Two Projects for Summer:

A BATTERY-OPERATED FLUORESCENT LAMP

Portable, high-efficiency light source draws current from a vehicle's 12-volt storage battery, but leaves plenty of charge for engine starting.

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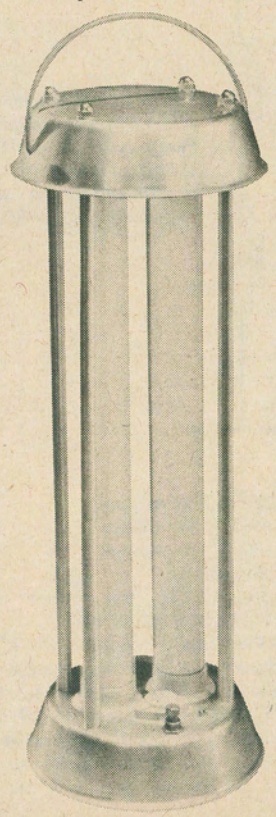
THE recreational vehicle is becoming more and more popular with campers who want a "home away from home." In such cases, the vehicle's 12-volt battery supply provides a convenient source of power for lighting around the camp. This is very handy, of course; but, for the amount of light they deliver, 12-volt incandescent lamps waste a lot of valuable battery power. Fluorescent lamps, on the other hand, produce good lighting at high efficiency. Unfortunately, they require a dc-to-ac converter.

The low-cost circuit described here not only performs the dc-to-ac conversion, it also provides automatic shut-



down when the battery reaches some predetermined voltage level, thus preventing a complete discharge. A LED indicator glows when the turnoff point is reached. Once turned off, the system draws only a few milliamperes.

Circuit Operation. When the 12-volt supply (Fig. 1) is applied to the circuit through fuse *F1*, switch *S1*, and the protective diode, *D1*, multivibrator *IC1* starts to oscillate at a frequency determined by the setting of *R2*. This is approximately 10 kHz. At this time, *Q1* is cut off to allow *IC1* to oscillate.

As the +12 volts are applied to the *R18*/zener diode *D2* network, 7.6 volts are applied to the emitters of *Q3* and *Q4*. At this time, the base of *Q4* is at zero voltage, thus turning this transistor fully on and developing approximately 7 volts across its collector resistor (*R12*). This voltage, applied via *R13* to the base of series-pass transistor *Q5*, turns the transistor on and allows the output of *IC1* to pass through *R7* to driver transistor *Q6*. The latter, in turn, drives power transistor *Q7* to its maximum output.

The collector load of *Q7* is formed by the 6.3-volt winding of transformer *T1*. Thus, as *IC1* oscillates, a high alternating voltage is developed across the 120-volt winding of *T1* and applied to the two series-connected fluorescent lamps (*L1* and *L2*), and across current-sensing resistor *R17*.

At lamp turnon, the voltage developed across *R17* is rectified and filtered by *D3* and *C5* and applied across lamp-current-adjust potentiometer *R16*. A preselected portion of this voltage is applied to the *R15*/*C4* network and to the base of *Q4*. When this voltage approximates the 7.6-volt emitter reference, *Q4* starts to reduce its conductance, thus lowering the voltage developed across collector resistor *R12*. This action lowers the bias on series-pass transistor *Q5*, reducing the drive to *Q6*/*Q7* to lower the lamp drive and reduce the voltage across *R17*. The circuit stabilizes lamp current preset by *R16*.

At initial lamp turnon, approximately 1.3 amperes will flow through *Q7* until the fluorescent lamps fire. This ensures lamp start even in cold weather. Once the lamps strike, the current will range from about 0.9 ampere at 13.2 volts to about 1.1 amperes when the battery voltage drops to near 10.6 volts.

Low battery protection is provided by potentiometer *R6*. The selected voltage is applied via *R8* to the base of *Q3*. In normal operation, *Q3* is cut off since its base voltage is higher than the 7.6 volts applied to its emitter. If the battery voltage drops so that the base of *Q3* goes below the emitter voltage, *Q3* starts to conduct and its collector current flows through *R10* to the base of *Q2*. When *Q2* starts to conduct, the base drive of *Q3* is further reduced until both *Q2* and *Q3* are latched fully on. Once latched on, the collector of *Q3* will be approximately 6 volts, which are applied through *R11*, causing *LED1*—the low-voltage indicator—to glow. This voltage is also applied via *R5* to the base of *Q1* to bias this transistor fully on. When this occurs, pins 2 and 3 of *IC1* become fully positive, thus disabling the multivibrator. At this point, battery consumption drops to about 50 mA, since *Q1*, *Q2*, and *Q3* are the only active elements. Operating power should now be removed via *S1*.

Capacitor *C4* at the base of *Q4* is a high value to prevent oscillation, while *C3* at the base of *Q2* allows the circuit to stabilize before low voltage levels can be detected. Once the circuit is

working, it responds very rapidly to voltage drops.

Construction. Since there is nothing critical about the circuit, it can be constructed on a small piece of perf board using point-to-point wiring and sockets for *IC1* and the seven transistors. Transistor *Q7*, transformer *T1*, power on/off switch *S1*, fuse *F1*, and the two fluorescent lamp sockets are mounted on the enclosure.

Select an enclosure that can support the circuit board, the transformer, a heat sink for power transistor *Q7*, and the sockets for the two fluorescent lamps. The two lamps can be mounted vertically on top of the enclosure, and provided with some form of transparent weather protection such as a plastic sleeve. If a metal enclosure is used, it can serve as the *Q7* heat sink when a suitable insulator is used. Connection to the +12 volts can be made with a length of conventional two-conductor lamp cord having a cigarette lighter plug at one end. The author used 33 feet of lamp cord.

• Since the secondary of transformer *T1* can develop as much as 1500 volts peak-to-peak across the output, and as much as 225 volts when the lamps are lit, suitable insulation must be used at these points. Also, keep these voltages in mind when performing the adjustments on the circuit.

Adjustments. Before applying power, remove the connection between low-voltage-adjust potentiometer *R6* rotor to the +12-volt end. Then set lamp-current-adjust potentiometer *R16* so that the rotor is at the ground end. Frequency-adjust potentiometer *R2* should be set to the *R1* side (highest resistance).

To make a complete test, use an adjustable power supply between 10 and 14 volts, with a capacity of at least 2 amperes. Connect an ammeter (about 2 amperes) in series with the positive battery connection, and a voltmeter (20-volt range) from the cathode side of *D1* to ground. Connect the power source.

When *S1* is turned on, the lamps may not fire due to the low frequency of the multivibrator, and about 0.3 to 0.4 ampere will be drawn. Transformer *T1* may also make sounds due to lamination movement, which indicates an operating circuit.

Slowly rotate frequency-adjust potentiometer *R2* and note that the ammeter current increases and the lamps start to glow. Continue to increase the frequency very slowly until the lamps come to full brightness at a current of about 0.6 ampere. At this point, the supply current will suddenly jump to about 1.2 to 1.3 amperes. Advance the frequency for an additional 0.2 ampere, but not higher, as both output voltage and efficiency will drop.

If desired, the multivibrator can be "fine tuned" using an oscilloscope. To do this, turn the power off, set the controls as described above, remove the lamps and replace them with four 100-kΩ, ½-W resistors connected in series. Connect the scope leads across *R17*, and set the scope vertical to 5 volts/division. Turn the power on and

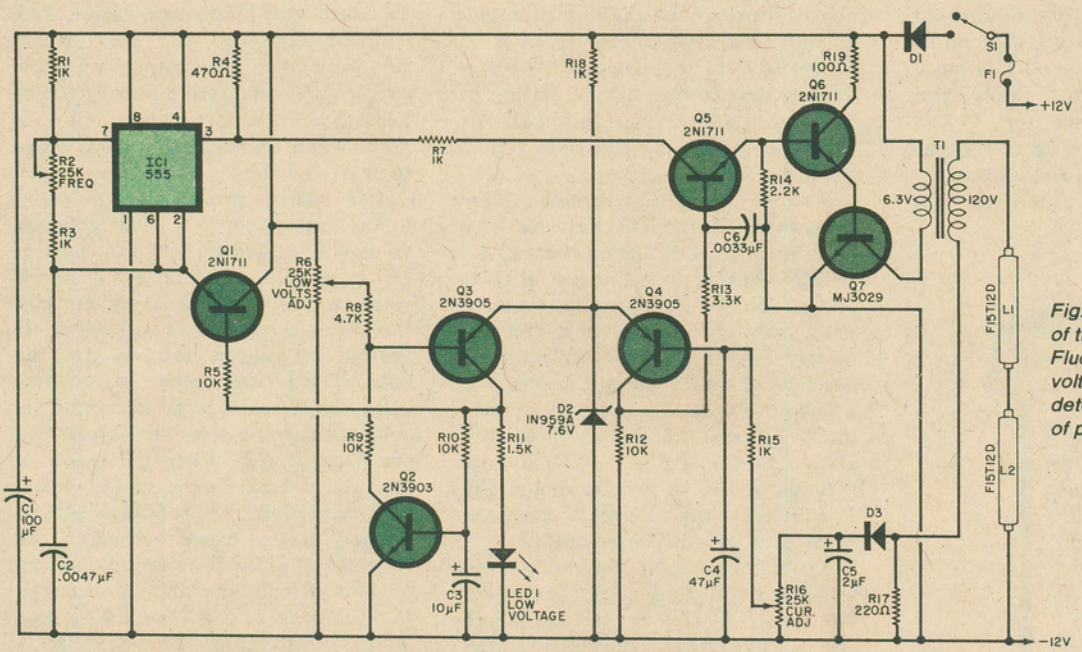


Fig. 1. Schematic diagram of the Battery-Operated Fluorescent Lamp. The low-voltage cutoff point is determined by the setting of potentionmeter R6.

PARTS LIST

C1—100-μF, 25-V electrolytic
C2—0.0047-μF, film capacitor
C3—10-μF, 60-V electrolytic
C4—47-μF, 50-V electrolytic
C5—2-μF, 50-V electrolytic
C6—0.0033-μF, 100-V film capacitor
D1,D3—2-ampere rectifier diode
D2—1N959A, 7.6-V zener diode
F1—4-A fuse and holder
IC1—555 timer
L1,L2—15-watt daylight fluorescent lamps (F15T12D or similar)
LED1—Red LED
Q1,Q5,Q6—2N1711 or similar npn silicon transistor
Q2—2N3903 or similar npn silicon transistor
Q3,Q4—2N3905 pnp or similar transistor
Q7—MJ3029 npn power transistor
R1,R3,R7,R15—1-kΩ, ¼-W resistor
R2,R6,R16—25-kΩ, pc potentiometer
R4—470-Ω, ½-W resistor
R5,R9,R10,R12—10-kΩ, ¼-resistor
R8—4.7-kΩ, ¼-W resistor
R11—1.5-kΩ, ½-W resistor
R13—3.3-kΩ, ¼-W resistor
R14—2.2-kΩ, ¼-W resistor
R17—220-Ω, 2-W resistor
R18—1-kΩ, ½-W resistor
R19—100-Ω, 1-W resistor
S1—Spst switch
T1—6.3-V, 1.2-A transformer (Radio Shack 273-0050 or similar)
Misc.—Perf board, sockets for *IC1* and transistors, heat sink and thermal insulator for *Q7*, sockets (4) for fluorescent lamps, suitable enclosure, length of conventional lamp cord, automotive cigarette plug, transparent weather shield for lamps, adhesives, mounting hardware, etc.