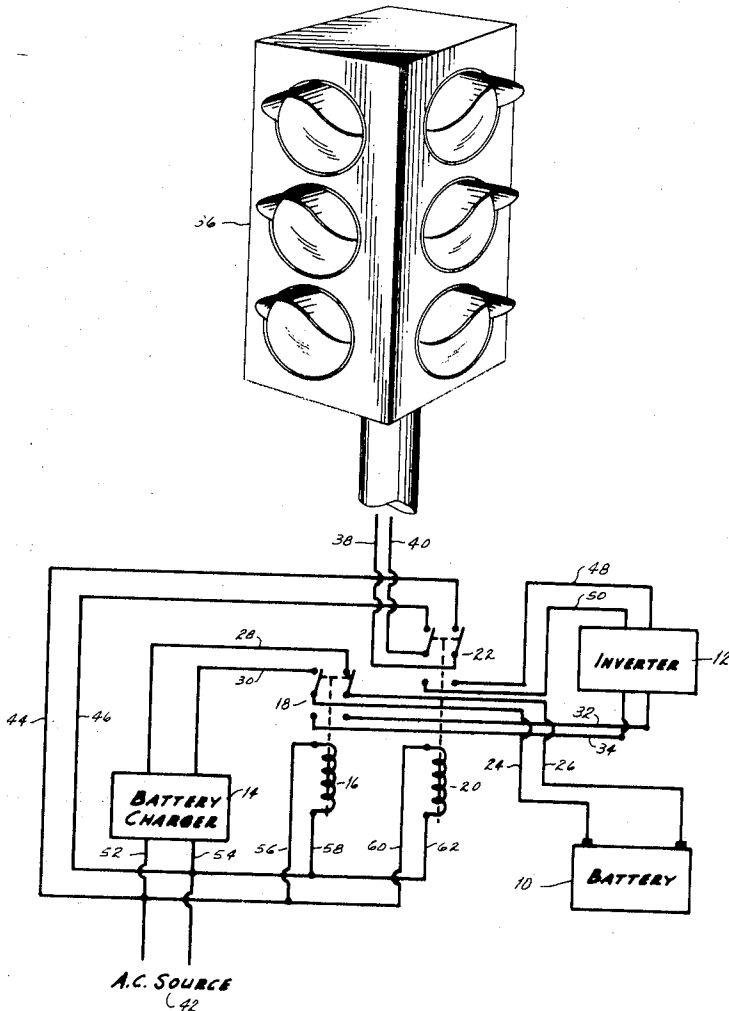
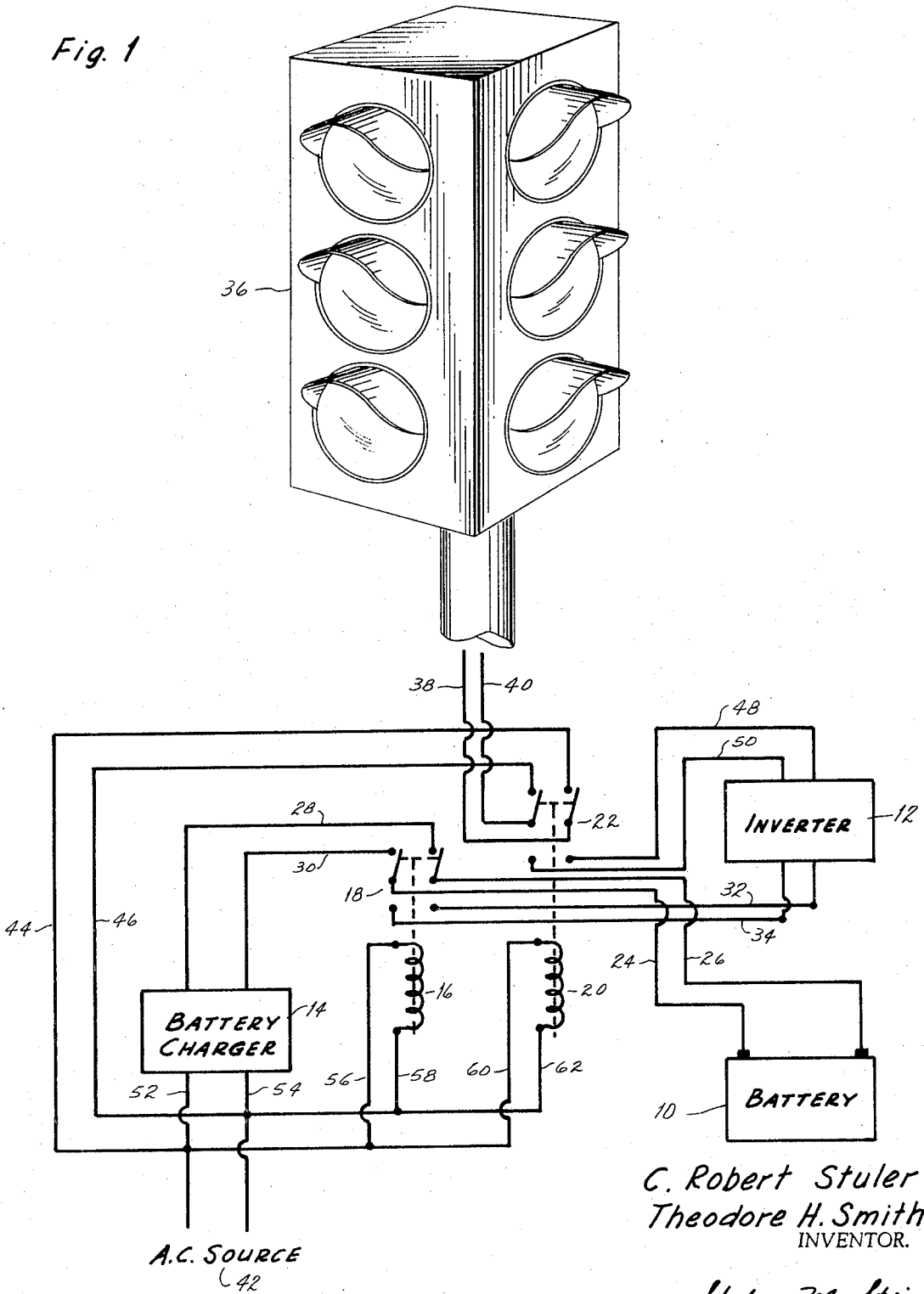
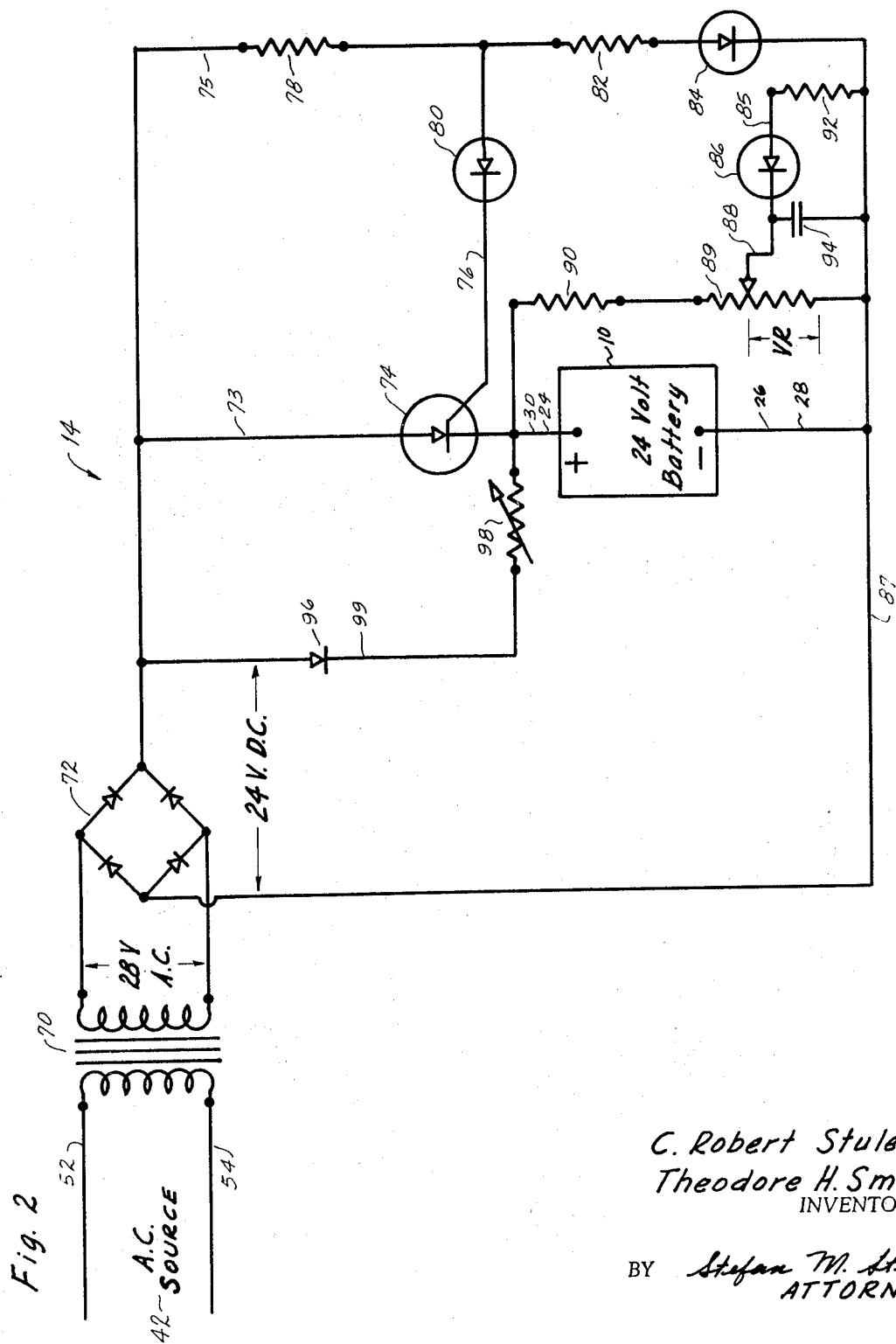


Fig. 1



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Fig. 3

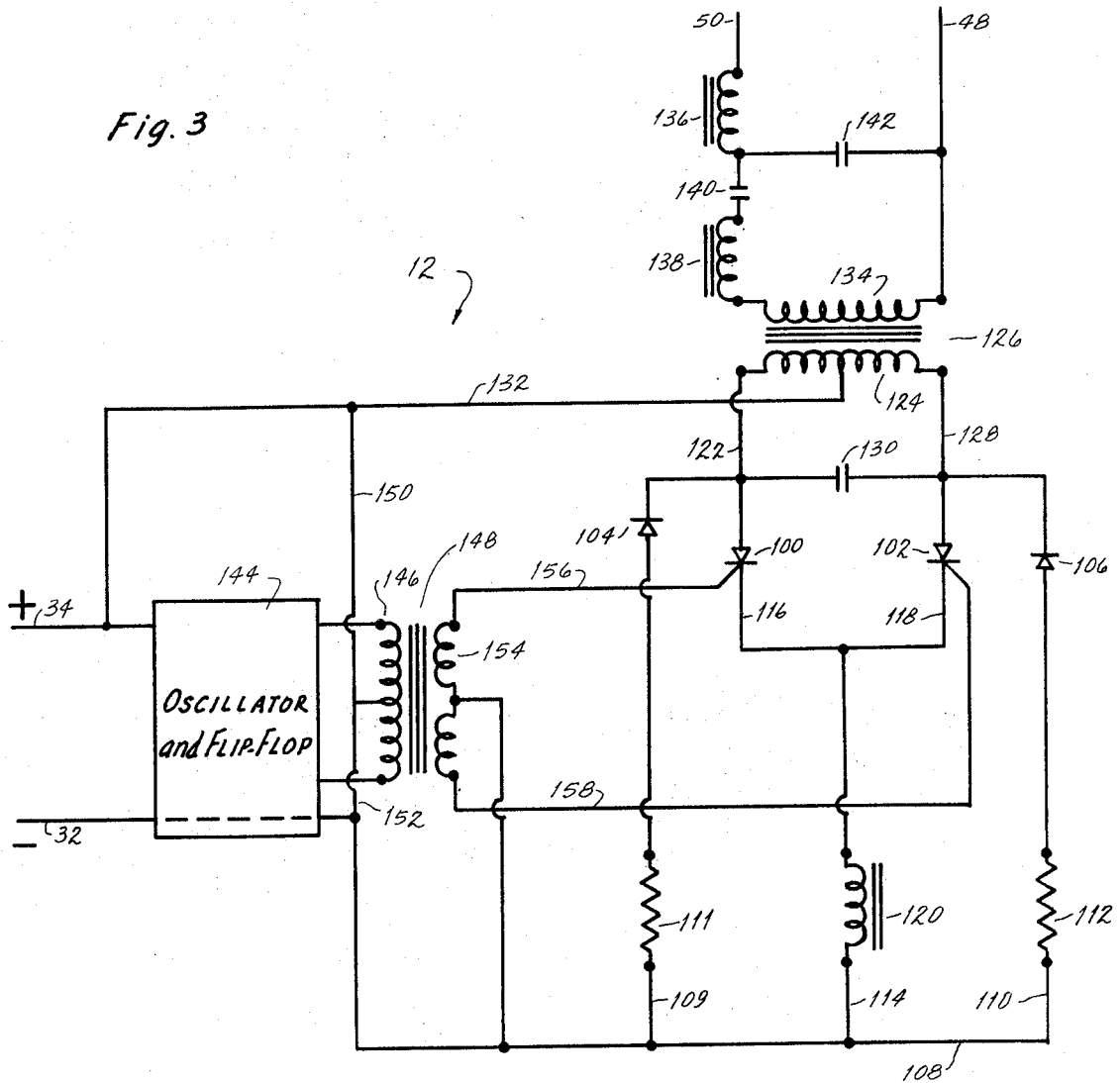
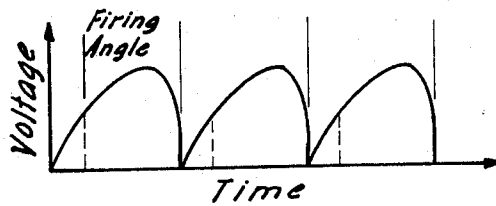


Fig. 4



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EMERGENCY TRAFFIC LIGHT CONTROL

This invention relates to an automatic changeover apparatus; more particularly, this invention relates to an automatic changeover apparatus for operating traffic lights under emergency battery power upon a power failure.

One of the many dangerous conditions that exist when a power failure occurs in a populated area is that the traffic lights for controlling vehicular movement become inoperative. When this occurs, vehicular traffic is jammed, particularly in crowded areas. This not only increases the possibility of accidents, but also blocks traffic lanes for emergency vehicles such as ambulances and fire engines. Unfortunately, this dangerous condition exists because there is presently no effective automatic changeover apparatus designed to provide standby power to the traffic lights upon failure of the primary power source.

To be effective in operating traffic lights under DC standby power, the changeover apparatus should automatically function with a minimum delay to provide standby power. It should be substantially fail safe and the power should be adequate to operate either one traffic light or a series of lights. To keep the battery providing the DC power at peak voltage, means should be provided to charge the battery. Moreover, the apparatus should also be portable whereby if a permanent installation is not desired, the apparatus may be transported to the inoperative traffic light as needed.

Accordingly, it is an object of this invention to provide an automatic changeover apparatus for supplying standby power to traffic lights upon a failure of primary power source.

Another object is to provide an automatic changeover apparatus for operating traffic lights with a simple, effective and substantially fail-safe switch means to switch from the primary power source to the standby power source upon failure of the primary power source.

Another object is to provide a portable automatic changeover apparatus for operating traffic lights upon a power failure of a primary power source.

Another object is to provide for operating traffic lights an automatic changeover apparatus which has sufficient power to operate one traffic light or a series of traffic lights.

Another object is to provide for operating traffic lights an automatic changeover apparatus which supplies emergency AC power to the traffic lights by a battery through an efficient, solid state inverter.

Another object is to provide for operating traffic lights an automatic changeover apparatus with means to maintain an emergency battery power source at peak voltage.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

In accordance with these objects, the changeover apparatus generally includes a battery, a DC to AC inverter, a battery charger, and a pair of relays, each of which comprises a double-pole, double-throw switch. Upon a power failure of a primary power source which operates the traffic lights, the relays are deenergized. When the relays become deenergized the switch operated by a first relay disconnects the battery from the battery charger and connects the battery to the DC to AC inverter. Simultaneously, the switch operated by the second relay disconnects the traffic lights from the primary power source and connects them to the output from the inverter. Thereafter, the traffic lights are operated by the battery until restoration of the primary power. The inverter has a high wattage output for operating one traffic light or a series of traffic lights connected to a common power buss. When the traffic lights receive power from the primary power source, a battery charger retains the batteries in a fully charged condition. The battery charger and inverter are light and compact enabling the apparatus to be easily carried.

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts which will be exemplified in the construction hereinafter set forth, and the scope of the invention will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings in which:

FIG. 1 is a schematic representation of an electrical circuit showing the components of the apparatus;

FIG. 2 is a wiring diagram illustrating schematically the circuitry for the battery charger shown in FIG. 1; FIG. 3 is a wiring diagram illustrating schematically the circuitry for the inverter shown in FIG. 1.

FIG. 4 is a diagram showing the general wave form of the current flowing from the rectifier of the battery charger.

Similar reference characters refer to similar parts throughout the several views of the drawing.

Referring now to the drawings in detail, particularly FIG. 1, the changeover apparatus as illustrated generally comprises a battery 10; a DC to AC inverter 12; a battery charger 14; a first relay means comprising a solenoid 16 operating a switch means in the form of a double-pole, double-throw (DPDT) switch 18; and a second relay means comprising a solenoid 20 operating a switch means in the form of operating a double-pole, double-throw (DPDT) switch 22.

Switch 18, also referred to as a first switch, is connected to battery 12 by conductors 24 and 26. When solenoid 16 is energized, as shown in FIG. 1, the switch connects battery 12 to battery charger 14 through conductors 28 and 30. When switch 16 is deenergized, switch 18 connects battery 10 to inverter 12 through conductors 32 and 34.

Switch 22, also referred to as a second switch, is connected to the power input of traffic light 36 through conductors 38 and 40. When solenoid 20 is energized, as shown in FIG. 1, switch 22 connects traffic light 36 to a primary AC power source 42 through conductor leads 44 and 46. When solenoid 20 is deenergized, switch 22 connects traffic light 36 to inverter 12 via conductors 48 and 50.

In normal operation, the AC primary power source 42 energizes battery charger 14 through conductors 52 and 54, energizes solenoid 16 through conductors 56 and 58 and energizes solenoid 20 through conductors 60 and 62. Upon solenoid 16 being energized, it moves the contacts of switch 18 into engagement with conductors 28 and 30. This connects battery charger 14 to battery 10 through conductors 28, 30, 34 and 36. The battery charger, as hereinafter more fully described, maintains the batteries at a fully charged capacity. It accomplishes this in a manner such that the rate of current flowing into the battery is dependent upon the battery voltage. That is, the lower the battery voltage, the greater will be the current flow into it and vice versa.

Upon solenoid 20 being energized, it moves the contacts of switch 22 into engagement with conductors 44, 46 from power source 42. This energizes traffic light 36 with the AC primary source through conductors 38, 40, 44, 46.

When a failure of the primary power source 42 occurs, solenoid 16 and switch 18 become deenergized and drop out. As solenoid 16 is deenergized, it moves the contacts of switch 18 into engagement with conductors 32, 34 leading to inverter 14 and out of engagement with conductors 28, 30. This electrically connects the battery 10 to inverter 12 through conductors 24, 26, 32, 34. When solenoid 20 becomes deenergized, it moves the contacts of switch 22 into engagement with conductor leads 48, 50 leading to inverter 12 and out of engagement with conductors 44, 46. The inverter 12 is then connected to traffic light 36 through conductors 38, 40, 48, 50. The battery 10 thereafter supplies power to the inverter 12 which in turn converts the DC power to AC to operate the traffic light. The AC inverter, hereinafter more fully described, gives a power output to operate either one traffic light or a plurality of traffic lights connected to a common power buss. Being the relays connect the battery standby power to the traffic light when deenergized, the switching system is substantially fail safe.

The circuitry for battery charger 14 is best seen in FIG. 2. The battery charger, a solid state component, receives power

from primary AC source 42 by conductors 52, 54 leading to a stepdown transformer 70 connected to a conventional diode rectifier 72. Rectifier 72 changes the AC current to a full wave rectified DC current in a well-known manner.

The full wave DC current is delivered by lead 73 from one terminal of rectifier 72 to the anode of a silicon-controlled rectifier (SCR) 74 whose cathode is connected to the positive terminal of battery 10 by leads 24, 30. Rectifier 72 is also connected by leads 75, 76 to the gate of SCR 74 through a resistor 78 and Zener diode 80. Resistor 78 is connected to a second resistor 82 which in turn is connected to the anode of second silicon-controlled rectifier (SCR) 84 for shutting off SCR 74 when a predetermined battery voltage is reached as hereinafter more fully described.

The gate of SCR 84 is connected by lead 85 to Zener diode 86. The cathode of SCR 84 is connected to the negative terminal of battery 10 by negative lead 87 which also connects the negative terminal of battery 10 to the other terminal of rectifier 72. Zener diode 86 is connected by lead 88 to wiper of a potentiometer 89. Potentiometer 89 is in turn connected on its positive terminal to a third resistor 90 and thereafter to the positive terminal of battery 10 by leads 90, 30 and 24. A fourth resistor 92 is connected across leads 85 and 87, and a capacitor 94 is connected across leads 87, 88. The other terminal of potentiometer 89 is tied into negative lead 87.

To trickle charge battery 10, rectifier 72 is also connected with the positive terminal of battery 10 through diode 96, variable resistor 98, and leads 99, 30, 24.

In operation of the battery charger, the full wave, bridge rectifier 72 produces a pulsating full wave current. Each pulse or wave fires SCR 74 in each half cycle. The wave form is shown in FIG. 4.

When the battery voltage is low, SCR 74 will be triggered on each half cycle via resistor 78 and diode 80 for approximately the firing angle shown in FIG. 4. During this time, a relatively high current is passed through SCR 74 to charge battery 10.

Under these conditions, the pickoff voltage of V_R at the wiper of the potentiometer 89 is less than the breakdown voltage V_Z of the Zener diode 86. Therefore, the "shutoff" SCR 84 cannot fire.

However, as the charge of battery 10 approaches full output voltage, its terminal voltage will rise and the magnitude of voltage V_R will equal V_Z which represents the breakover voltage of Zener diode 86, and also the trigger or gate voltage of SRC 84. At this point SCR 84 will also be triggered on each half cycle, but it is on for a shorter time than is SCR 74 and at a later time in each half cycle. At the start of each half cycle, SCR 84 will fire at $\Pi/2$ radians after the start of that half cycle and coincidentally with peak power supply voltage, peak charging current and maximum battery voltage.

As the charging cycle continues and as the battery voltage continues to increase, the firing angle of SCR 84 will advance slightly each half cycle until eventually SCR 84 is firing before the input since wave has sufficient magnitude to fire the battery charging SCR 74.

With SCR 84 on first in each half cycle, the voltage divider action of resistors 78 and 82 will keep silicon diode 80 back biased and SCR 74 is consequently unable to fire.

High rate charging of the battery will now cease and that part of the circuit consisting of diode 96 and variable resistor 98 will take over and trickle charge the battery.

Heavy charging of the battery will not reoccur until such time as the charge on the battery is depleted. This will commence automatically when voltage V_R drops below V_Z causing SCR 84 to stop firing.

The inverter circuit, a solid-state circuit, is shown in FIG. 3. The inverter 12, comprises a suitable means for converting DC power from battery 10 into AC power for delivery to the traffic lights. Inverter 12 is a square wave SCR (Silicon-controlled rectifier) inverter incorporating first and second SCRs 100, 102 which are reverse orientated relative to diodes 104 and 106. The inverter is connected to a negative terminal at battery 10 by means of a negative or ground lead 108 tied into

negative conductor lead 22 from the battery. Ground lead 108 is connected by leads 109 and 110 through resistors 111, 112 to the anodes of diodes 104 and 106 respectively. Negative lead 108 is also connected through leads 114, 116, and 118 to the cathodes of the SCRs 100, 102. An inductor 120 is positioned along leads 114 in series with the cathodes of SCRs 100, 102.

The cathode of diode 104 and the anode of SCR 100 is connected through lead 122 to one end terminal of a primary winding 124 of a transformer 126. Similarly, the cathode of diode 106 and the anode of SCR 102 are connected through lead 128 to the other end terminal of primary 124.

The indicated SCR inverter requires a suitable commutating means. A capacitor 130 in the circuitry is provided therefor. The capacitor is bridged across the inverter output between leads 122 and 128. A center tap of primary 124 is connected through a positive lead 132 to the positive battery conductor lead 34.

The secondary of transformer 126 is connected to an inductance capacity network to produce a sine wave of 60 cycles from a 60-cycle square wave originating at the transformer's secondary 134. The inductance capacity network includes inductors 136, 138 and capacitors 140 and 142. The sine wave output from the inductance capacity circuit is delivered to traffic light 36 by conductors 48, 50.

The means for supplying triggering pulses to SCR gates 100, 102 comprises a conventional relaxation oscillator which is suitably connected to a flip-flop designated 144. These devices are well known in the art and need not be described in detail. For example, circuit 144 may comprise a square wave inverter trigger circuit described on page 155 et seq. of the General Electric SCR Manual, Second Edition. This circuit is a conventionally unijunction transistor relaxation oscillator associated with conventional transistor flip-flop.

The output of oscillator and flip-flop 144 is connected to a primary 146 of a pulse generator 148. The center tap of the primary is connected to positive lead 132 by lead 150 and to negative lead 108 by lead 152. The secondary 154 of pulse transformer 148 is connected at one terminal by lead 156 to the gate of SCR 100 and by lead 158 to the gate of SCR 102. The pulse transformer steps up the pulses emitted from oscillator and flip-flop 144.

The operation of the inverter will now be described. In summary, the direct voltage obtained from battery 10, is converted by the inverter into a square wave alternating voltage, which is fed to the transformer primary 124. The SCRs 100, 102 alternatively connect the end terminals of primary 124 to the negative battery terminal; the center tap of the transformer being connected to the positive battery terminal. In such manner, the battery voltage is impressed on each half of the primary winding, in a push-pull relationship. Capacitor 130 alternatively charges to the full primary voltage, then discharges through the SCRs to commutate the conduction thereof.

For example, assuming that both SCRs are initially nonconducting and that a suitable pulse is fed to the gate of SCR 100 by pulse transformer 148, SCR 100 then fires and impresses the battery voltage on a left half, as seen in the figure, of primary 124 through a circuit including leads 34, 132, 122, 116, 114, 108 and 32. By autotransformer action, the voltage present in the left half of primary 124 reflects across the entire primary, a voltage equal to twice the battery voltage. This results in rapid charging of commutating capacitor 130 to twice the battery voltage, the right side of the indicated capacitor 130 being of positive polarity.

Upon completion of the first half cycle interval, a light pulse or gating signal supplied to the gate of SCR 102 by oscillator 144 through pulse transformer 148. Both SCRs then conduct simultaneously. This causes capacitor 130 to discharge therethrough in a clockwise direction, the current flow being downwardly through SCR 102 and upwardly through SCR 100. The reverse current flow through SCR 100 causes it to cease conducting as soon as the junctions thereof are swept

clear of current carriers. Since SCR 102 is in conduction, the voltage of battery 10 is impressed across the other half of primary 124, namely the right half thereof as seen in the Figure. This produces a voltage of twice the battery voltage across the entire primary but with a polarity the reverse of that indicated previously, the left side of capacitor 130 being positive.

Upon completion of the second half cycle, SCR 100 is again triggered. Capacitor 130 then discharges to both SCRs in a counterclockwise direction, causing a reverse current through SCR 102. This stops SCR 102 from conducting, thereby completing the cycle.

Function of diodes 104 and 106 is to prevent the output voltage from varying from a square wave when the inverter is only lightly loaded as would otherwise happen. This is because that in accordance with Lentz's law, the interruption of current flow through primary 124 effects generation of a high reverse voltage in an attempt to maintain the current flow. This high voltage is clipped by diodes 104 and 106 which hold the square wave across each half of the primary winding 124 to the battery voltage. The square wave is thus preserved even when the inverter is only lightly loaded.

Another function of diodes 104 and 106 is to permit the inverter to be employed with reactive loads both inductive and capacitive. If the load of the inverter is reactive, load current flows in out-of-phase relationship relative to the square wave voltage. It follows that during a portion of each half cycle, which portion is proportional to the phase angle, current attempts to flow in opposition to the drive voltage. Such reverse-current flow turns off the conducting SCR prior to the above indicated time when capacitor 130 discharges in a reverse direction to one of the SCRs. Therefore, in the absence of diodes 104, 106, there would exist a period when primary 124 would cut off from battery 10 so that the voltage across the primary would rise to excessively high value. Diodes 104 and 106 operate to permit the reactive current to flow back to the battery during indicated interval, thus clipping the high inductive voltage.

By incorporating the inductance capacity network to the output of the secondary 134 of transformer 126, the square wave output from the secondary is converted into a sinusoidal wave output impressed upon conductor leads 48, 50 for operating the traffic lights.

It should now be evident from the above description that an automatic changeover apparatus for supplying standby AC power to traffic lights upon failure of a primary power source has now been provided. The apparatus is simple yet effective. It may easily be adapted in a form which can be portably carried to an inoperative traffic light, and the power generated by the inverter is sufficient to operate one traffic light or a series of traffic lights. Conveniently, the circuitry includes a battery charger for charging the batteries to maintain the batteries in a state of readiness. The battery charger is a solid-state type which puts an output current in proportion to the charge on the battery. The inverter for changing the battery current to an AC current is also solid state increasing its reliability and compactness. Being simple, the apparatus is economical and practical to manufacture.

It will thus be seen that the objects set forth above, among

those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above construction without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention, which, as a matter of language, might be said to fall therebetween.

Now that the invention has been described,

What is claimed is:

1. An emergency traffic light control apparatus for auxiliary operation of traffic lights upon failure of a primary AC power source comprising: an auxiliary DC power source, an inverter connected to said DC power source for converting said DC power to AC power to operate said traffic lights when said primary AC power fails, said inverter including solid state circuitry comprising a square wave inverter trigger including a relaxation oscillator and flip-flop, a pulse transformer for stepping up the pulse emitted from said inverter trigger connected across the output of said inverter trigger, an inverter output transformer, a parallel square wave SCR inverter circuit including two SCRs the anodes of which are connected to the primary of said output transformer, two diodes of which the cathodes are connected to said primary of said output transformer, means to connect the anodes of said diodes and the cathodes of said SCRs to the negative terminal of said DC source, means to connect the positive terminal of said DC source to a center tap in the primary of said output transformer, the output from said pulse transformer adapted to drive the gates of said SCRs, said SCRs when firing producing a square wave AC voltage across the secondary of said output transformer, and an inductance capacity network connected across said secondary to produce a sinusoidal wave at 60 cycles from the 60-cycle square wave originating at said transformer's secondary terminals, a relay means energized by said AC power source, said relay means including a first switch means arranged such that when deenergized said first switch means connects said DC power source to said inverter and a second switch means arranged such that when energized said second switch means connects said AC power source to said traffic lights and when deenergized said second switch means connects the output of said inverter to said traffic lights.

2. The apparatus of claim 1 wherein said DC power source comprises a battery connected to a battery charger by said first switch means when said first switch means is energized, said battery charger including solid-state circuitry comprising rectifying means for rectifying the current of said primary AC power source to full wave DC current, means for firing a first SCR when the voltage or charge on said battery is relatively low, said battery being charged with a relatively high rate of current when said first SCR is firing, means to fire a second SCR when said battery voltage is relatively high, said second SCR when firing stopping the firing of said first SCR, with means to trickle charge said battery when said second SCR is firing.

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