Two Projects for Outdoor Use

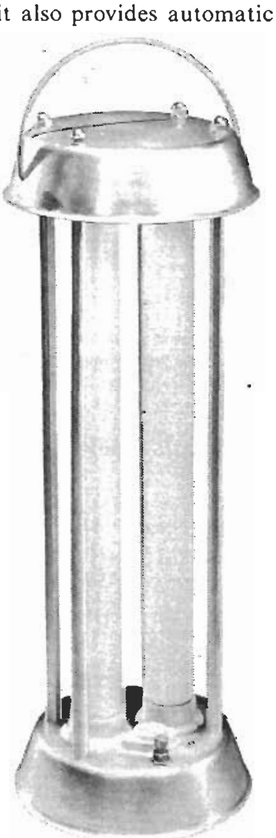
A BATTERY-OPERATED FLUORESCENT LAMP

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

BY LAWRENCE M. WALDEN

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 shutdown 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

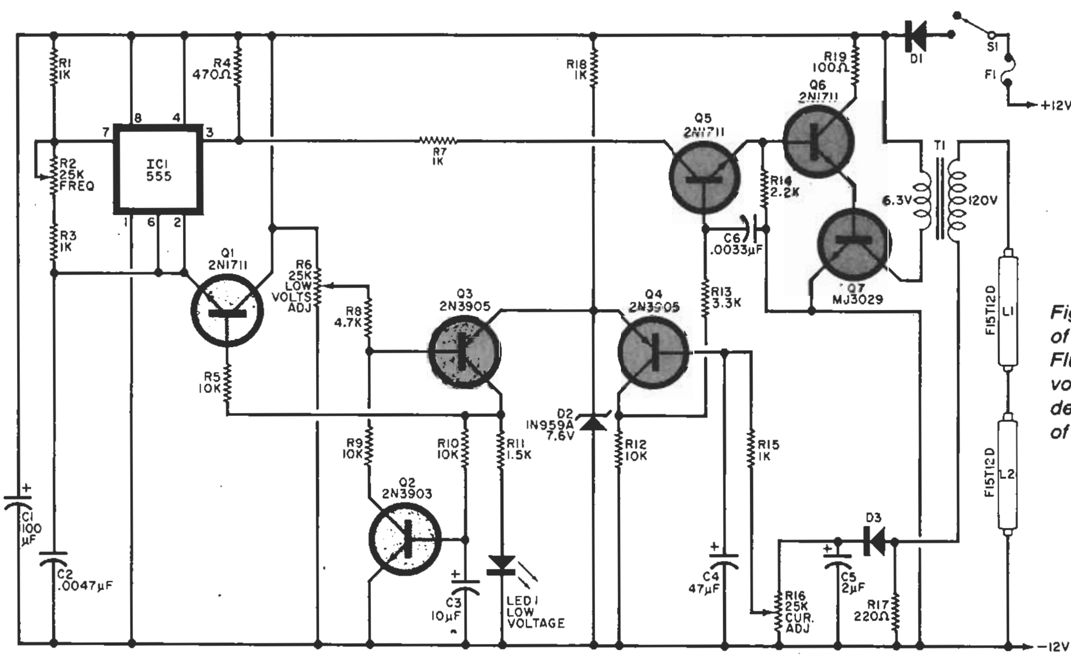
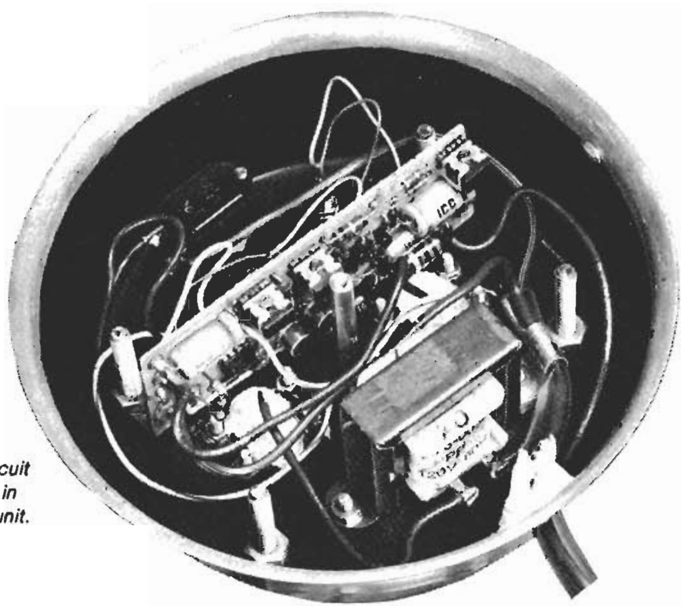


Fig. 1. Schematic diagram of the Battery-Operated Fluorescent Lamp. The low-voltage cutoff point is determined by the setting of potentionmeter R6.

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
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.



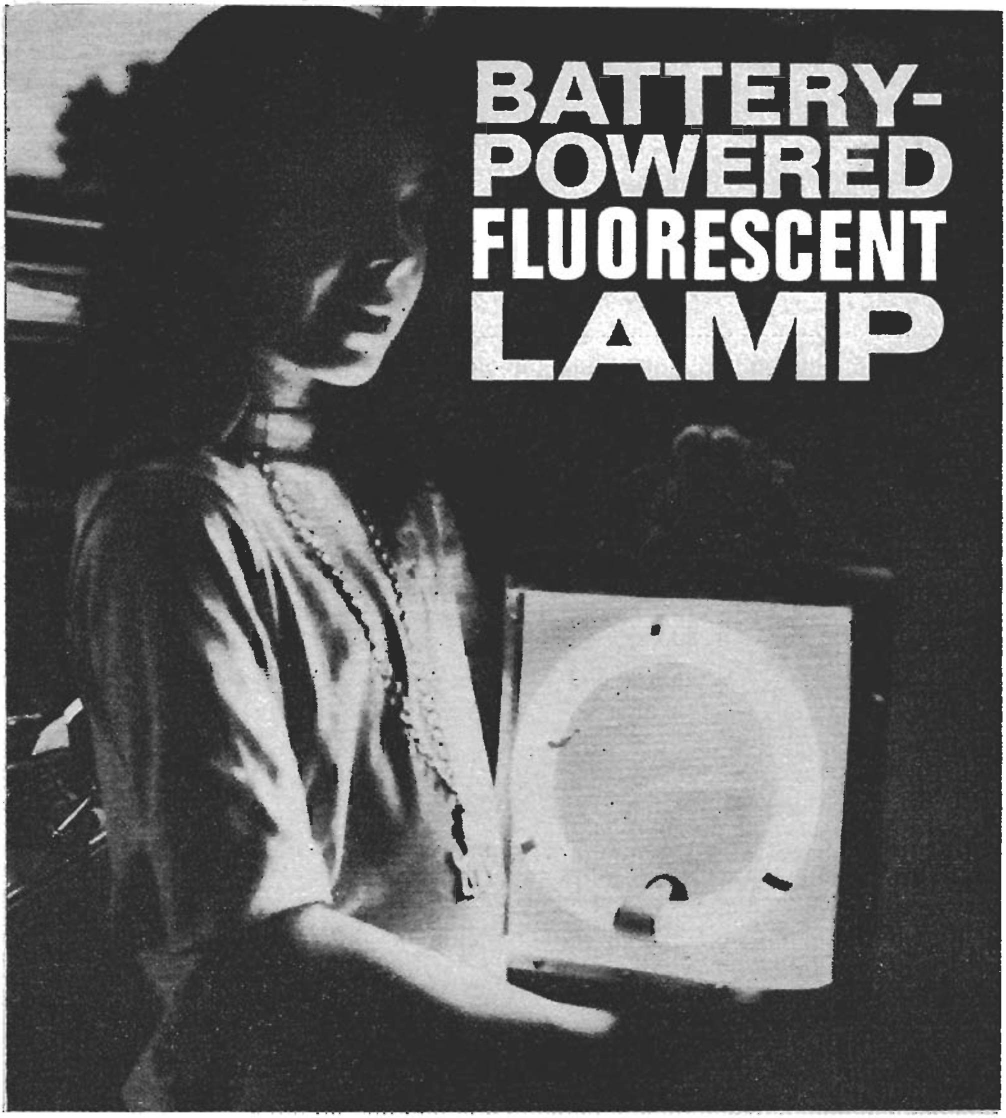
Lamp circuit mounted in base of unit.

note that about 0.5 ampere flows and a 3-to-4-volt waveform appears on the scope. Slowly increase the frequency (via *R2*) until the scope trace peaks at about 15 volts peak-to-peak. The supply current should reach about 1 ampere at this point. Do not adjust the frequency higher than this, or the efficiency will be reduced. Turn the power off, remove the resistors, and replace the lamps.

To adjust the lamp current regulator with the lamps glowing, slowly rotate current-adjust potentiometer *R16* until the current approaches 0.8 ampere and there is a decrease in light output. Then slowly adjust *R16* until the current reaches 1 ampere. Lower the power supply to 10.6 volts, then re-adjust *R16* for 1.1 amperes current flow. This becomes the maximum current drain at the lowest operating voltage.

Increase the supply voltage from 10.6 to 13.2 volts and note that the light output remains constant as the current decreases. With 12 volts applied, about 1 ampere will flow, and with a 13.2-volt supply, the current drops to about 0.9 ampere.

To adjust the low-voltage cutoff, reconnect *R6* to the +12-volt line. and with the voltmeter still in the circuit, allow a 5-minute lamp warm-up. Reduce the power supply to 10.6 volts (or other desired low-voltage point) and slowly rotate *R6* until the lamps go off and *LED1* glows. Recheck this point several times. If, during operation, the lamps go out, the presence of glowing *LED1* indicates that the low battery voltage has been reached, and the circuit has not been accidentally removed from the power source. ◇



BATTERY-POWERED FLUORESCENT LAMP

Extra brightness for your camping/boating trips

BY BEN RICHARDS

IT'S EASY to make an outdoor lighting system for your camping or boating trips. All you need is a 12-volt incandescent bulb and some wire to attach it to your car or boat battery. Unfortunately, there are some drawbacks to this approach: the intense point-source of light generated by a relatively small bulb can be very annoying to the eye; the amount of illumination delivered by such a bulb is limited in coverage, producing a small bright area surrounded by darkness; and the efficiency of such a lighting system is low. To get any appreciable amount of light, either a number of bulbs or a large, high-power bulb must be used. If you use either of these approaches, it won't be long before your battery gives out.

All these troubles can now be alleviated if you build the battery-powered fluorescent light described here. The light uses a 22-watt fluorescent lamp and

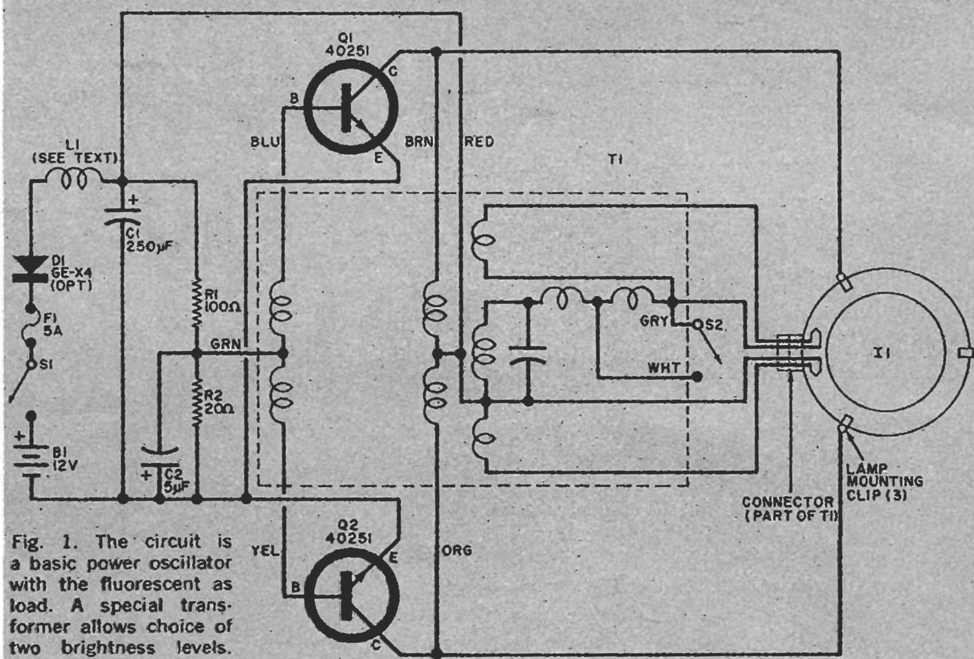


Fig. 1. The circuit is a basic power oscillator with the fluorescent as load. A special transformer allows choice of two brightness levels.

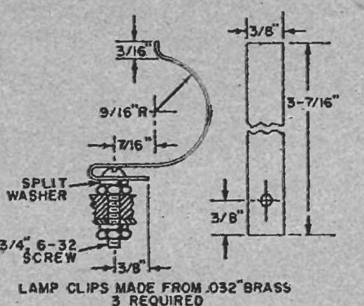


Fig. 3. Make three clips for mounting the fluorescent lamp. It is important that you get the correct curvature.

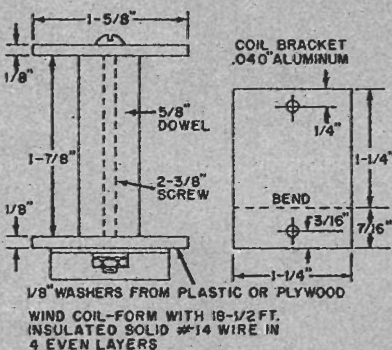


Fig. 4. Construction data for L1. Plastic tape can be wound over coil to keep it from unravelling during mounting.

works from a conventional 12-volt d.c. car, boat, or trailer battery. It produces large-area illumination without harsh glare and has two levels of illumination —bright, or subdued for extra-low battery drain. Efficiency is high, thus getting the most from the battery, and generated heat is almost non-existent. You can attach the fluorescent light to the end of a 20-ft, conventional two-conductor rubber-covered appliance cord and position it where it is needed.

Construction. A parts list is given on page 58 and a schematic in Fig. 1. Although almost any type of construction can be used, Fig. 2 and the photos illustrate the method used by the author. To duplicate this version, fabricate the wood and metal parts as shown. Note that there are two electrically isolated metal chassis, one for each power transistor. When drilling the holes for these transistors, make sure that both the base and emitter holes are large enough to prevent short circuits. Each transistor can be mounted directly on its chassis without using insulated mounting kits,

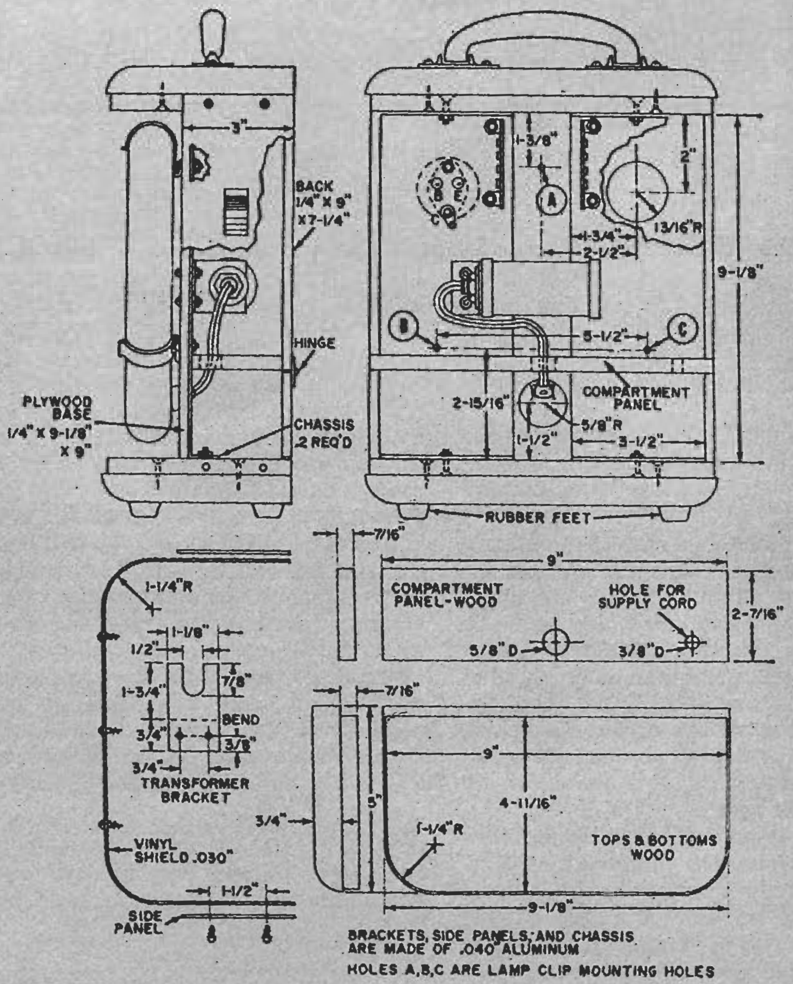
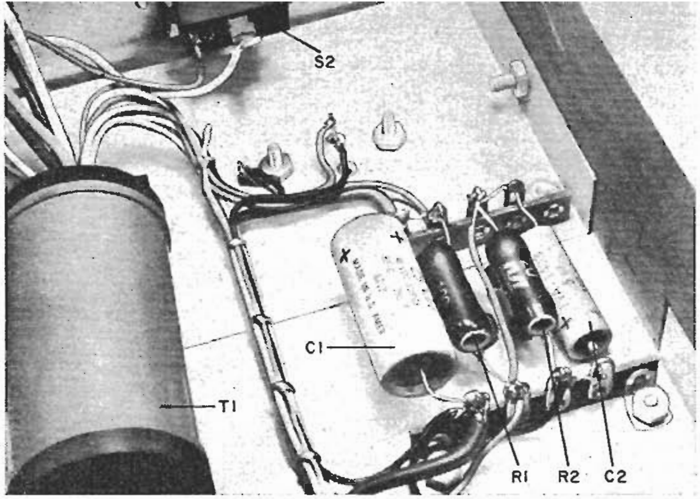


Fig. 2. If you want to duplicate the author's prototype, follow the construction details shown here. Note that the two transistors are mounted through the wooden front panel and the metal chassis. All wiring is done afer components are mounted.

since isolation is provided by the two independent chassis. Put a solder lug under one of the collector (mounting) screws of each transistor. Fabricate three lamp-holding clips as shown in Fig. 3, making sure that the edges are smooth and that they are shaped correctly.

Assemble the two chassis, the two four-lug terminal strips (no ground lugs), and the three lamp-holding clips to the plywood front panel. Note that the two chassis are spaced so that they do not touch either each other or the metal side panels to be mounted later. The tops of the two transistors fit through holes drilled in the wooden panel. At this time, make sure that holes have been drilled to mount the fuse holder (one screw), inductor *L1* (one screw), and transformer *T1* (two screws). If optional diode *D1* is to be used, drill a hole near one end of the fuseholder to support an insulated standoff. Use countersunk machine bolts to attach the 7/16"-thick wood top and bottom to the chassis ends. Then use countersunk wood screws to secure the 3/4"-thick top and bottom to the 7/16" top and bottom wood parts.



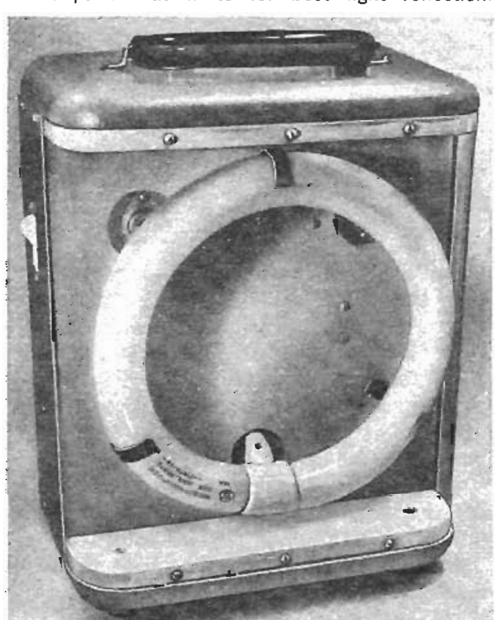
Resistors and capacitors are mounted between two terminal strips. Note how a wire harness makes for a clean, neat internal arrangement. This photo also shows the two isolated metal chassis and the method of wiring the power transistors. Both the emitter and base connections are soldered direct to the transistor leads; the collector connection is made to a solder lug under the collector (and case) mounting hardware.

A carrying handle can be secured to the top surface, but make sure that it does not cause a short circuit between the two metal chassis.

Attach the line-cord stowage compartment panel to the base-and-chassis assembly using wood screws. (A small magnetic door-latch assembly can be used to keep the stowage compartment door closed.) Assemble the entire cabinet to make sure that everything fits properly. Note that, of the three lamp clips, one is electrically connected to each chassis while the third is insulated by the wood front panel.

Construct inductor *L1* in accordance with Fig. 4. Using the photos as a guide, assemble all components in the cabinet and wire in accordance with Fig. 1. Note that the two "hot" lamp clips are connected automatically to their respective transistor collectors through the metal chassis. Be careful to observe the color coding on transformer *T1*. (The transformer is mounted to the chassis with an L bracket.) Connections to the transistor base and emitter leads are made by direct soldering. Use a long-nose pliers as a heat sink to avoid transistor damage while soldering. Do not mount resistors *R1* and *R2* too close to capacitors *C1* and *C2* to avoid heat damage to the capacitors. If the optional diode is used, it can be mounted on the chassis using a small standoff insulator at one end,

Front view of the completed cabinet. Clear vinyl shield wraps around entire front surface. Paint front panel flat white for best light reflection.



PARTS LIST

B1—Car, boat, or trailer 12-volt battery
C1—250-µF, 25-volt electrolytic capacitor
C2—5-µF, 150-volt electrolytic capacitor
D1—20 ampere, 200-PIV diode (General Electric X4 or similar) (optional)
F1—5-ampere, 3AG fuse
I1—22-watt, 7" circular fluorescent lamp (Westinghouse FC8T9/CW or similar)
L1—see text and Fig. 4
Q1, Q2—Transistor (RCA 40251)
R1—100-ohm, 5-watt, wirewound resistor
R2—20-ohm, 5-watt, wirewound resistor
S1, S2—S.p.s.t. switches (rocker-type preferred)
*T1—Ballast transformer**
Misc.—Wood, aluminum, brass strip, line cord, 4-lug terminal strips (2), fuseholder, machine screws, wood screws, transparent plastic shield, wire, solder, etc.
**An inverter-ballast transformer, Type EC-0501-LM, is available from Milwaukee Electromagnetics, P.O. Box 4476, Milwaukee, Wis. 53207, $9.60, postpaid.*

HOW IT WORKS

A.c. power to operate the fluorescent lamp from a d.c. source is generated by a pair of power transistors, operating in conjunction with a saturable transformer in a feedback-type power oscillator circuit.

Oscillation frequency is slightly above the audible range to avoid any annoying buzz from the device. A portion of the transformer winding can be shorted to provide high intensity.

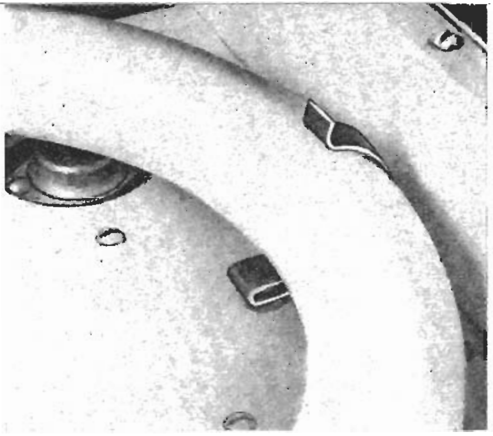
Were it not for the ballasting action of the transformer, lamp brightness would fluctuate excessively with small changes in input voltage and the lamp current could easily exceed its safe value. This happens because a fluorescent lamp acts like a voltage-regulator tube, or zener diode, and tries to maintain a constant voltage while the current through it varies. The type of lamp used has low-power filaments which are continuously heated to allow rapid self-starting and dimming.

Diode *D1* is optional and is used to prevent transistor damage if the d.c. supply leads are accidentally reversed. Inductor *L1* and capacitor *C1* minimize radio interference. Fuse *F1* is used to protect the wiring only. If the battery polarity were wrong, the transistors would fail before the fuse could blow. That is the reason for using diode *D1*.

with the other end connected directly to the fuseholder.

Once the lamp assembly has been checked electrically and mechanically, paint all exposed exterior surfaces any color desired and paint the surfaces surrounding the lamp flat white.

Attach the lamp connector (part of *T1*), then install the lamp in its three clips, making sure that it is a snug fit. Then mount the transparent plastic shield, clamp the line cord in its storage compartment, and attach the back and storage-compartment access door.

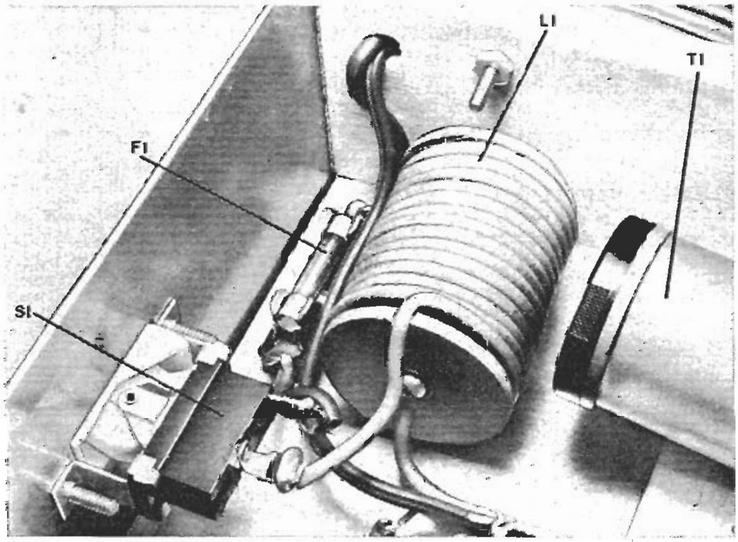


Fluorescent lamp is held by three clips (one shown here). Two of them are at same potential as the transistor collectors to aid fluorescent starting.

Testing and Use. Before placing the light in operation, carefully identify both the positive and negative input power leads. Connect the leads to a source of 12 volts d.c. capable of delivering at least 3½ amperes.

Turn switch *S1* on and note that the fluorescent lamp lights almost immediately. Current drain is about 3 or 3½ amperes when the lamp is started at high intensity (with switch *S2* closed). At low intensity, current drain should be about 1½ amperes when starting.

The author used a cigarette-lighter connector with a 20′ two-conductor (#16) appliance cord so that the light can be plugged into the cigarette lighter socket and positioned anywhere within 20 feet of the car. –30–



If optional diode D1 is used, mount it near the fuse and L1 (shown here).

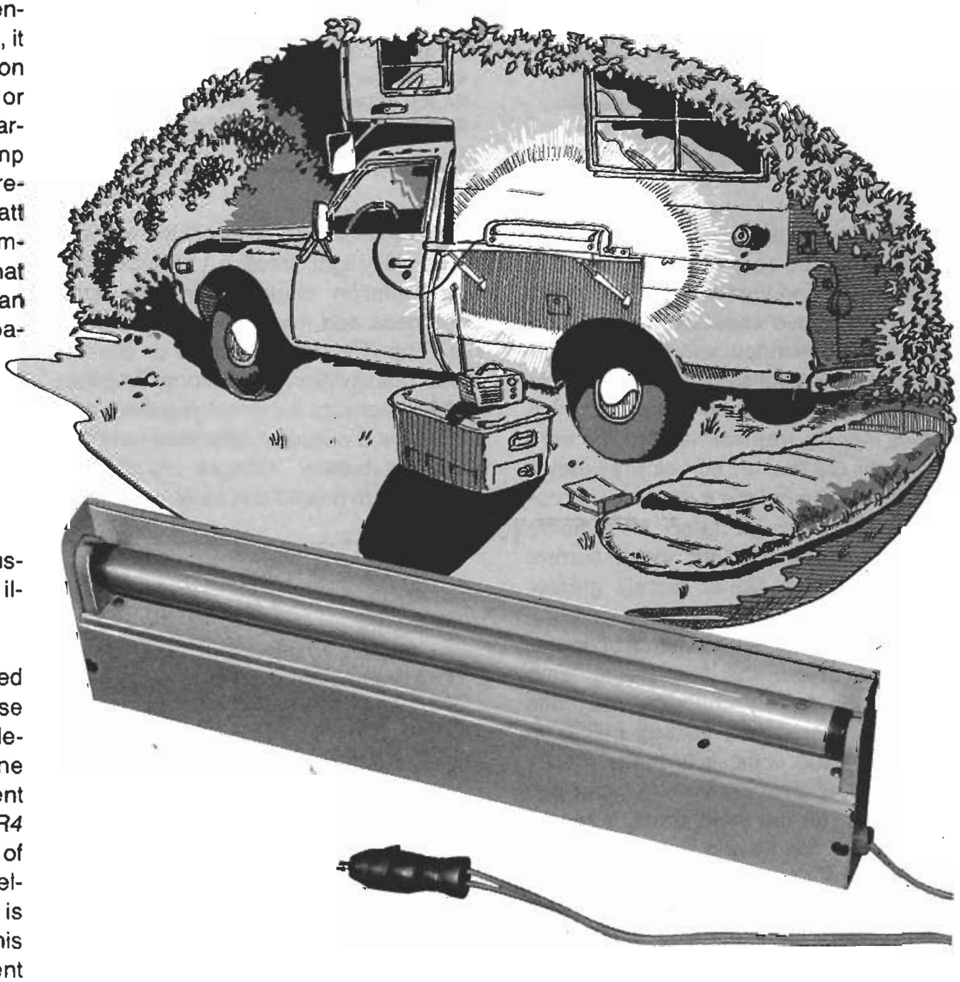
I would also like to bring to light the fact that *D1* in Fig. 3 of the "Battery-Powered Fluorescent Lamp" article (December, 1968) is shown incorrectly connected. To rectify the problem, the arrow should point in the opposite direction to that shown.

DON LANCASTER
Goodyear, Ariz.

Build a FLUORESCENT Utility Lamp

Operates from 12-volt dc source.

BY JOE DUNCAN



A PORTABLE, battery-powered emergency lamp can be a life-saver on the highway and a great convenience at camp sites. To be truly useful, it should provide reasonable illumination without quickly depleting the battery or confining its light output within too narrow a beam. The utility fluorescent lamp described here satisfies these requirements. It uses a conventional 15-watt fluorescent tube and drive circuitry compact enough to fit in the fixture that houses the tube. Operating power can be drawn from any 12-volt source capable of delivering 2 amperes continuously. Thus, the lamp can also be used to illuminate the inside of a camper.

Circuit Operation. Timer integrated circuit *IC1* in Fig. 1 serves as a pulse generator whose output frequency is determined by *R1, R2,* and *C3*. When the output of *IC1*, at pin 3, goes low, current flows from the base of *Q2* through *R4* and *R5* and then to ground via pin 1 of the 555 timer. The voltage drop developed by the load current across *R3* is applied to the base of *Q1*, turning on this transistor, while part of the load current from *R4* and *R5* flows through transistor *Q1* to ground.

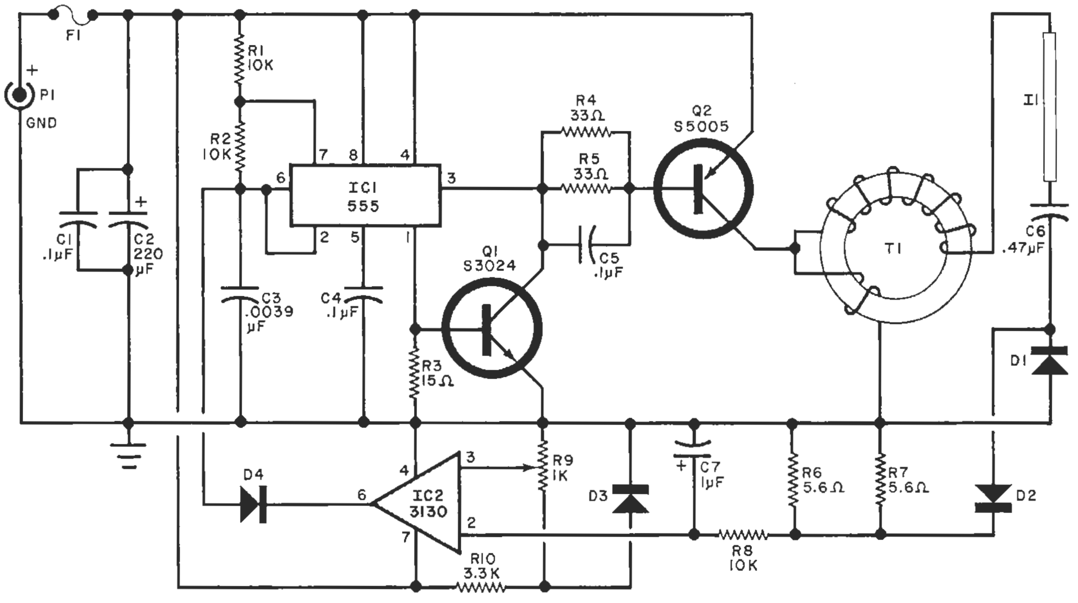


Fig. 1. The 555 oscillator drives Q2 which causes a high voltage across the lamp through T1. The IC2 circuit is a form of voltage regulator.

PARTS LIST

C1,C4,C5—0.1-µF, 50-V disc capacitor
C2—220-µF, 50-V electrolytic capacitor
C3—0.0039-µF silver-mica or polystyrene capacitor
C6—0.47-µF, 200-V capacitor
C7—1-µF, 35-V electrolytic capacitor
D1,D2—1N4001 (1-ampere, 50-PIV) rectifier diode
D3,D4—1N914 or similar switching diode
F1—3-ampere fuse
I1—F15T8 15-watt fluorescent lamp (with fixture, Sears Model 8934 or similar)
IC1—555 timer
IC2—CA3130 op amp (RCA)
P1—Auto lighter accessory plug (Radio Shack No. 274-331 or similar)
Q1—HEP S3024 transistor (Motorola)
Q2—HEP S5005 transistor (Motorola)
R1,R2,R8—10,000-ohm, ¼-watt resistor
R3—15-ohm, ½-watt resistor
R4,R5—33-ohm, 2-watt resistor
R6,R7—5.6-ohm, ½-watt resistor
R9—1000-ohm trimmer potentiometer (Radio Shack No. 271-227 or similar)
R10—3300-ohm, ½-watt resistor
T1—See text (No. T-184-2 ferrite core available for $3.50, including postage and handling, plus 6% tax for California residents, from Amidon Associates, 12033 Ostego St., N. Hollywood, CA 91607)
Misc.—In-line fuse holder for F1; 18' No. 20 enamelled wire; 126' No. 26 enamelled wire; 18' conventional twin-lead lamp cord; machine hardware; hookup wire; solder; etc.

When the output of *IC1* goes high, the voltage drop across *R3* is very low. This turns off *Q1* and the transistor increases the current-drive capability of *IC1* without altering the output wave-shape.

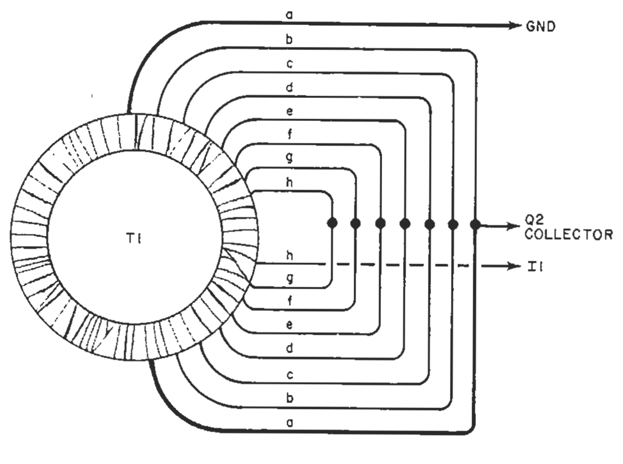
The current-boosted output of *IC1* is applied to switching transistor *Q2*, which drives step-up transformer *T1*. The transistor for *Q2* has an 80-volt breakdown rating and can handle 8 amperes. In operation, fluorescent lamp *I1* requires 1.75 amperes, and the peak current flowing through *Q2* is slightly greater than 6 amperes.

During the first few moments of operation and before the fluorescent lamp strikes, the rapidly changing magnetic field of *T1* produces voltage pulses in excess of 600 volts. It is these pulses that are applied to the lamp to cause it to conduct. After the lamp starts, it serves as the load for *T1* and limits the output potential of *T1* to about 90 volts. The time between power-on and lamp lighting is about a second.

A vehicle's electrical system voltage might vary by 15% or more, depending on whether or not the engine is running and also on the condition of the battery. In the utility light circuit, a 15% input voltage variation could mean low lamp brightness and might cause *Q2* to burn out. The *IC2* circuit is used to obviate these possibilities. Operational amplifier *IC2* functions as a current regulator that maintains a constant light level over the range of battery voltages usually encountered in mobile electrical systems.

The voltage drop across *R6* and *R7* is proportional to the current through the fluorescent lamp. This voltage is filtered and smoothed by *C7* and *R8* before being applied to *IC2*. The op amp then compares the filtered voltage from *C7* with a reference voltage that is preset by *R9*. The output of *IC2* then develops a correction signal that is fed to *IC1* to vary the oscillator's frequency and pulse

Fig. 2. Wiring diagram for T1. Conductor "a" is No. 20 wire. Others are No. 26.



width as required to maintain a constant current and lamp brightness.

During operation, the potential at pins 2 and 3 of *IC2* is only on the order of 0.5 to 0.6 volt above ground, which is sufficient to drive the FET input stage of the CA3130 used for *IC2*. This potential, however, is too low to drive other op amps, such as the 741, that do not have FET input stages.

Construction. With the exception of *F1*, *Q2*, and *T1*, all components should be mounted on a small piece of perforated board or a printed circuit board of your own design. The circuit board assembly and other components then mount inside the selected fluorescent lamp fixture. Hence, select the fixture before making the board assembly so that you are sure the latter has space to fit inside the fixture. Also, select a metal fixture so that it can serve as a heat sink for *Q2*. The fixture should have at least a 2½" (6.4-cm) wide by l" (2.54-cm) deep channel to accommodate the board assembly and *T1* (see Fig. 3). If the selected fluorescent fixture has a ballast and starter, remove them.

Transformer *T1* must be home fabricated by winding enamelled wire on a ferrite core. Cut an 18′ (5.5-m) length of No. 20 enamelled wire and seven l8′ lengths of No. 26 enamelled wire. Form the eight wires into a single bundle and temporarily tie one end to a door knob or other support. Liberally coat the bundle with contact cement. The easiest way to do this is to pour a small amount of the cement into the palm of your hand and pull your hand along the length of the bundle. Leave one end of the bundle attached to the support as you coat it with enough cement to make all wires adhere to each other. Remove the contact cement from your hand with acetone or nail polish remover. Allow the cement on the bundle to dry before removing it from the support.

The wire bundle forms about 75 turns around the ferrite toroid core specified in the Parts List. Before proceeding, carefully scrape away about ½" (12.7 mm) of the enamel coating from all wire ends. Then, referring to Fig. 2, locate one end of the No. 20 wire and attach a tag labelled GND to it. Now, using an ohmmeter, identify and label all remaining wire ends for quick identification.

Once the No. 26 wires have been identified, connect them in series exactly as shown in Fig. 2. As you twist together and solder each wire connection, be sure to insulate the connection. Note that the unconnected end of the wire labelled *h* goes to the fluorescent lamp and that the junction where the heavy *a* and lighter *b* wires meet connects to the collector of *Q2* This method of winding produces the tight coupling required to prevent high-voltage switching transients from appearing at the collector of *Q2*. The finished transformer can be mounted in the trough of the fixture with silicone rubber or urethane adhesive.

Transistor *Q2* mounts on the metal fixture so that it makes thermal but not electrical contact. Use a mica insulator and silicone heat-transfer compound to assure good heat-sinking action. A typical installation of the components in the central channel of the light fixture is shown in Fig. 3.

Test and Adjustment. You can test the utility lamp by applying 12 volts dc to the power input before final mounting of all elements. Fuse *F1* goes in an in-line fuse holder located in the power cable. The free end of the cable can be terminated with an automobile cigarette lighter plug or some other type of connector that mates with its counterpart in an electrical system. Make certain that the correct polarity is observed when connecting the power line leads.

There is only one adjustment that need be made to get the lamp operating properly. This is to set the current drawn by the lamp by adjusting *R9*. To do this, it is necessary to measure the current to the lamp. Set your multimeter to the 2- or 5-ampere range and connect it in series with the fuse holder. (If your meter does not have a 2- or 5-ampere measuring capability, temporarily connect a 0.1-ohm resistor in series with the fuse holder and measure the voltage across it. The current is then this voltage divided by 0.1.)

Set *R9* to midscale when you initially power up the utility lamp. As you adjust the setting of *R9* to both sides of its center position, you will note that the meter indication will vary from a low of about 0.5 ampere to a high in excess of 2 amperes. Adjust *R9* for a 1.75 ampere indication (0.175 volt across the 0.1-ohm resistor). Once *R9* is properly set, daub some nail polish on its rotor to fix the setting. If you used a 0.1-ohm resistor in series with the fuse holder, remove it. The lamp is now ready to use.

One word of caution is necessary at this point: DO NOT plug the utility light into a power source unless a fluorescent lamp is in the circuit. Without the lamp serving as a load, high voltage switching transients are likely to destroy *Q2*. ◇

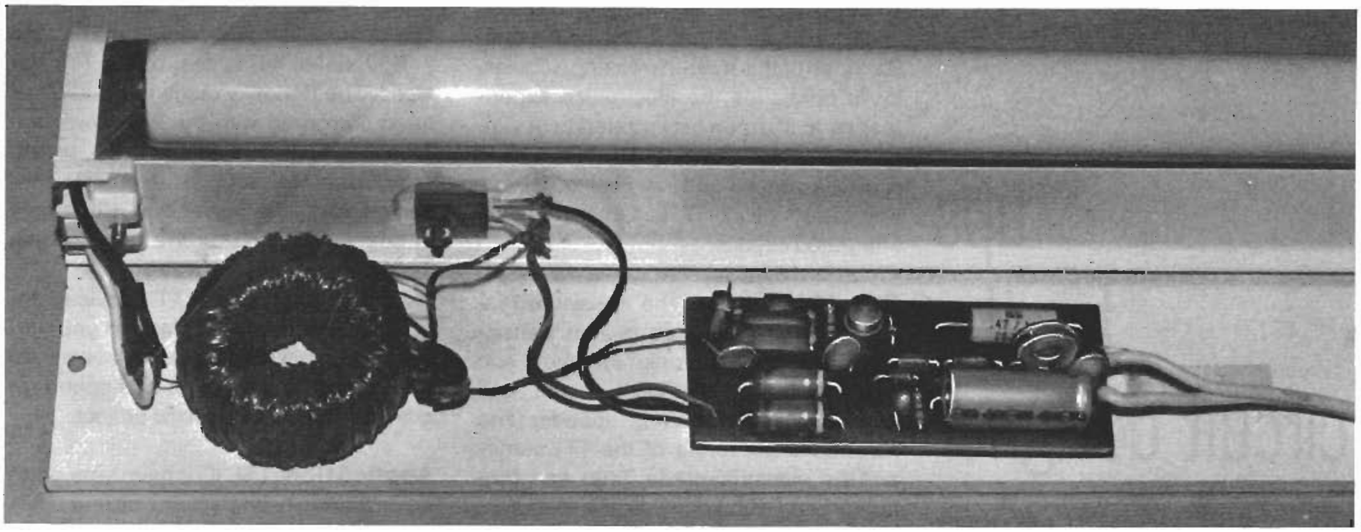


Fig. 3. Photo shows author's prototype. Note how fixture is used (with insulation) as heat sink for Q2.

TRANSISTOR-OPERATED PORTABLE LAMP

By THOMAS J. BARMORE

Construction details on a fluorescent utility or emergency light that is battery powered via a transistor oscillator.

MOST of us in the electronic repair business have had to work on equipment in the dark, with only a flashlight as a source of illumination. Even if you don't fall into this classification, you will appreciate this unusual light source if you've ever had to change a tire in the dark or had the power go off in your home at a crucial moment.

This fluorescent lamp is small, battery powered, and has a light output of 5 footcandles over an area of 16 square feet at a distance of two feet or 20 footcandles over an area of 4 square feet at a distance of one foot from the lamp. In order for a tungsten lamp to generate this same amount of light, 7.8 watts of power must be consumed while this unit draws only 3.7 watts (based on an average battery voltage of 5 volts and a power-supply efficiency of about 94%).

Unlike a conventional tungsten lamp, a fluorescent lamp is an electric-discharge source. It is a tube coated with a special powder (in this case, calcium phosphate) and filled with mercury vapor and a small amount of argon vapor. In the ends of the tube are filaments much like those found in directly heated vacuum tubes. These filaments are coated with an electron-emitting material which will give off a dense cloud of electrons when heated. In operation, these filaments are first heated while an a.c. potential is applied between the ends of the tube. Once the filaments are heated and the electron cloud present, the filament voltage is removed and an arc is established along the length of the tube.

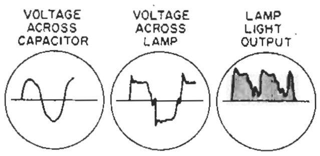
Electrons, in collision with the mercury atoms, release ultraviolet radiation which is absorbed by the wall coating. Light is then given off as this coating fluoresces.

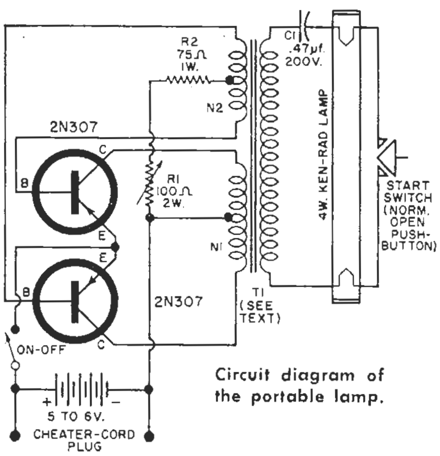
Circuit Design

Since fluorescents must have a potential for starting and operation that is higher than can be conveniently supplied by batteries, the lamp employs a simple d.c.-to-a.c. converter, consisting of a transformer, two inexpensive power transistors, and two resistors.

This supply is much like those which use an electro-mechanical vibrator to switch the primary voltage. In this supply, the primary circuit is actually a high-current multivibrator with feedback supplied *via* winding N2 and controlled by resistors R_1 and R_2. The switched d.c., or square wave, is applied to the primary winding (N1) and stepped up to about 100 volts.

The transformer used may be a commercial unit such as a *Triad* TY-100 (which costs around $12) or the constructor may wind his own. The author used a small tape-wound toroid about 1¼ inches in diameter, but a small audio transformer may be used with reduced efficiency. Winding N1 is about 50 turns, center-tapped, of #18 enameled wound about the periphery of the core. N2 is a center-tapped feedback winding of the same number of turns but of #30 enameled, wound between the windings of N1. Once these windings are in place and insulated with fiberglass tape, a secondary output winding of 600 turns may be wound over the top of the primaries. This secondary output winding is then insulated with cambric tape.





Circuit diagram of the portable lamp.

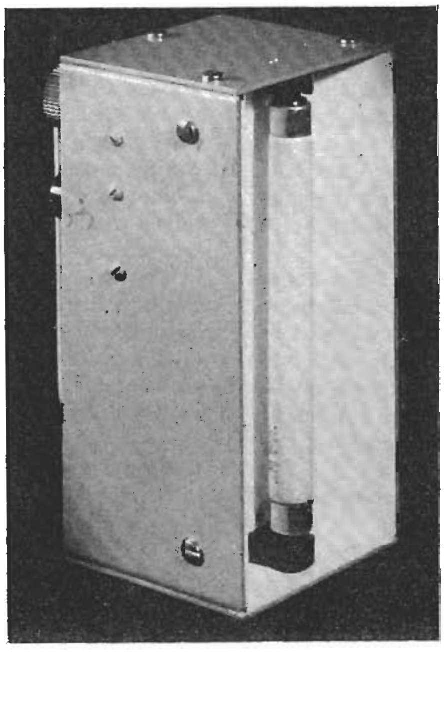
In operation, a fluorescent lamp behaves in a strange manner. Since it is an arc, some sort of current-limiting device must be used in series with the lamp. Since the lamp operates on a frequency of 5000 cps, a capacitor serves as an excellent current-limiting ballast as it has no power loss even though there is a voltage drop across it.

Power Sources

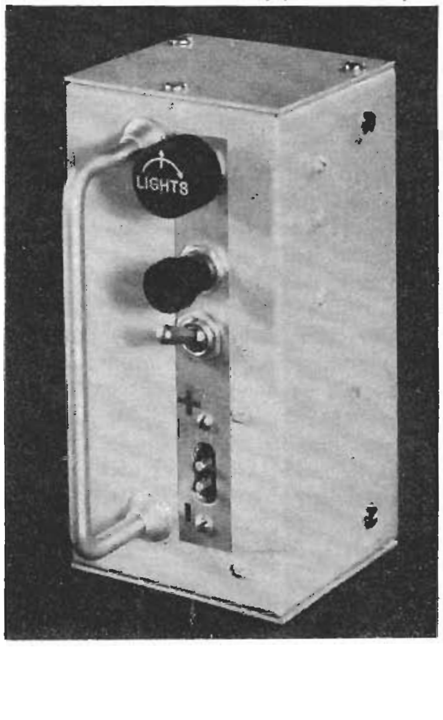
Power for the lamp may be supplied by one of several sources. The author used a 5-volt sintered-plate nickel-cadmium battery that is normally used in the *Black and Decker* cordless drill, but this was used only because of its shape. It will supply about 1 amp. for over two hours and is rechargeable. A set of four *Burgess* #CD-7L nickel-cadmium cells will power the lamp for an hour, while an *Eveready* cathodic envelope battery #2744 will operate the lamp for three hours. An *Eveready* #744 will supply power for about one-half hour, while four size D flashlight cells will operate it for about 15 minutes. Of course the unit can use an automobile battery as a power source, provided it is 6 volts. Otherwise, resistors R_2 and R_1 should be changed to a total of approximately 600 ohms. Resistor R_1 is made variable in order to increase battery life. Starting is facilitated with weak cells by increasing the bias on the transistor bases, while less current is actually needed to operate the lamp.

The unit is housed in a simple 3" x 3" x 6" case. One-half of the case houses all components, while the lamp sockets and lamp are mounted on a concave cover plate. All controls are mounted on the rear, enclosed by a handle. ▲

Ordinary 4-watt fluorescent tube is used.



A rear view of the battery-powered lamp.



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Puzzled by Kirchhoff

Q *I understand Ohm's Law but can't understand Kirchhoff's First Law, which says the currents into and out of any point in the circuit add up to zero. Can you explain it and recommend some books on the topic? — D. G., Harrisburg, IL*

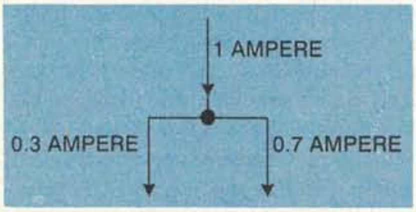

FIG. 3—AS STATED IN KIRCHHOFF'S first law, what flows into a node, must flow out.

A Certainly. Kirchhoff's Laws, in plain English without math, are:

(1) All the current that flows into a point must flow out again.

(2) All the voltage in a series circuit must be distributed among the components.

Making it even simpler: Current cannot disappear and voltage cannot disappear. As you note in your letter, those facts follow from the conservation of matter and energy.

Physics textbooks often explain those concepts by saying that the currents into a point add up to zero, and the voltages around a loop add up to zero. That's confusing until you realize that negative numbers are involved.

Suppose for example that some point in the circuit has 1 ampere flowing into it, 0.3 ampere flowing out through one path, and 0.7 ampere flowing out through another path (see Fig. 3). We count the incoming current as positive and the outgoing current as negative, so:

$$1.0 + -0.3 + -0.7 = 0.0$$

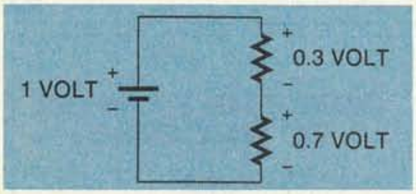

FIG. 4—KIRCHHOFF'S SECOND LAW states that the sum of all voltages in a loop must be zero. Watch the polarities to avoid confusion.

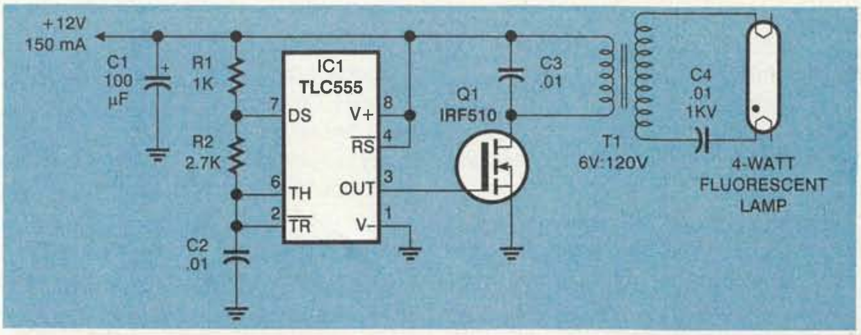

FIG. 5—THIS CIRCUIT lets you power a fluorescent light from a 12-volt DC source. You might need to experiment with the transformer.

and Kirchhoff's First Law is satisfied.

Now consider the circuit in Fig. 4. The battery supplies 1 volt and the resistors take up 0.3 volt and 0.7 volt, respectively. Notice that the polarity of the voltage on the resistors is opposite that of the battery. So the resistor voltages count as negative. Again,

$$1.0 + -0.3 + -0.7 = 0.0$$

(volts this time, not amps) and Kirchhoff's Second Law is satisfied.

We suggest you go to a good library and look for an electronics textbook that meets your needs. Bear in mind that every mathematical formula is actually a statement of how something works. For example, Ohm's Law tells us that voltage is the force that drives a current through a resistance. Bear in mind, also, that you won't need to solve complicated circuit networks in order to design most kinds of electronic equipment. Ohm's Law and the reactance formulas are almost all you need.

Custom Crystal

Q *I plan to build a couple of projects that will be operating on 18.990 MHz and am unable to find a crystal that matches my specifications. Should I use a PLL synthesizer? — R. P., St. Louis Park, MN*

A Easier than that—you can order a custom crystal for a few dollars from JAN Crystals, PO Box 60017, Fort Myers, FL 33906. Write to them for a price list.

Battery Fluorescent Lights

Q *I would like to know how to make a 12-volt battery-operated fluorescent light for use in my truck. Would you be able to help me, either by publishing a sample circuit or by explaining how it works? — S. A., San Jose, CA*

A Figure 5 shows a circuit you can experiment with. It's a close relative of the high-voltage power supply in our September, 1996, issue. The fluorescent tube is fed about 350 volts AC; at that voltage, the filaments don't have to be heated, so only one pin at each end is used. The ballast, or current-limiting element, is a capacitor rather than a coil.

The circuit consists of a 20-kHz oscillator, a switching transistor to amplify its output, and a step-up transformer. We used a 120-volt to 6-volt power transformer connected backward (Radio Shack 273-1352, using half of the 12-volt side for 6 volts). In the circuit, the transformer is working at considerably more than its rated voltage, but the high frequency keeps it from saturating. Although the lamp does not glow at full brightness, the circuit is energy-efficient, requiring only 150 mA.

The exact characteristics of your transformer will make a big difference here, so experiment. The transformer specified in our September issue will work better, but it's probably too expensive for the purpose. A 10-volt to 240-volt transformer would be ideal, if you can find one. Be careful around the high voltage, and remember that it's easy to burn out the IRF510 with excessive current.

BIOS Queries

Q *I have two related questions. Will the BIOS chip from a 386DX-25 work on a 386DX-40 motherboard? Also, I have a 386DX-25 motherboard with an AMI BIOS chip. When I power it up, it beeps 3 times over and over. Can you tell me what that code means? — B. F., Newport News, VA* should be rated ...

OUT OF TUNE

In "Peak Unlimiter" (September, p 75), the 1N82 diode should have been specified as silicon not germanium.

In "A Battery-Operated Fluorescent Lamp" (August, p 53), in the first step of the adjustment procedure, instead of removing the connection between the rotor of *R6* and the 12-volt end, the instructions should be to disconnect the potentiometer from the 12-volt supply.