elementary MAY-JUNE 1972 Electronics

Light-Comm

All Solid-State Light Beam Communicator Uses Infrared Light Emitting Diode

by Forrest Mims

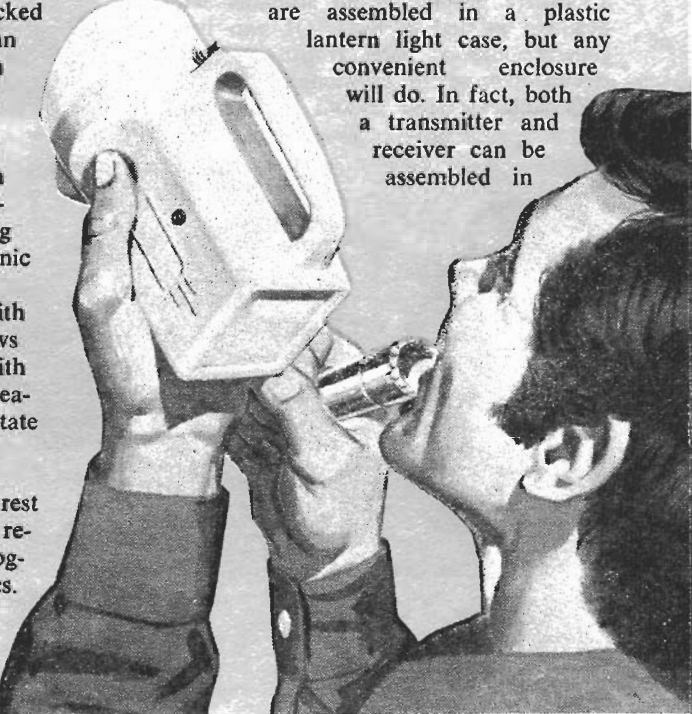
Light beam communications have been around since prehistoric man first used a chunk of shiny mica to signal a buddy. Fortunately for us, electronics has considerably improved things; today all it takes is a handful of components for you to assemble your own sophisticated, invisible light communicator. With our plans, your unit will operate in the infrared portion of the electronic spectrum to transmit voice up to nearly a thousand feet.

Unlike radio, optical communications make use of relatively narrow beams of light, and because the wavelength of light is so high, engineers have shown how a tremendous amount of data can be packed on a single beam. Since the beam can be invisible—like the infrared system used in the communicator described here—transmission is completely private and undetectable. Interestingly enough, the light beam communications idea originally developed by stone age man is being given a real boost with electronic techniques.

Here's your chance to jump in with both feet. Get the feel of tomorrows communication techniques today with Light-Comm—e/e's project that features invisible light from a solid-state lamp.

Get the LED Out. The revived interest in optical communications shown recently is the result of significant progress in the field of electro-optics. Several types of lasers show great promise for optical communication applications, but the light emitting diode (LED) is currently one of the most practical contenders. The LED, usually made of gallium arsenide, is a semiconductor which emits infrared light when forward biased. It was invented more than ten years ago, but only recently has the price of commercial units dropped to the point where they can be purchased by experimenters.

How it Works. The communicators consist of two self-contained units, one a transmitter and the other a receiver. Our units are assembled in a plastic lantern light case, but any convenient enclosure will do. In fact, both a transmitter and receiver can be assembled in



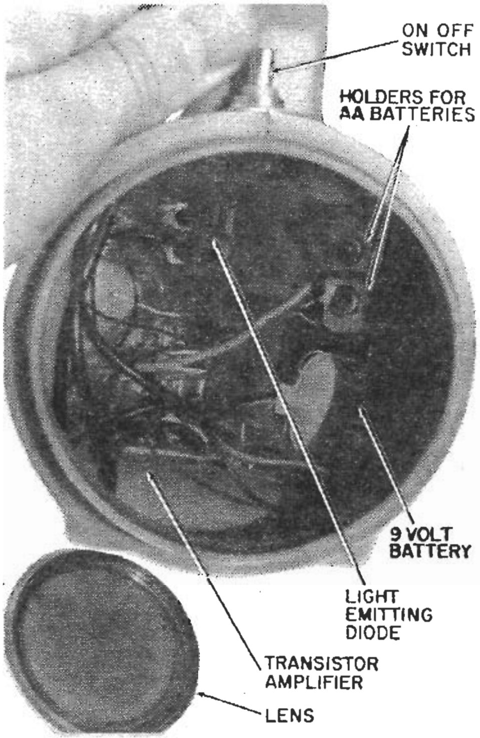
the same enclosure to fabricate a transceiver.

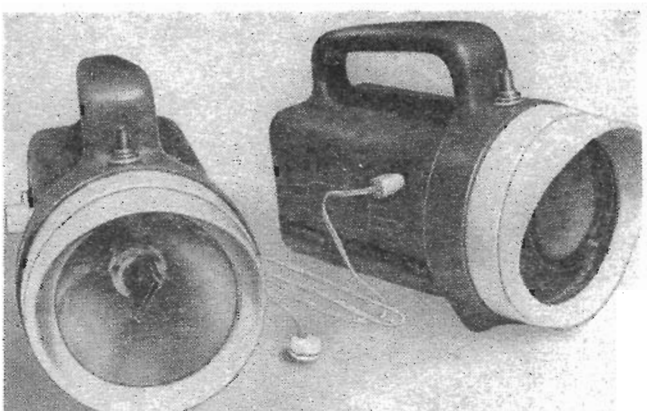
The LED is modulated by means of a pre-assembled miniature transistor amplifier. It is connected to the amplifier's output transformer through a single transistor coupling stage. Two penlight cells provide the LED's driving voltage. Excessive current can degrade or damage a LED, so current limiting is provided by a 100-ohm resistor (R2).

An amplifier similar to the one used in the transmitter is used in the receiver. But a pair of silicon solar cells are connected to the amplifier's input and serve to convert the optical signal to a corresponding audio signal. The amplifiers are available from most mail order electronics distributors, but usable amplifiers can often be salvaged from discarded portable transistorized tape recorders or players.

Transmitter Construction. Begin construction of the transmitter by drilling three 1/32 inch holes in an open space on the output end of the amplifier board. Insert transistor Q1 into the holes and solder its base and emitter leads to the appropriate terminals on the printed circuit board. If necessary, use short lengths of insulated tubing to prevent Q1's leads from shorting against other wiring. Q1 can be practically any general purpose PNP transistor. (Note: the Radio Shack amplifiers used here have a positive ground. If an amplifier with a negative ground is used, Q1 can be any general purpose NPN transistor. See the circuit diagram for additional information.) Q1's collector lead should be left unconnected in preparation for the next step.

Next, cut a 2-in. x 3/4-in. rectangle of perforated board and mount two fahnestock clips on it with appropriate hardware. The board's purpose is to permit you to mount the LED in a position where its light is unobstructed and to mount one or two other components. Drill a 1/8-in. hole in the output end of the amplifier board and mount the perforated board to the amplifier with an aluminum bracket. Place the bracket so that it doesn't short against any of the amplifier's printed wiring. Insert a





Dr. Leakey's illusive rock-in-hand ape man couldn't operate these space age goodies even if he had a pair. But you can build and operate your own if you wish by starting with low cost lantern cases and filling them with transmitter parts shown above. See open receiver and parts location drawings later in article. Finished units, left, show collimating lens in transmitter and solar cells in receiver reflector.

100-ohm resistor in the perforated board below the clips and solder it in place according to the circuit diagram. Where necessary, use lengths of hook-up wiring to reach distant portions of the circuit. Also, solder Q1's collector lead to the appropriate terminal of the LED clips.

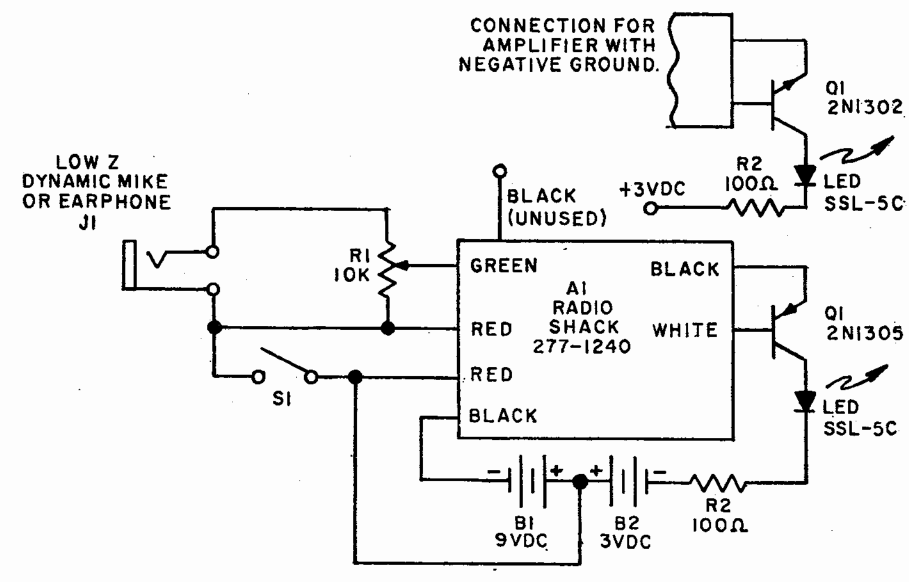
Screwdriver Drift. The 10K gain control potentiometer can be mounted on the inside of the plastic case, or, since adjustment is infrequent, to the perforated board. The latter approach was used in the prototype; a ¼-in. hole drilled into the back of the flashlight case permits the pot to be adjusted with a screwdriver. If the pot is mounted to the perforated board, be sure to drill an appropriately spaced and sized hole in the board before mounting it to the amplifier.

Before mounting the amplifier-LED assembly in the enclosure, install the battery holders. Use AA penlight cell holders for both the penlight cells and the nine volt battery. The latter holder should be modified by sawing the terminal end off and using a standard clip connector to make contact with the battery connectors.

When the battery holders are installed, mount the amplifier-LED assembly inside the enclosure. First, insert the LED into the clips and carefully orient it so that it will face toward the portion of the enclosure where a collimating lens will be installed.

Get it Focused. The amplifier board is mounted to the enclosure with 4-40 hardware. Cut a pair of slits in the bottom of the enclosure so the focus of the LED can be varied by simply moving the entire amplifier-LED assembly in the case. Also at this point, connect leads to the circuitry for the microphone jack and switch. Be sure to leave battery holder, microphone jack, and switch leads long enough to permit the amplifier-LED assembly to be removed for servicing.

Our communicator used a plastic lens with a focal length of about 4½-in. to collimate the infrared light from the LED



PARTS LIST FOR TRANSMITTER

A1—100mW Audio amp. (Radio Shack 277-1240 or equiv.)
B1—9 volt transistor radio battery
B2—3 volts (two AA penlight cells)
J1—Microphone jack
LED—SSL-5C light emitting diode (General Electric Co., Miniature Lamp Dept., Cleveland, OH 44112, $7.15 each)
Q1—Transistor, 2N1305, HEP-629
R1—10,000-ohm potentiometer
R2—100-ohm, ¼ watt resistor
S1—Push button switch, normally open

A partial kit consisting of the following components is available for $10.00 (add $1.00 postage and handling) from MITS, Inc., 2016 San Mateo SE, Albuquerque, NM 87110: Transmitter—LED, Q1, J1, R1, R2, low impedance earphone (for use as microphone), lens, and battery holders. Receiver—J1, P1, R1, and battery holder.

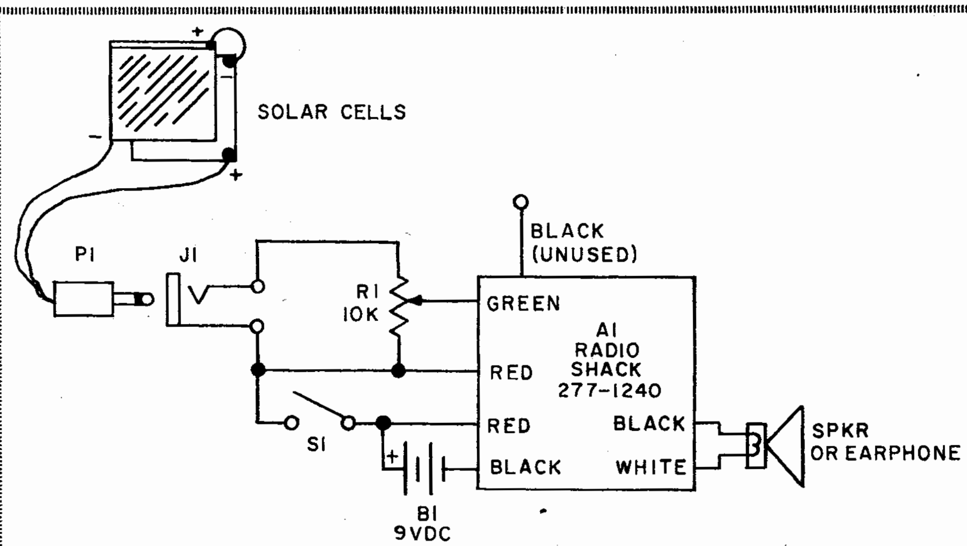
into a narrow beam. An identical lens is available from a source listed in the Parts List. Actually, almost any convex lens can be used to focus the light beam; just be sure the focal length is several inches and the lens diameter is sufficient to intercept the entire beam from the LED. Edmund Scientific Company (see their ad in this issue for address), sells many lenses which work well with the communicator, and most department stores carry a variety of inexpensive magnifiers which can also provide an appropriate lens.

The plastic dust cover which protects the flashlight's parabolic reflector is used to mount the lens. Since it is not required, remove the reflector and set it aside for use in another project. Cut a hole in the clear plastic dust cover for the lens; if the plastic lens available from the source in the parts list is used, the hole should be 2-in. in diameter. A plastic shoulder on this lens permits easy mounting. Insert the lens and glue its edges to the dust cover.

Receiver Construction. Assembly of the receiver is similar to that of the transmitter. The amplifier board can be mounted in a fixed position, however, and there is no need for an additional circuit board. Mount the battery holder and volume control on the inside of the case. A speaker was included on our unit (along with an earphone jack), but it can be eliminated in favor of an earphone if desired.

The infrared light from the transmitter is detected by a pair of back-to-back solar cells in the receiver. The cells, which must be the silicon type, are mounted in the receiver's parabolic reflector by their wire leads. Mount the cells back-to-back by *very* carefully soldering a small wire from the positive terminal (along the front side of one cell) to the negative terminal, which covers the entire back surface of the other cell. Silicon solar cells can be purchased economically in kits that include silicon, cadmium and selenium cells. Or, International Rectifier type S1M cells can be used if the case is opened and the wafer of cells inside is removed.

The remaining positive and negative leads are used to hold the two cells in position; feed them through the reflector's aperture, and wrap them around the protruding neck. A small plug is soldered to the leads, and *(Continued on page 94)*



PARTS LIST FOR RECEIVER

A1—100mW Audio Amp. (Radio Sack 277-1240 or equiv.)
B1—9 volt transistor radio battery
J1—Miniature jack
P1—Matching plug for above
R1—10,000-ohm potentiometer
S1—Push button switch, normally open
SO1—Silicon solar cells, unmounted (see text)
SPKR—8-16 ohm speaker
Misc—Hardware, battery holder, flashlight case (Burgess "Dolphin" lantern or equiv.), hook-up wire, optional earphone and jack.

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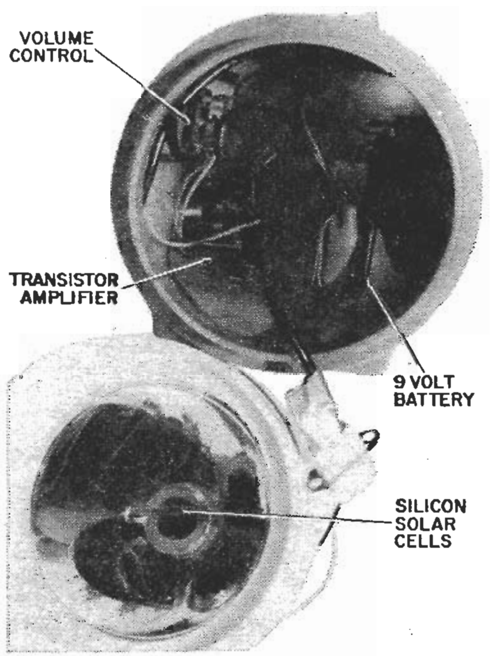
a jack is soldered to the amplifier input so that the detector-reflector assembly can be quickly disassembled if necessary.

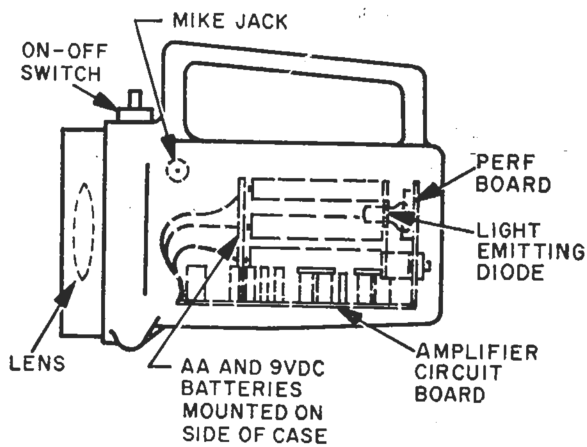
Note. When soldering to the solar cells, use a 30 watt soldering pencil. Do not use a soldering gun. With reasonable care, the experimenter with average soldering ability should have no trouble soldering the leads to the cells. If it is preferred not to solder to the cells, make use of the wire leads already soldered to the cells. Also, it is not absolutely necessary to use two cells since the cells are mounted in a reflector to capture a fairly large quantity of signal. It is more efficient to use two of them, but just one cell may be used.

Getting On The Air. When the receiver is assembled, insert a nine volt battery in its holder, clip on the terminal snaps, and place the detector-reflector assembly back on the unit. With the reflector pointed toward a standard room lamp (incandescent or fluorescent) a 60 Hz tone should be heard from the speaker or earphone. If the tone is heard, the receiver is operating properly and the transmitter can be checked out. If not, carefully check the circuit for wiring errors. Also, make sure the battery is fresh.

To check the transmitter for proper operation, insert the batteries, turn the unit on, and point it at the receiver. Speak into the microphone and listen for the received signal in the receiver. If the signal is heard and the voice is reasonably good audio quality, the units are both operational and ready for field testing. If the voice is not heard or is of poor quality, turn the transmitter off and check for possible wiring errors. Pay particular attention to possible shorts and polarity reversal. Also, make sure the batteries are fresh.

The Long Reach. Range test the completed communicators for maximum DX with the help of a friend. First, align the optical elements of both transmitter and receiver. For the transmitter, adjust the position of the amplifier board until the LED fills the





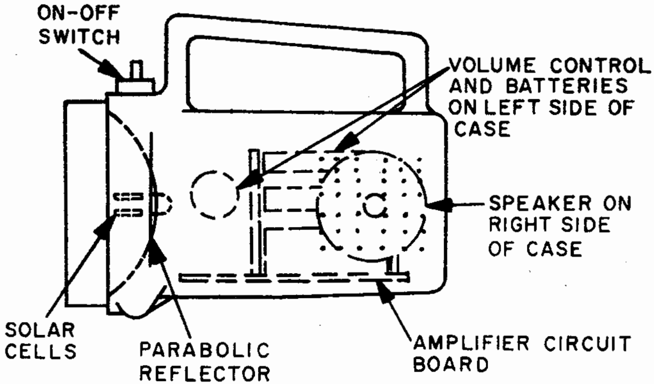


Photo on page 94 shows inside view of receiver with quick disconnect plug for solar cell separation. X-ray views show suggested parts location in detail AA batteries in transmitter power LED. 9-volt battery in each unit provides amplifier power.

aperture of the lens when the lens is observed several feet distant. Adjust the receiver's solar cells so that the entire reflector takes on the dark color of the cells when observed straight-on. This means that all light striking the reflector will be reflected to the cells.

When the units are aligned, leave the transmitter and its operator at a fixed location, and slowly walk away while directing the receiver toward the point of maximum signal. Instruct the transmitter operator to count into the microphone. As the range is increased, reception will be more difficult (because of alignment), but the signal from the transmitter should be receivable at about 1,000 feet at night. Range will be dependent on the size of the receiver's reflector. Daylight operation will result in considerably reduced range due to saturation of the detector solar cells. The problem can be partially alleviated by placing a cardboard tube over the front of the receiver to shield the detector from stray sunlight. Reception can be further improved by placing an infrared filter over the receiver detector. Edmund Scientific Co. sells several inexpensive filters. These optical shielding techniques will also reduce effects of buzz and hum from artificial light sources. ■