The Theory and Construction of a

Transistorized Tracking Light

for Night Launched Model Rockets

By Capt. Forrest M. Mims

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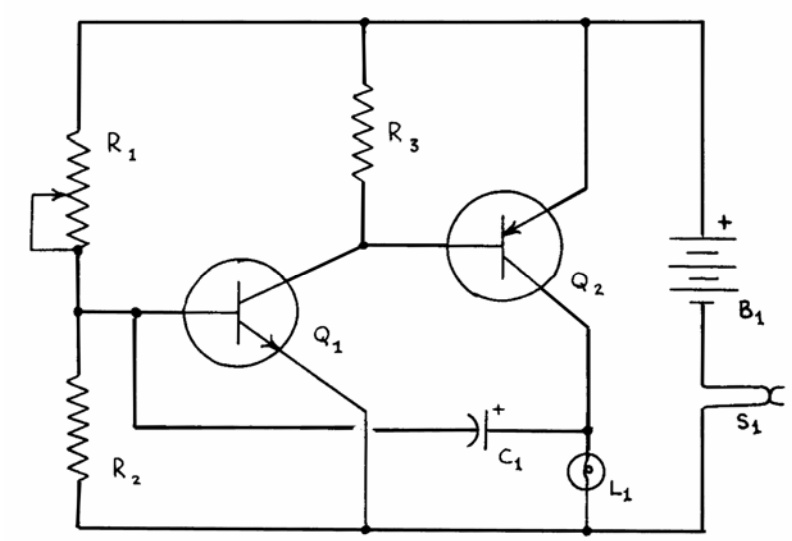
With a simple tracking light assembly, it is possible to launch, track, and recover model rockets flown at night. Certain experiments, particularly those involving micrometeorology or guidance and control benefit from night launchings. Altitude and velocity determinations can also be made by photographing the rocket-borne light.

Several approaches to a tracking light exist, the most common being: (1) Steady source, (2) Mechanical blinker system, and (3) Transistorized flasher. The steady source design has been used successfully by the author on several occasions. It consists of a small incandescent lamp and a dry cell. The method works fine for tracking rolling rockets if the lamp is visible from only one side of the rocket. In this configuration, the lamp appears to flash as the rocket completes each revolution of roll. Unfortunately, this simple system has a very short battery life due to the large amount of current drawn by the lamp.

The mechanical blinker system has several configurations, the most common being a small electric motor and wiper arm which alternately makes and breaks contact with current supplied to a small lamp. The result is a flashing lamp which requires less current than the steady source method but which is mechanically unreliable and requires a heavy, bulky power source to supply both motor and lamp.

The most efficient approach to a flasher is the transistorized method. Numerous circuits can perform this duty. The author has found the one shown in Figure 1 to be simple, reliable, and economical.



Parts List

B1	1½ to 6 volts (see text)
C1	20 uF, 6-volt electrolytic capacitor (Sprague Type 30D)
L1	1.2 to 3 volt lamp (see text)
Q1	2N4400, 2N4401, or similar NPN Transistor
Q2	2N4402, 2N4403, or similar PNP Transistor
R1	100,000-ohm miniature trimmer resistor (Allied 46 F 1809 or similar)
R2	5,600-ohm, ¼ watt resistor
R3	1,200-ohm, ¼ watt resistor
S1	Exposed leads (see text)

Miscellaneous small perforated phenolic board, hookup wire, solder, silicone rubber (see text), transparent payload section, and small amount of foam plastic.

Figure 1. Circuit diagram for tracking light assembly.

Construction

Readers with a knowledge of electronics will recognize the circuit as a free running multivibrator. Construction of the device is straight-forward. However, if extreme miniaturization is desired pay particular attention to the possibility of shorted leads.

The author's original device was miniaturized and encapsulated in transparent silicone rubber. For the purpose of this article, an almost identical unit was constructed on a small 5/8" x 1 1/2" perforated phenolic board as shown in the accompanying illustration. Experienced electronics hobbyists may wish to modify the circuit or construct the unit to suit the specifications of a particular payload section. However, those inexperienced in electronics should follow the general guidelines provided below for best results.

Begin construction by cutting a piece of phenolic to slightly less than the diameter of the payload section in which the flasher will be mounted. The length of the phenolic is not critical (1 1/2" should be more than adequate). Place the prongs of the trimmer resistor through holes in the phenolic board at the location shown in Figure 2. Notice that the moving contact corresponds to the arrow in the circuit diagram. Solder a short length of hookup wire from this terminal to one of the other trimmer terminals.

Bend the leads of the two resistors at right angles to the resistor and insert at the locations shown in Figure 2. Solder one lead of each resistor to the trimmer terminals as shown in the Circuit Diagram. Next, carefully examine the transistors. Note that each of the three leads is labeled "E" (emitter), "B" (base), or "C" (collector) on the plastic case. *Carefully* spread the leads of each transistor so that they will readily fit into a triangle of holes on the phenolic board. Insert the transistors and carefully loop each lead around its proper connection point as shown in Figure 2. Solder the connections with care to prevent damage to the transistors. Next, bend the leads of the capacitor and insert the component into the board making solder connections to the points shown in Figure 2.

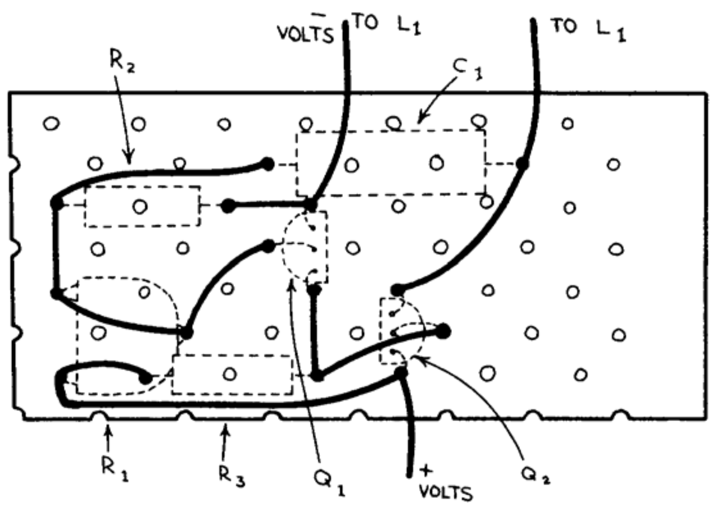


Figure 2. Tracking light wiring board (view from underside).

Connect the small lamp to the collector of transistor Q2 and the emitter of Q1 . The lamp should be a small incandescent type rated at from 1.2 to 3 volts. Flashlight lamps will do, but the author prefers the small grain of wheat lamps used in model trains and available in most hobby shops for about $.25. If necessary, adjust the trimmer resistor so that the rotating contact is closest to the side to which R2 is soldered. This should be done to prevent possible damage to the transistors. A 5,600 ohm resistor may be connected between R1 and R3 if it is desired to provide permanent protection, but this is not necessary if care is used when adjusting the trimmer. Connect the positive terminal of a 1 1/2 or 3 volt battery to the emitter of Q2 and the negative terminal to the emitter of Q1. If the lamp fails to flash or stays "on," adjust the trimmer resistor until the desired flashing rate occurs. If the circuit still does not flash, disconnect the battery and carefully recheck the wiring. Two leads may be shorted together, there may be an improper connection, or the transistors may be reversed. Also check the battery and lamp to insure that they are both good.

It is extremely important that the circuit be carefully checked to insure its proper operation before the next step - encapsulation of the unit - is undertaken. It is far better to detect a malfunction at this stage than after "potting", for then it will be much more difficult to correct.

When the circuit is properly operating, solder stranded, insulated hookup wire to the circuit board for permanent battery connections. Extend the lamp and battery leads to one side and pot the unit with silicone rubber. Silicone rubber is sold as "Silastic" or "Silicone Seal" in most hardware or variety stores. It comes in a tube and is available in black, white, and transparent. Do not pot the adjustable portion of the trimmer resistor. Encapsulating the unit in silicone rubber is not absolutely necessary, but does provide a great amount of protection in the event of a parachute failure.

The completed flasher is mounted in a payload section as shown in Figure 3. The type of battery used is not critical as the circuit will operate on 1 1/2 to 6 volts. If long battery life is desired and the additional weight can be tolerated, use a 4.2 volt mercury cell (Burgess H 163 or equivalent). With this battery, the flasher will produce 3-5 flashes per second (adjustable with the trimmer resistor) with a flash duration of about 0.2 seconds. A strong solder joint from the battery leads to the battery is important. The shocks of acceleration, parachute ejection, or landing will invariably separate a poor connection.

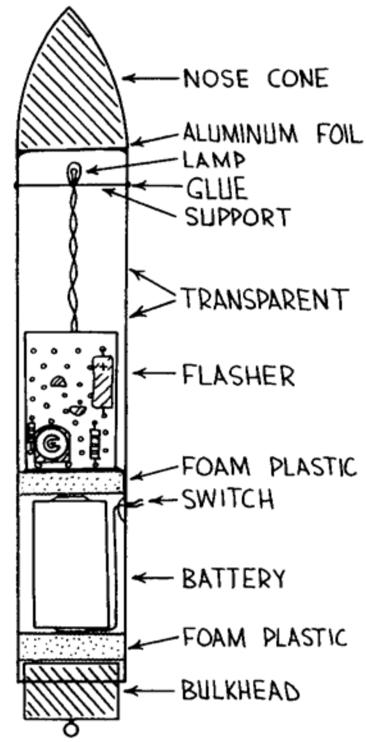


Figure 3. Tracking light assembly installed in transparent payload section.

To solder leads to a mercury battery, first roughen each end cap with a file. Using a hot soldering iron or gun, heat a corner of each end and apply a small amount of solder. Do the same for the battery leads and with the battery supported in a vise or by a clothes pin carefully solder the leads to the battery. Observe polarity to prevent damaging the flasher circuit. Some readers may have difficulty with the above step. If so, try the following approach: Apply a small pool of molten solder to each end cap. Cut a small square of copper foil (available in hobby and craft shops), apply a coating of solder, and place it on the molten solder pool at each end of the battery. The copper squares will readily adhere to the end caps and are very easy to solder. Important: whichever method of soldering is employed, use care and do not cause the entire mercury battery to become heated as extreme heat may cause these devices to explode. A good idea is to keep a small container of cold water handy. If the soldering process begins to heat the entire battery, simply dunk it into the water for a minute. If the 23 gram weight of the 4.2 volt mercury cell is excessive, use a pair of penlight cells in series (Burgess N or equivalent). This will provide 3 volts with somewhat less weight than the mercury battery.

After the flasher circuit is soldered to the battery, cut one of the battery leads at midpoint and extend the two ends through a small aperture in the side of the payload section. Remove a small amount of insulation from each lead. At launch, the exposed ends are twisted together and pushed into the payload section. Use a stiff length of wire with a small hook at one end to remove the twisted leads to permit switching the unit off at recovery.

Applications

The transistorized flasher described here weighs a scant 4.2 grams minus battery and silicone encapsulent. Using the relatively heavy mercury battery, the entire assembly should weigh no more than an ounce. The author's original unit was used in a series of 16 flights conducted during a 5 hour period on a dark night. The flasher operated perfectly during each flight and recovery. Ground recovery was relatively easy, the flashing light being visible in relatively tall grass for about 50 feet. Visual tracking of the descent by parachute was also easy. Note, however, that the tracking light of a normally descending rocket will be inverted and not necessarily as visible as in the normal configuration. The rocket assembly may therefore have to descend to a fairly low altitude before the light becomes visible. If this is the case, determine wind direction by observing the sparks from the ejected parachute wadding. A perpendicular from a line in that direction to the ground will eventually reveal the tracking light of the descending rocket. Of course, the model rocketeer may wish to design his particular tracking light assembly so that the rocket may be tracked during its entire flight (sometimes important in micrometeorology experiments involving determination of wind velocities at various altitudes).

In order to derive quantitative information from flasher carrying rockets, photographic techniques are recommended. Any camera which can be set to "time exposure" or "bulb" will do. Recommended films are Kodak Hi Speed Ektachrome for color and Tri X Panchromatic for black and white. Other film will also work, and the rocketeer is encouraged to experiment in order to find the best film for a particular situation.

The author uses two photographic techniques. The first is to mount the camera on a tripod or immovable surface several hundred yards from the launcher. The camera is focused to infinity and aimed so that the lower edge of the viewfinder is centered on the launcher. In the second technique, the camera is mounted about a meter from the launch apparatus and faced vertically. The rocketeer will want to experiment with both methods in order to determine which provides the best coverage for a given experiment. Also, the rocketeer will probably wish to employ port burning engines in order to prevent the long lasting fire trail of end burning engines from obscuring the tracking light.

Conclusion

The author's flasher was used in a series of experiments which provided important data about a miniaturized guidance and control system for model rockets. The model rocketeer is urged to investigate the numerous possibilities of using a tracking light to provide quantitative data or to provide a recovery beacon in experiments involving telemetry or night photography. Careful construction and proper padding will insure a working flasher for each launch.

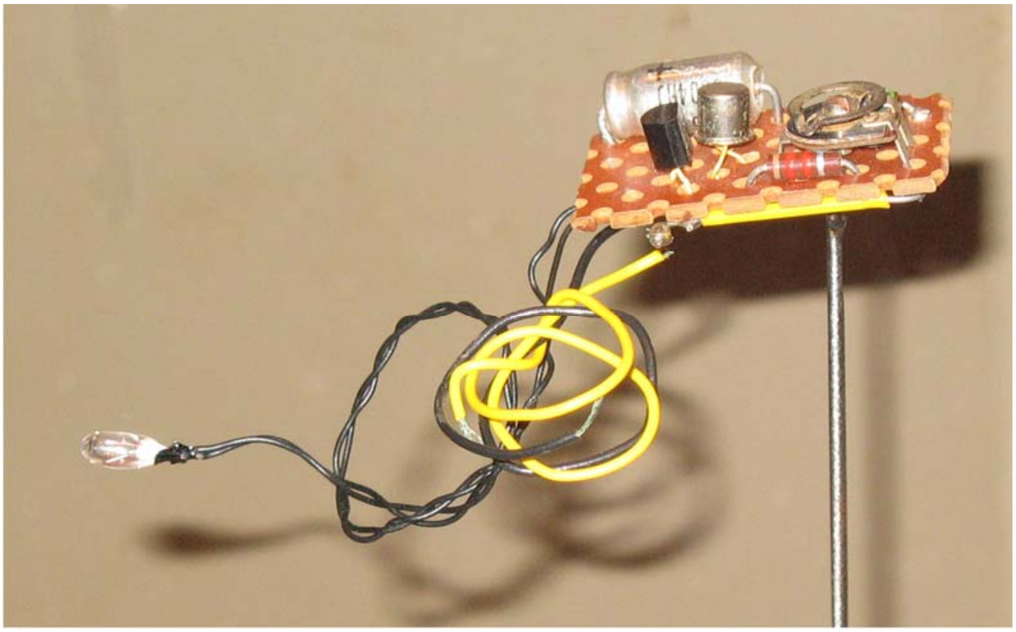
Press Release: *Model Rocketry*, December 1969

Reliance Engineering in Albuquerque, New Mexico has announced the formation of a subsidiary company for the manufacture of miniaturized electronic and telemetry systems designed for model rockets. The company is called Micro Instrumentation and Telemetry Systems (MITS). Reliance Engineering president Henry Roberts announced that "MITS is presently conducting an intensive research program involving high quality miniature telemetry systems."

The first commercially available model rocket telemetry transmitter is among the first items to be offered by MITS. Accessory modules including a tone beacon, temperature sensor, and a roll rate sensor, as well as tracking lights, ground systems for data reduction, and light weight, water activated batteries will soon be available.

MITS has prepared The Booklet of Model Rocket Telemetry to introduce rocketeers to their telemetry equipment. Copies of the booklet are available at 25 cents from MITS, 4809 Palo Duro Ave. N.E., Albuquerque, New Mexico 87110.

Prototype Flasher



Forrest Mims' prototype flasher. New Mexico Museum of Natural History and Science.