The Forever Flashlight II - Batteries Not Required

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I have always had an interest in unusual designs for electrical and electronic products. I am especially interested in products that actually work as I expect them to. I don't mean that they just work right out of the box, but rather that they work in my world, which it seems, is not part of the "normal" product design world. Reliable, well thought out, well engineered, feature rich products will always get my attention.

How many times have you needed a flashlight and when you found one it didn't work? The reasons are many; dead or corroded batteries, loose connections (discovered by beating on or shaking the flashlight), or a burned out bulb. Mag Lite has addressed the latter issue with their policy of including a spare bulb in the flashlight.

The Forever Flashlight (and others, see the last part of this report) utilizes the energy you spend shaking or beating on a conventional flashlight to actually provide the power to operate it. See figure 1 for an overview of the Forever Flashlight.

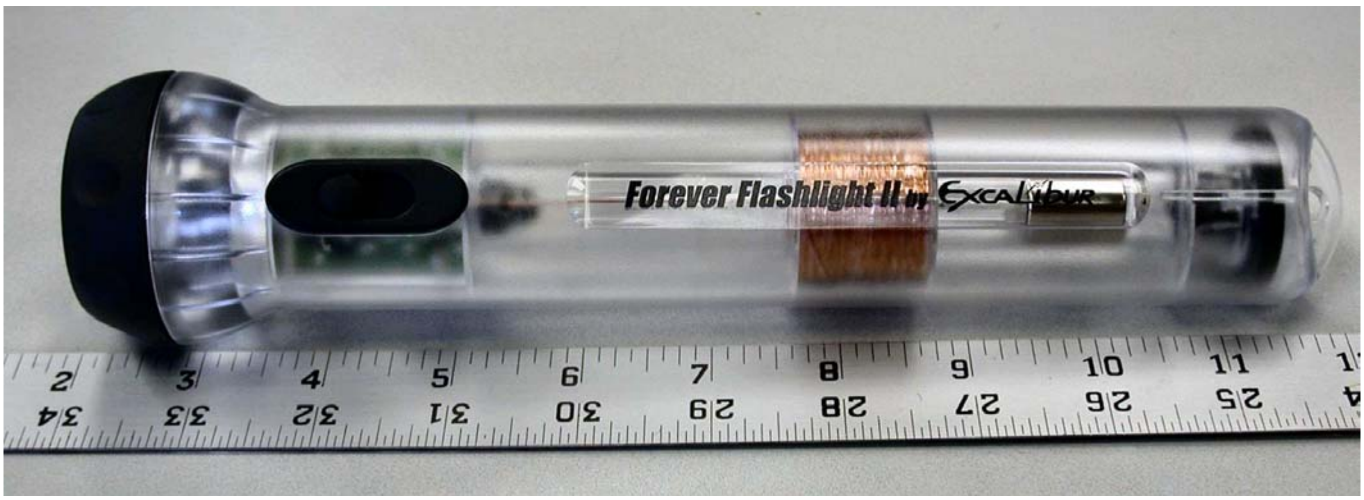


Figure 1 — Overview of the white LED shake powered Excalibur Forever Flashlight, batteries not required.

Seeing one a friend had bought inspired this technical product exploration. I immediately bought one at Brookstone, store 241, supplied by Excalibur Electronics Inc. of Miami Florida. The flashlight was actually made in China, of course. Find Excalibur on the Internet at www.excaliburelectronics.com

Excalibur has a broad product line but the "new" Forever Flashlight II has only a casual mention. There wasn't even a decent (sized) photograph of the product. Since I recommend this product to friends I felt that a few words describing it were needed.

The Excalibur website lists the flashlight at $39.95 and Brookstone sells it for $30.00. The Brookstone website has a better photo. In addition to the shake powered mechanism I was impressed with the lens system and its quite narrow beam projection of light. See figure 2. Do the math using the numbers shown in figure 2 to calculate the beam (included) angle at about 15 degrees. This means that you will be able to see your path in total darkness as you walk out of the mountains after a long weekend hike. Adding oil or power steering fluid to your engine at night requires a reliable flashlight, one that has been untouched for years.

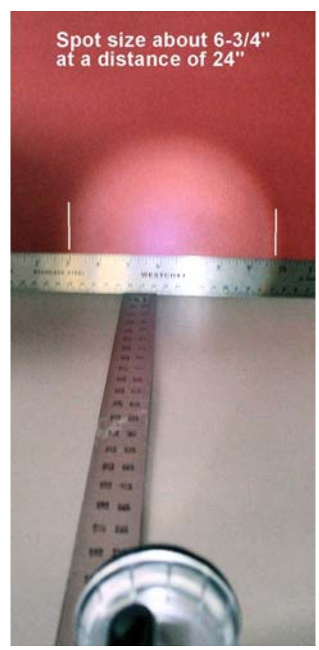


Fig. 2 — White LED Beam.

The future of low power lighting is in the use of the Light Emitting Diode, LED. Sooner or later you will buy one or more LED lights or lamps. The two primary advantages of an LED light source is it's efficient light generation (exceeding that of fluorescent lamps) and long life, typically 100,000 hours. That is 50 to 100 times more life than most of the bulbs in your house.

Most traffic lights now use LED's because the cost of replacing the bulbs is labor intensive and the electrical savings of 24-hour operation mean a very fast payback of the investment. An added bonus is that there are many LED's for each of the colors and the failure of one of them doesn't affect the system very much. Old style traffic lights only use two bulbs per color.

Newer vehicles also use LED's for their taillights. Hewlett-Packard is a major supplier of LED's for the automotive industry.

I bought the clear cased model because I am technically curious and I wanted to "see" it work. I had to ask for the clear version at the store I visited at the Valencia Mall in the Santa Clarita Valley (CA). A clear case may not be the best choice if you don't want light spilling out from the sides of the flashlight when being used. Tape comes to mind, or a little black paint applied to the inside of the LED Chamber.

The flashlight uses a moving magnet through a coil to charge a capacitor to power the LED. The charging process described in the instructions suggests holding the flashlight horizontal and moving back and forth at about three "shakes" per second for a total of 90 shakes - for five minutes of light. See more on that topic later. Obviously shaking a heavy magnet requires shock-absorbing bumpers and shaking vertically or too hard only endangers the flashlight mechanically and electrically.

The Forever Flashlight looks like most two "D" cell flashlights you have used. It is made of plastic and is mostly empty space inside so it is much lighter and it actually floats. It is different from most flashlights in that it only unscrews from the LED bulb end. Mine was quite tight and I don't believe that the design calls for cementing the two pieces together. I can't think of any reason to open the flashlight except for curiosity or possibility service. After you read this and study the photos you will not have to open yours.

When you first see the flashlight you will naturally want to look into the LED to see how bright it is. The lens/reflector system, as mentioned above, is quite effective. You will be able to look through it deep into the LED to actually see the two gold one-mil diameter (a mil is 0.001"- a human hair ranges from 1 to 3 mils in diameter, a sheet of copy paper is about 3 to 4 mils thick) bond wires used internally to connect the LED die to the leads. You may have to look a little off-axis to see these bond leads. The LED is not that bright. If you are bothered by its brightness just wait two or three minutes and it will dim. Figure 3 illustrates what I am talking about.

Fig. 3 — The lens magnifies the two 1 mil diameter LED bond wires to make them more visible.

Conventional LED's usually only have one bond lead. The semiconductor die is attached to one lead post making an electrical connection on the bottom. A bond wire is then used to connect the top of the die to the other lead post. See figures four and five on the next page.

If you are interested in LED's and how they work you may check the Internet. There is lots of information available from the manufacturers, schools, and how things work web sites.

The Forever Flashlight, FFL, is opened by unscrewing the black rubber like ring at the LED end. See figure 7 below. The "O" ring that seals the case against water is shown below the threads in figure 6. The "O" ring is estimated to be about 37.25 mm in inside diameter (1.465") and 2.5 mm in in diameter (0.089"). These may be stretched measurements. If you use your FFL around water you may want to apply a small amount of lubricant to the "O" ring to insure that it stays pliable and water resistant. The seat groove diameter is 44 mm (1.732")

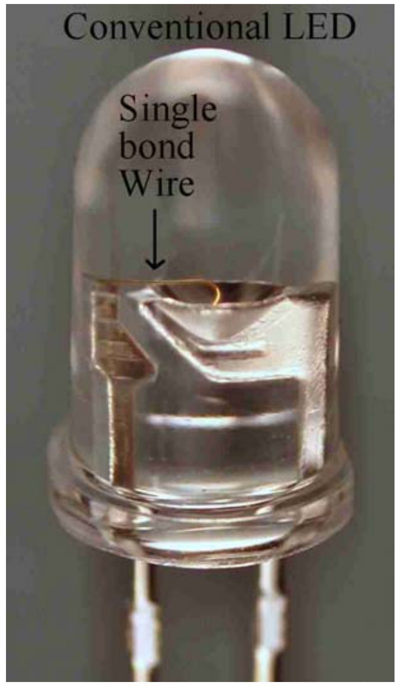


Fig. 4 — Conventional LED wire bonding, single bond wire.

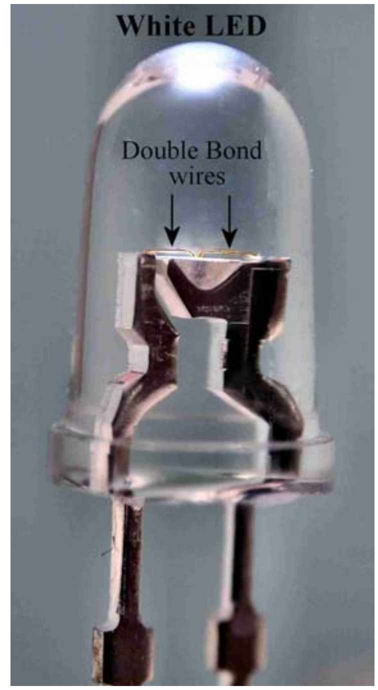


Fig. 5 — White LED wire bonding, two bond wires

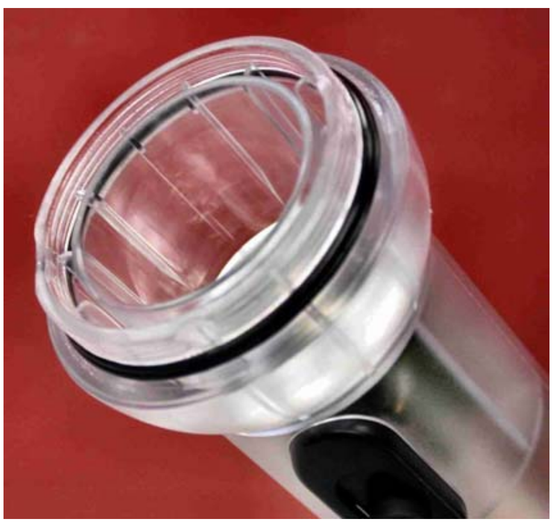


Fig. 6 — The retainer ring unscrews to show the black "O" ring used to insure water tightness.

Fig. 7 — The retainer ring and lens. The lens is glued to the retainer ring and projects a 15-degree beam.

The Forever Flashlight, FFL, uses two magnets. A large NIB magnet (Neodymium - Iron - Boron, the most powerful magnet made) is used internally to generate the power to run the FFL. The switch, partially seen at the lower right bottom in figure 6, operates much like your standard flashlight except it is many times better, smoother, and electrical contact free. The switch itself is on the inside of the sealed plastic case (it is water proof, remember) and it uses a second magnet in the button to actuate a magnetic reed switch inside the case. You may also operate the FFL with an external magnet if you wish. Figure 8 shows the LED mounted in the LED chamber about 26.9 mm (1.06") from the end of the inner housing. Figure 9 shows a close up of the white LED, turned off for better visibility. See figure 10 for a photo of the inner housing.

I will describe the parts of the flashlight grouping each major section as indicated in the notations of figure 10, A through F. What follows is specific to model 422-M purchased in CA mid February 2004.

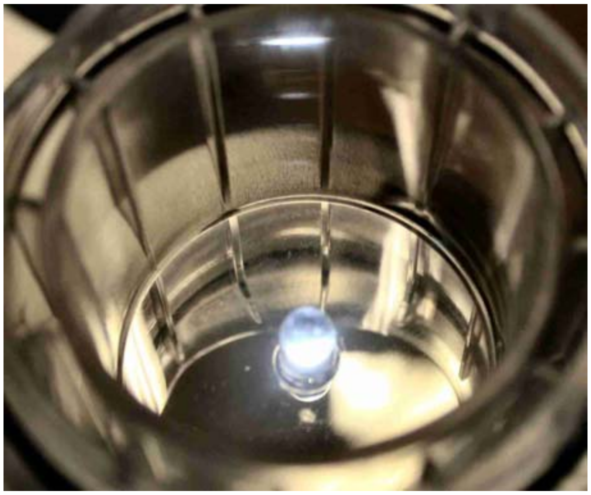


Fig. 8 — LED shown in its housing. Note the clear sides and flat reflector at the base of the LED

Fig. 9 — The single LED as viewed from the side through its housing. The LED reflection is on the right.

Figure 10 — Internal housing with each section identified for reference in the text.

A - LED Chamber: The LED chamber has been mostly described above when discussing the LED light performance characteristics of the FFL. A couple of additional points need to be made. The light itself is not pure white. There is a tinge of blue "spots" in the center of the beam. This is due to the type of white LED being used. White LED's are not really "pure" white. This is an especially important quality if you are taking photos using white LED's as a light source. You will definitely notice the blue. It is not clear to me how the LED is mounted. Read more on this in the next section. It seems that the base of the LED is glued to the flat circular reflector sheet that is, in turn, glued to the bottom of the LED chamber. The beam focusing system consists of the dome-lens LED mounted on a flat reflector and a double convex plastic lens to focus the beam. The lens is 40 mm (1.567") in diameter with an aperture of 31.3 mm (1.232") and focal length of about 35 mm (1.38"). The plastic lens is glued to its retainer ring

B - Circuit Board Chamber: The two flat rigid leads of the LED pass through two rectangular holes in the wall between the LED chamber and the circuit board chamber as shown in figure 11. These leads must be unsoldered before the circuit board may be removed from its housing. The two screws (see fig. 12) holding the circuit board, upper left and lower right corners, must also be removed with a #0 Phillips screwdriver. The coil leads may be straightened out and left attached if desired.

One component on the etch side of the circuit board is the reed switch mounted on a rigid standoff straddling the two LED leads. A close up view of the reed switch is shown in figure 13. The internal housing has three short "tongues" at the rear end that must be aligned with the black rear bumper retainer when inserting the inner housing into the case. The "tongues" insure proper alignment and positioning of the reed switch with the magnet in the button of the external sliding "switch."

Reed switches are composed of two magnetic blades mounted at the opposite ends of a rigid glass tube. When the blades are exposed to a magnetic field they bend towards each other providing a switched electrical circuit.

Fig. 11 — Flat rigid LED leads pass through the LED chamber wall and are soldered onto the circuit board. See figure 12 for a circuit board chamber overview.

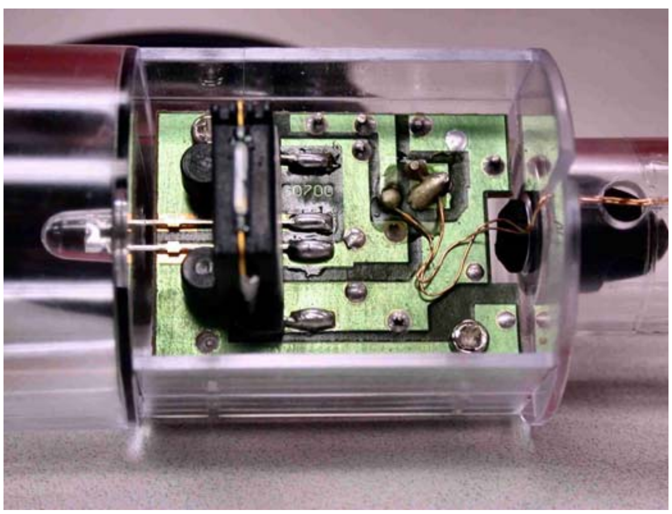


Fig. 12 — Circuit board chamber containing a single sided circuit board that connects LED, reed switch, storage capacitor, four full-wave-bridge-connected discrete rectifier diodes, and coil leads.

Fig. 13— Close up of the magnet actuated reed switch mounted on a rigid plastic stand off to position it close to the external slide switch. A magnet in the sliding "switch" on the outside of the case closes the switch.

An enlarged view of both sides of the circuit board is shown on the following page as figures 15 and 16. The circuit board is screw attached to standoffs on the inside its chamber. You must remove it as described above to see it clearly. Refer to figure 14. The largest component is the energy storage capacitor seen at the right side just to the left of the upper right standoff. The four standard rectifier diodes are seen along the bottom. Two screws (left end) secure the reed switch stand off.

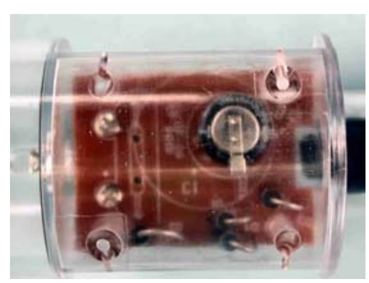


Fig. 14 — Ckt board Component side.

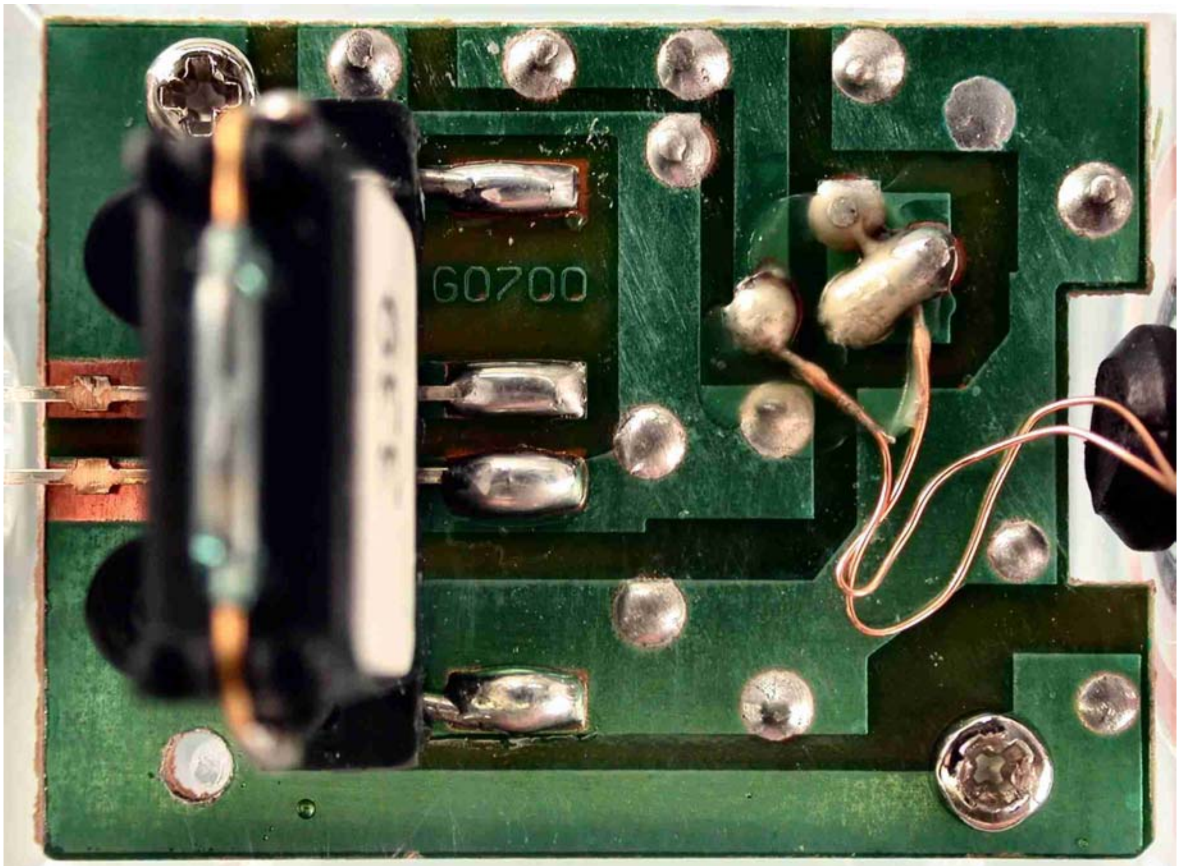


Fig. 15 — Enlarged view of etch side of the single sided circuit board. Traces are accessible for measurements.

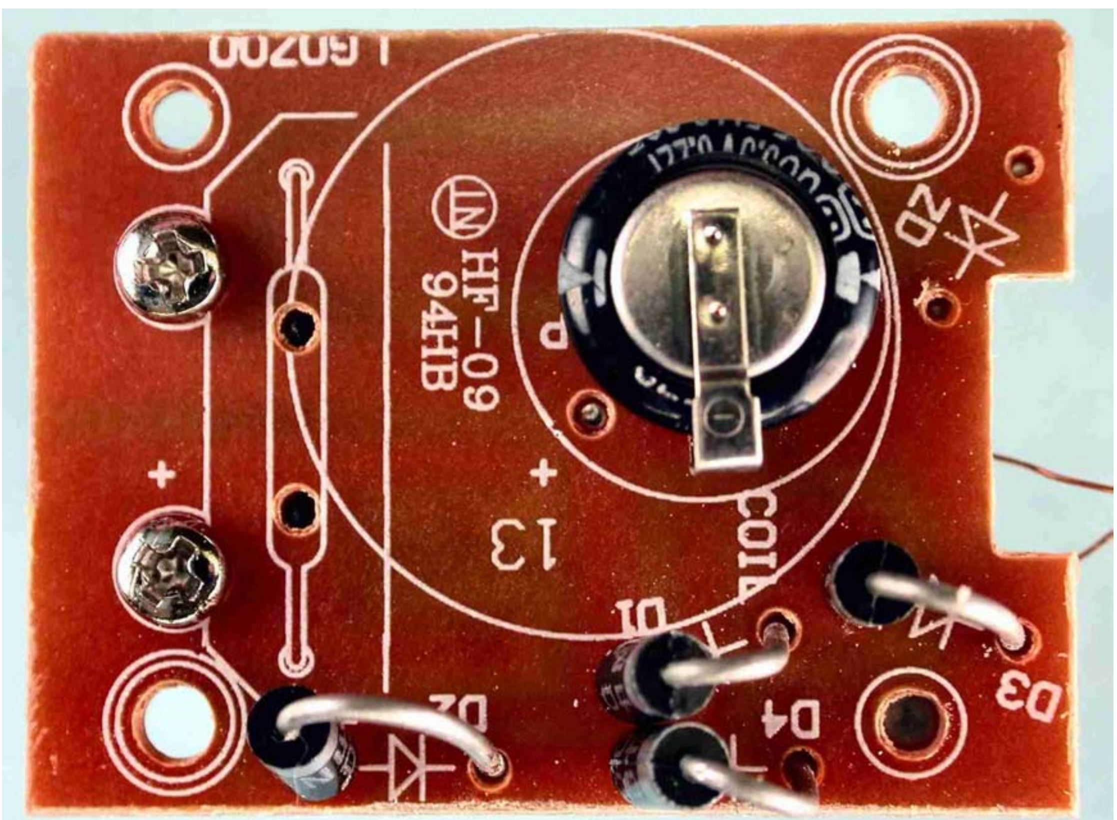


Fig. 16 — Enlarged view of the component side of the circuit board. The components are inside the housing.

The photographs provide an idea of the physical layout of the FFL. The electrical schematic is shown in figure 17 below. Reference designations A through E will be used to describe the operation of the circuit.

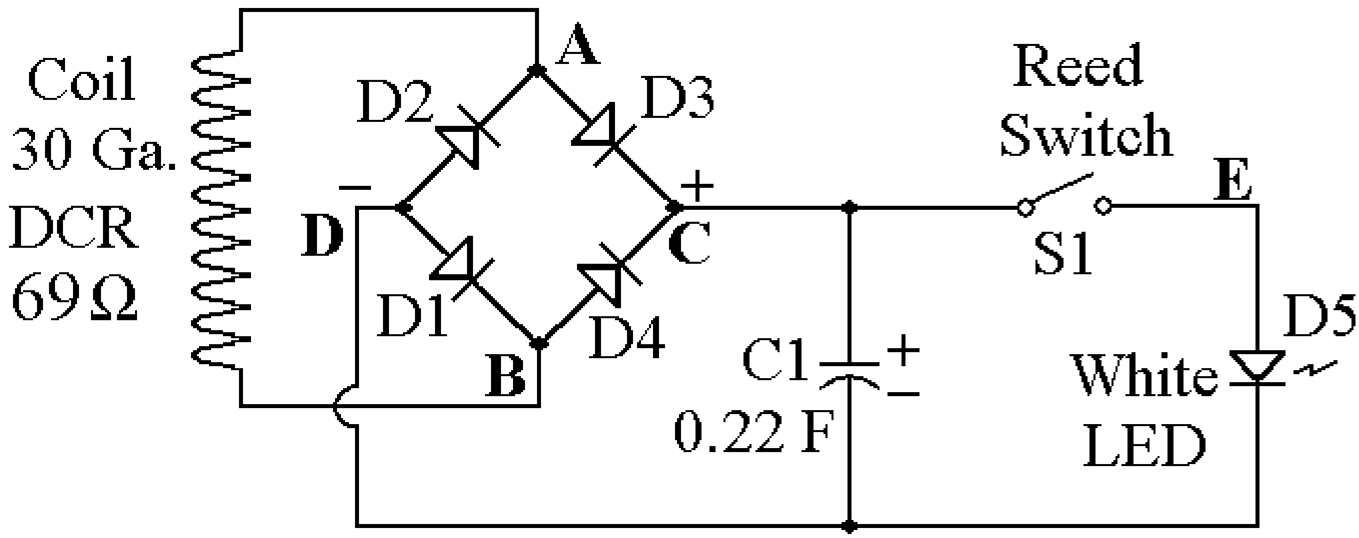


Fig. 17 — Schematic of the model 422-M Forever Flashlight. Letters A-E identify the various portions of the circuit for reference in the text. The same designations have been added to an enlarged view of figure 15 shown as figure 20, which will serve as a "working" guide to probe the circuit board to make measurements.

As the magnet slides through the coil, a bipolar pulse is generated proportional to the strength of the magnet, the speed it passes through the coil, and the number of turns in the coil. When the magnet slides back another pulse is generated of the opposite "polarity." See additional details in part E - Coil Form. The pulses of alternating positive and negative values appear across the coil at points A & B. Diodes D1 through D4 form a full wave bridge rectifier circuit. When A is positive diodes D3 and D1 conduct and diodes D2 and D4 do not conduct. A diode has the property of conducting current in one direction only.

When the polarity is reversed, Diodes D2 and D4 conduct and diodes D1 and D3 block current flow. Each diode has about 0.6 volts across it when it is conducting. The total voltage drop of a bridge rectifier is about 1.2 volts. Another important characteristic of a bridge rectifier is that it provides isolation from the circuits that follow. The purpose of the bridge is to charge capacitor C1. Once charged we certainly wouldn't want the coil to discharge it. The capacitor, C1, is often called a super capacitor and it may be seen up close in figure 18.

Fig. 18 — Super capacitor label.

The capacitance is 0.22 farads at a rated voltage of 5.5 volts. This voltage is important because exceeding it could degrade the capacitor and it may no longer hold a charge and the flashlight is no longer able to work. If you are tempted to really shake it, don't. A farad is a unit of charge, which will provide one ampere of current for one second into one ohm, or 1 watt second. Most capacitors are measured in microfarads or one millionth of a farad. Once charged, the reed switch, S1, is turned on and the LED is powered by the capacitor.

LED's have a very non-linear voltage current curve and work best at about 2.5 to 3 volts. At higher voltages their effective resistance is very low and some means, usually a series resistor, is used to limit the current to a safe value. There is no series resistor in this circuit. The LED, however, does not appear to be severely over driven (very bright). Perhaps the LED itself has current limiting. Is the extra bond wire shown in figure 5 used for this purpose? This is left for the reader to research.

If you examine the circuit board photo in figure 20 you will notice five solder pads with "X" marked on them. These are unused holes that have filled with solder during the solder process. The corresponding A through E points shown on the schematic are also indicated. The capacitor traces are identified with the C1- and C1+ designations. The LED has long leads that pass through channels in the reed switch standoff. They are soldered at their ends even though there are pads on the far left edge of the board. This is another clue to indicate that this is a multifunction circuit board (used for several different models). Point E indicates a trace that is not visible because of this standoff. It connects to the upper LED lead under the standoff.

If you study figure 16, which is the other side of the circuit board, you will notice several designations for components that are not used. One is a zener diode, ZD, which appears to be intended to clamp the voltage applied to the capacitor to protect it. Could a properly designed coil and bumper system work well enough to eliminate the Zener clamp diode? Reduced parts count is always a design goal.

Another designation is the circles around the capacitor. Are there models that use a larger capacitor? Commercial sizes up to 1 Farad are readily available. This would provide five times the storage - and increase LED operation time.

The diodes are conventional standard garden-variety general-purpose rectifier diodes of the 4000 series, 1N4001. This version has a 50-volt peak repetitive reverse voltage specification and a 5-microampere leakage current at room temperature. They are cheaper than a complete bridge in a single package, which would also require less assembly time.

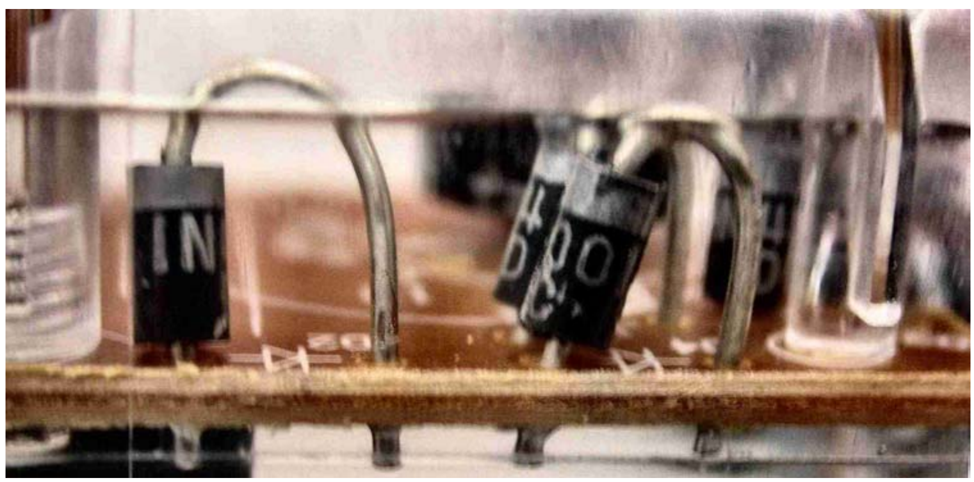


Fig. 19 — Bridge diodes, 4 - 1N4001, 50 V PRRV, 5 μA leakage at 25°C.

The circuit is very simple to keep the parts count to a minimum. Products like this usually evolve over time as additional engineering effort is made to further refine the circuits and component selection to reduce costs and improve performance.

The most expensive part of this product design is the tooling required for the case and inner housing. These are large plastic molds that require a substantial investment. Assembly labor is cheap in china so the circuit board assembly operations are minimal. All of the electrical components except the coil (and perhaps the reed switch standoff) are off the shelf items. The magnet is another fairly expensive part.

C - Front Bumper: The front bumper and the rear bumper are the same. They are part of the mechanical parts that are tooled especially for the product. The purpose is to absorb the energy of the moving magnet. You will notice the shape of the bumper shown in figure 21. The magnet is quite heavy and it is human nature to want to shake the FFL very hard - even thought the instructions say not to. The material is similar to a hard rubber.

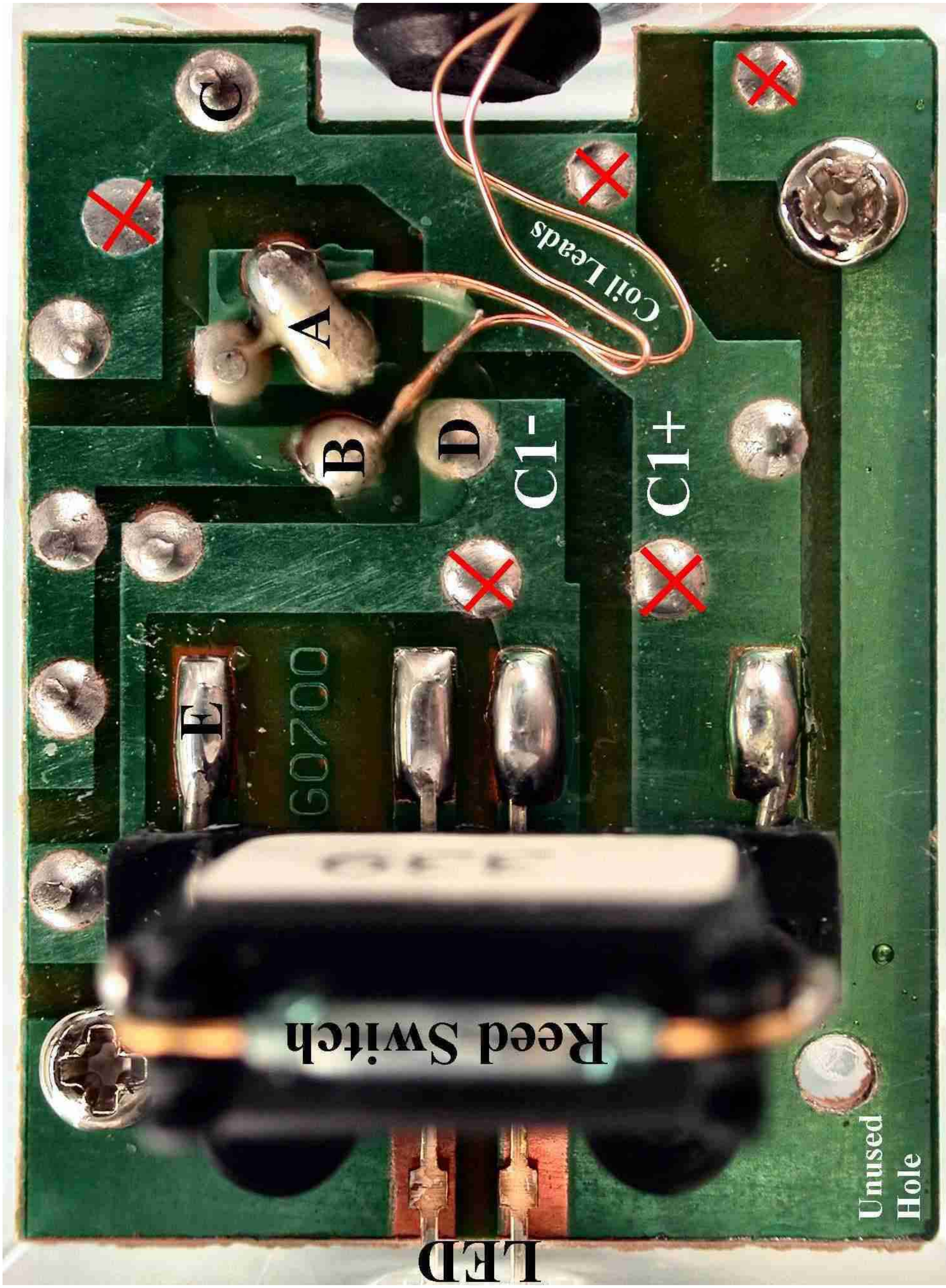


Fig. 20 - Circuit board with schematic designations added to make test and measurements easier.

D - Magnet: The magnet is the most powerful type available. It is a Neodymium Iron Boron, NdFeB or simply, NIB magnet. Neodymium Iron Boron (and Samarium Cobalt) magnets are generally known as rare earth magnets since their compounds come from the rare earth or Lanthanoid series of the periodic table of the elements. They were developed in the 1970's and 1980's. Refer to www.magnetsales.com for additional very general information on magnets.

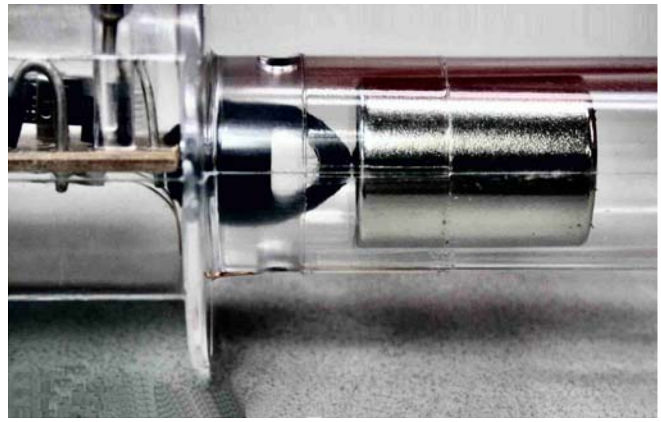


Fig. 21 — Magnet against front bumper.

You may easily remove the magnet to "play" with it (see the rear bumper section). It is strong enough to attract metal objects with such force that you could pinch your skin. You must be very careful in handling it. The same force could chip objects and flying pieces may get in your eyes. Exercise caution. This is not a joke. Do not bring the magnet to the surface of a TV or computer monitor. You may move it moderately fast with the thickness of your fingers between the magnet and the glass surface to demonstrate the effect. DO NOT HOLD THE MAGNET ON THE SURFACE. It will put a permanent dark "mark" on the screen.

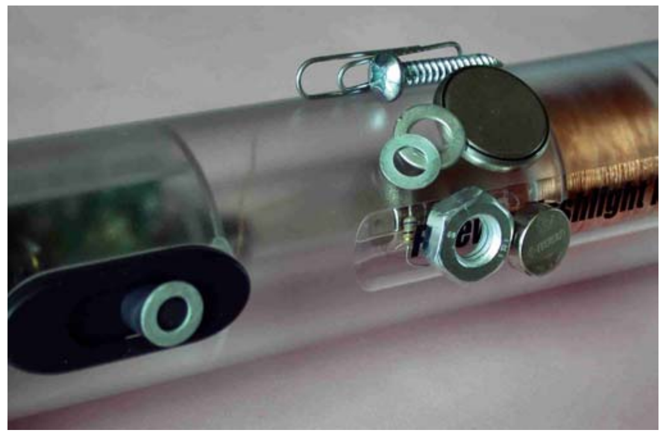


Fig. 22 — Typical objects the FFL magnet attracts.

Even normal use of the FFL may cause small objects to be attracted to it even though the magnet is over 8 mm (0.315") from the "outside world." See example in figure 22. The washer on the slide "switch" shows the reed switch magnet.

The magnet measurements are:

Diameter. . . . . . . 15 mm (0.587")
Length. . . . . 20 mm (0.787")
Weight. . . . . 53.0 gr. (1.87 oz.)

E - Coil Form: The heart of the FFL system is the coil (and magnet). One advantage of sliding the magnet back and forth is that it only requires one hand. A cranking generator would require either two hands or that the generator be secure in some way. This not convenient for a personal portable device like a flashlight. *See page 13.*

Fig. 23 — FFL coil form width wound with 30 Ga. wire.

The coil is wound directly on the inner housing using 30 Ga. 0.254 mm (0.01", 10 mils) magnet wire. Refer to the coil form drawing on the next page to follow the calculations used to estimate the coil resistance.

Turns per layer: 0.984/0.01" = 98.4 t/l, use **99 turns per layer**.
Thickness of layers: 0.335 - 0.078" = 0.257". 0.257/0.01 = 25.7, use **26 coil layers**.
Total turns = 26 x 99 = use **2,574 turns**.

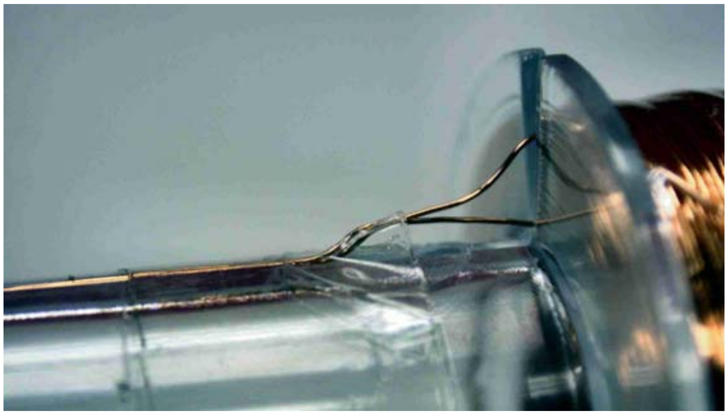


Fig. 24 — Coil leads taped into inner housing groove.

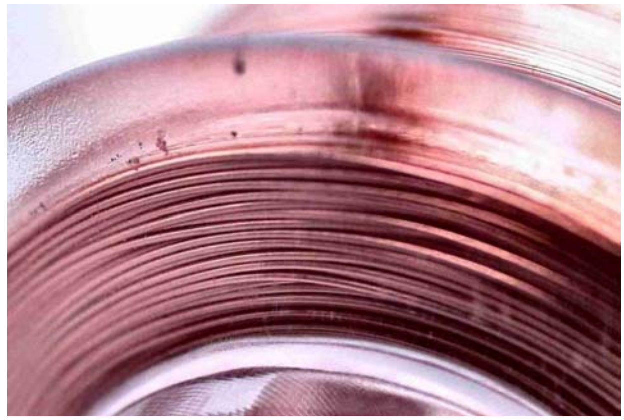
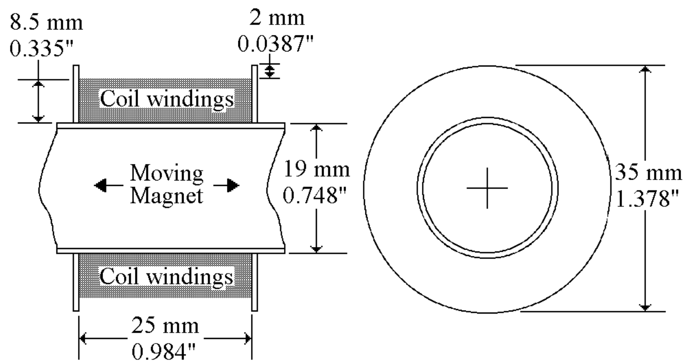


Fig. 25 — Coil wire layers allow counting turns.

Outer turn diameter = 1,378 - 2(0.0787) = 1.2206"
Inner turn diameter = 0.748"
Average turn diameter = (1.2206 + 0.0787)/2 =
<u>0.984" average turn diameter</u>.
Average turn length = C =πD = 3.1415 * 0.984 =
<u>3.092" average turn length</u>.
Total length of 2,574 turns = 2,574 * 3.092 =
7,959" or **<u>663 total winding feet</u>**.
Extimated coil resistance = 663 * 0.1037 =
<u>68.8 Ω</u>.



Forever Flashlight Coil Form Measurements

A measurement check using four different meter types provided values from 50 to 63 ohms. Using a DC supply and passing 10.1 MA current with a measured voltage of 0.700 volts makes the resistance 69.3 ohms. Why were the various meter types inaccurate? They use either AC or pulse waveforms to make the measurement. The coil has a substantial amount of inductance and capacitance (reactive components) and this caused the error. Using an LRC meter the inductance was measured as 61 mH and the capacitance at 398 nF using 120 HZ.

The coil was disconnected from the circuit board and an oscilloscope was connected (no load) to see the voltage. A 68-ohm resistor was also connected across the coil. Figures 26 and 27 show the results.

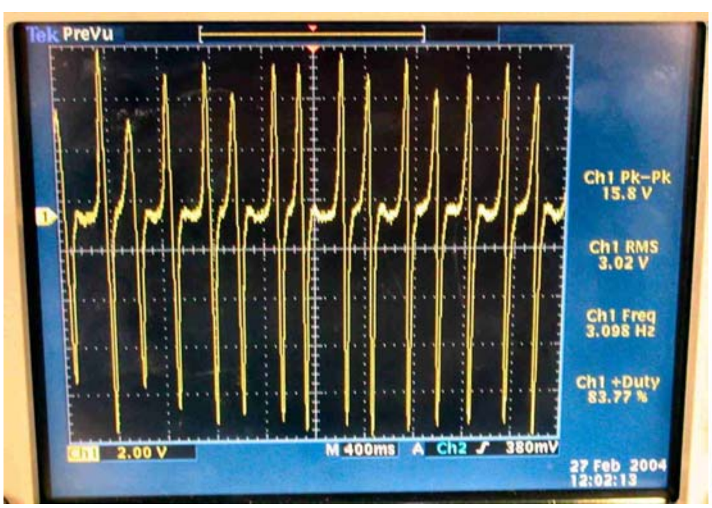


Fig. 26 — Waveforms of voltage generated by magnet being shook in the coil - no load on coil.

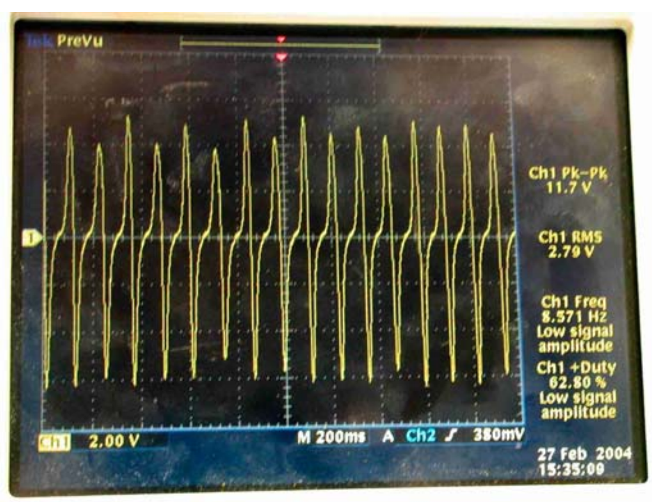


Fig. 27 — Coil voltage with a 68-ohm resistor load. See text for waveform discussion.

The waveforms will be dependent on a wide range of factors such as the rate the magnet passes through the coil, the time it takes to stop and reverse, the strength of the magnet, the inductance and capacitance of the coil, and the number of turns in the coil.

The LED used needs about 3 volts for a minimum brightness so the capacitor must be charged to a voltage greater than three volts. This is why it takes longer for the first charge of the capacitor. The capacitor will take all the energy the coil provides as long as the voltage does not exceed it's rating of 5.5 volts. If you study figures 26 and 27 you will note that when a load is placed on the coil its voltage drops. A typically charged capacitor measures on the order of 4 plus volts. If, however, you monitor the voltage cross the capacitor you will find that it "wonders around" a great deal. Once it settles down it may remain steady for long periods of time. This is measured with the LED turned off. If you shake the magnet the voltage will rise with each shake and it may go to 6 volts or higher quite easily. I even went as high as 8 volts before stopping. If you stop shaking when you hit six plus volts it settles down to about 4.7 volts in 15 seconds. When the voltage hits 8 volts it settled down to about 5.3 volts. After 12.5 hours the voltage was 3.86 volts and the LED worked just fine. The LED "glowed" for over 20 minutes and the voltage dropped to 2.52 volts. There was just a very faint light at a voltage of 2.39 volts. The voltage was still slightly above 2 volts after 72 hours. The meaning of capacitive exponential voltage decay is clearly illustrated - as is low leakage.

F - Rear Bumper: The Rear bumper snaps into a plastic retainer as I have shown in figures 28, 29 and 30. Note the three notches in the retainer as shown best in figure 29. These notches must be aligned when the inner housing is slid into the FFL case to align the slide "switch" magnet. Use a No. 0 Philips screwdriver for this task. Use caution when "playing" with the magnet. Note the shake sound after assembling. If the black lens retainer is not very tight the inner housing will move. I didn't want to tighten mine to the original tightness so I placed a small piece of rubber in the bottom to take up the slack. I can then open my FFL to demonstrate it easily and I don't crush the "O" ring.

Fig. 28 — Rear bumper with black retainer.

Fig. 29 — Retainer is held with two screws.

Fig. 30 — Remove retainer to slide magnet out.

If you examine figure 28 (and figures 10 and 21) you will notice two holes in the inner housing at the magnet travel extremes near each bumper. These allow air to flow freely as the magnet zips back and fourth. If you cover these holes with tape you will notice a significant difference in the speed of the magnet and the sound it makes when you shake it. I didn't have time to record the waveform traces to see how they are affected by this damping.

Final Observations And Conclusions: The exploration of the Forever Flashlight was a fun and interesting project. It provided an opportunity to explore several technical areas and learn a little about flashlights. This is more fun than just exploring the Internet.

Opening the FFL required that it be held in a vice (wrapped with a cloth to avoid nicks) and turning the lens retainer ring with a channel lock pliers. When the product is assembled the internal housing is held tightly in place by the "O" ring pressure. You will notice a different sound when shaking the FFL if you don't retighten the retainer ring fully.

I would like to see a smaller version, one that could fit into your pocket. Another consideration is a magnet lock to retain the magnet. This could also be part of a magnetic shield that would avoid the picking up of small ferromagnetic metal objects (as shown in figure 22). I held the inner housing of the FFL LED up to slide the magnet to the bottom. I then put a nut (Fig. 22) on the magnet. The magnet was easily held in place so it wouldn't rattle around while I was making tests and measurements on the FFL.

A friend pointed out the fact that the Excalibur is not the only shake powered flashlight, and not the first. Check the following URL's for additional information.

http://www.nightstar1.com/

http://www.nightstar-flashlight.com/

http://www.nightstar2flashlight.com/comp.htm

These URL's give a great deal of technical information on a very similar product. Perhaps Excalibur is licensing the design from Applied Innovative Technologies Inc. They list two patents and compare their product with "others" including the Forever Flashlight. I also found - I haven't made a serious search - a product called Mr. Dynamo at: http://www.myspace.com.tw/

This is a hand squeeze LED flashlight that gives 5 minutes of light with 15 seconds of squeezing. If I find one - the URL is a wholesaler (see Global Sources URL below) and 3,000 pieces is their minimum order @ $3.30 each - I will explore that one as well. I have a Russian made similar model (all metal) that powers an incandescent bulb.

I also had intended to include a few ideas for modifying the FFL (and making more electrical measurements) but that will have to wait for an Appendix B. At least this description will give the curious reader some technical information about the product. Appendix A is the Excalibur FFL Instruction sheet.

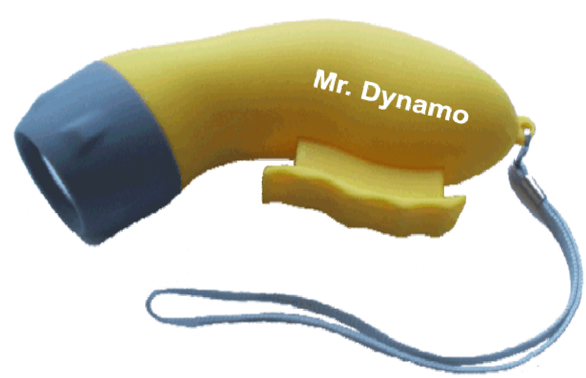


Fig. 31 — Hand squeezed LED flashlight.

http://www.globalsources.com/am/article_id/9000000048123/page/showarticle?action=GetArticle

Two questions remain unanswered. (1) Is the voltage (>8V) applied to the capacitor (5.5 Volt rating) an issue? Perhaps the 5.5-volt rating is conservative, or it self heals under these conditions. (2) Is the LED being over stressed without a current limiting resistor? Perhaps this is built into the LED itself.

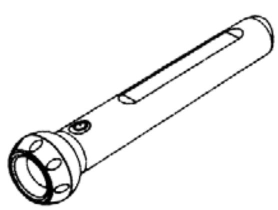
Comments and additions welcome. March '04 Richard J. Nelson, rjnelson@aemf.org R1

Appendix A - FFL Instruction sheet

Below is the FFL instruction sheet (1/2 sheet, folded). The four pages are arranged in page order

Excalibur Electronics

Forever Flashlight



Model 422-M

Congratulations on your purchase of Excalibur Electronics' Forever Flashlight, the flashlight that *never* lets you down. At home, in the car, in your camper or boat or storm emergency kit, Forever Flashlight is always ready, even if you haven't used or checked it for years!

Features

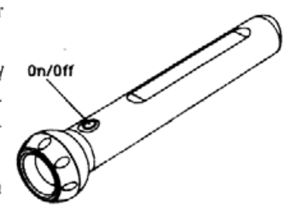
- Rechargeable capacitor
- Super-bright LED visible for over a mile
- Zero maintenance required
- Floats on water
- Water and weatherproof

Charging the Forever Flashlight

Your Forever Flashlight never needs a battery. It is charged by shaking the unit. For the best results, follow these steps in charging:

1. Turn the unit off. (See figure at right.)

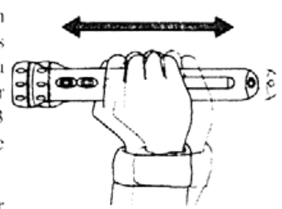
2. Hold the unit parallel to the ground and shake it with moderate force about two to three times per second. (See diagram at right.)



NOTE: *Shaking the unit too hard may cause damage. Shaking vertically won't charge the unit efficiently.*

Forever Flashlight will provide you

2



with up to five minutes of light when charged for 30 seconds. If the unit is completely drained of energy, you should give the unit 90 shakes—or about 30 seconds of shaking at 3 shakes per second—to fully charge its capacitor.

During prolonged use, the Forever Flash should be turned off and shaken for 10 to 15 seconds every two to three minutes.

Cautions

The Forever Flashlight generates a strong magnetic field that surrounds it. Keep the unit at least one foot away from medical devices, computers, magnetic storage media, or other devices such as:

- Pacemakers
- Cassette tapes
- Computer disks
- Video tapes
- Credit cards
- Televisions
- Any device with a cathode ray tube (CRT)

Do NOT attempt to remove the Light Emitting Diode (LED) or any internal part.

Special Care & Safety

- Avoid rough handling such as bumping or dropping.
- Use only warm water and mild soap to clean the housing.
- Rinse with fresh water.
- Clean the lens with glass-cleaning products.
- Do not use petroleum distillates (such as gasoline or kerosene) or solvents such as acetone to clean any part of the Forever Flash.

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Limited One-Year Warranty

EXCALIBUR ELECTRONICS, INC., warrants to the original consumer that its products are free from any electrical or mechanical defects for a period of ONE YEAR from the date of purchase. If any such defect is discovered within the warranty period, EXCALIBUR ELECTRONICS, INC., will repair or replace the unit free of charge upon receipt of the unit, shipped postage prepaid and insured to the factory address shown below.

The warranty covers normal consumer use and does not cover damage that occurs in shipment or failure that results from alterations, accident, misuse, abuse, neglect, wear and tear, inadequate maintenance, commercial use, or unreasonable use of the unit. Removal of the top panel voids all warranties. This warranty does not cover cost of repairs made or attempted outside of the factory.

Any applicable implied warranties, including warranties of merchantability and fitness, are hereby limited to ONE YEAR from the date of purchase. Consequential or incidental damages resulting from a breach of any applicable express or implied warranties are hereby excluded. Some states do not allow limitations on the duration of implied warranties and do not allow exclusion of incidental or consequential damages, so the above limitations and exclusions in these instances may not apply.

The only authorized service center in the United States is:

Excalibur Electronics, Inc.
13755 SW 119th Ave
Miami, Florida 33186 U.S.A.

Phone: 305.477.8080
Fax: 305.477.9516

www.ExcaliburElectronics.com

Ship the unit carefully packed, preferably in the original carton, and send it prepaid and adequately insured. Include a letter, detailing the complaint and including your daytime telephone number, inside the shipping carton.

If your warranty has expired and you want an estimated fee for service, write to the above address, specifying the model and the problem.

DO NOT SEND YOUR UNIT WITHOUT RECEIVING AN ESTIMATE FOR SERVICING. WE CANNOT STORE YOUR UNIT!

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