

An Improved Fingernail Trimmer

by

Alexander Lawrence Allen

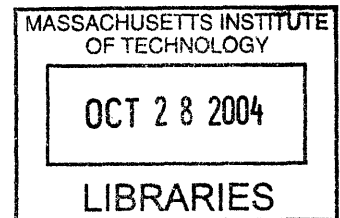
Submitted to the Department of Mechanical Engineering in Partial Fulfillment of the
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Abstract

The purpose of this undergraduate thesis project was to design and develop a first iteration prototype fingernail trimming device. The device was designed to make nail trimming easier, especially for people with poor eyesight, limited hand coordination or problems with hand steadiness. As such the device was designed to meet several design requirements such as improved nail trimming over conventional mechanical devices, simple mechanical design, safety, ease of use and a marketable construction.

Thesis Supervisor: Ernest E. Blanco

Title: Adjunct Professor

Acknowledgements

I would like to thank my wife for putting up with me and my son while I worked on this project and all of my other projects at MIT. I would like to thank my son and his resistance to getting his fingernails clipped inspiring me to do this project. I would like to thank Professor Blanco for helping me to hash out the ideas, for his great enthusiasm for the project and providing me with various parts needed to build it. Lastly I would like to thank John Diccaccio and the MIT NRL machine shop for letting me use their machines, steal their materials and their training as a machinist.

Table of Contents

1	Introduction	5
2	Background	5
3	Design	6
3.1	Design Requirements	6
3.2	Design Characteristics	7
4	Development and Testing	8
4.1	Parts	8
4.2	First Build	9
4.3	Second Build	10
4.3.1	Machining the Motor Housing	10
4.3.2	Attaching the Trimming Wheel to the Motor Shaft	13
4.3.3	Wiring the Motor, Battery and Switch	16
4.3.4	Assembling the Second Build	17
4.4	The Third Build	18
4.4.1	Correcting the Second Builds Problems	18
4.4.2	Securing the Switch, Battery Housing and Depth Guide to the Motor Housing	19
5	Results	20
6	Discussion and Conclusion	21

List of Figures

4-1	Parts	8
4-2	Motor casing, machined and new bulb housing	9
4-3 and 4-4	Different views of the first build	9
4-5	Solid Model of Motor Housing	11
4-6	Dimensions of Motor Housing	11
4-7	Solid Model of Faceplate	13
4-8	Solid Model of Assembled Motor Housing	13
4-9	Saw-toothed Dremel® tool	14
4-10 and 4-11	Different views of the grinding wheel	15
4-12	Maglite® with bulb partially withdrawn	16
4-13	Maglite® with bulb connections replaced with wires	16
4-14	Bottom view of second build showing the wiring	16
4-15	Schematic of wiring circuit	16
4-16, 4-17 and 4-18	Different views of the second build	17
4-19	Side view of completed prototype	19
4-20	Top view of completed prototype	20
5-1	Prototype in action	21
6-1	Artistic model of marketable device	22

1 Introduction

The purpose of this thesis project is to design a better fingernail trimmer. The original idea for this project was to produce a safer nail trimmer for babies. That idea developed after the birth of my son and the difficulties of trimming his small nails with conventional, albeit smaller, nail clippers and files. After discussions with Prof. Ernesto Blanco, we realized the value of such a device for adults and the greater market for an adult version. The focus of the project subsequently shifted to designing a better fingernail trimmer for adults. While a better infant nail trimmer is still needed, an improved adult nail trimmer is more feasible.

Grooming fingernails can involve many aspects, but this project focuses on developing a device to trim nail growth. While a more complicated device, with more functions, aimed at producing a manicured fingernail would be useful; it is not the intent of this project to produce a device that complicated. This project focuses on the consumer use of keeping nails trimmed to a short and clean length.

2 Background

Simple mechanical nail trimmers have existed for quite some time; however these devices have several deficiencies that warrant the development of an improved fingernail trimming device. The two main types of mechanical fingernail trimmers are files and clippers. Files require excessive manual labor in order to remove growth, and so tend to be used only for shaping. Fingernail clippers leave sharp points and edges that often require additional filing and attention. Clippers also lack depth guides allowing users to cut too deep, possibly injuring the sensitive quick. Furthermore, fingernail clippers require a degree of steadiness, two-hand coordination and visual acuity making their use difficult for people with tremors, limited mobility, or poor eyesight. The device could also have medical applications where patients with reduced mobility after such things as car accidents must remain bedridden for a long time. A safer device would allow nurses to trim the patients' nails more easily and with less risk of cutting the patient.

The idea of an improved nail trimmer is also not a new idea with patents for such devices dating back as far as 1926¹. Previous devices were not successful, as indicated by the lack of such devices in the market place². Some previous devices tended to be so large or cumbersome they required table mounting³. Earlier motorized devices required a wall outlet or several large batteries, making them heavy or limiting their usefulness. Other devices lacked safety guards leaving exposed grinding wheels that required more coordination than manual clippers to prevent injury⁴.

The shortcomings of current devices, as well as the attempts of other designers to overcome these shortcomings, indicate a market opportunity. Furthermore, the success of specialty electronics stores, such as Brookstone⁵ and the Sharper Image⁶, suggests a demand for improved grooming devices.

3 Design

3.1 Design Requirements

The design requirements for an improved nail clipper can be garnered from the shortcomings of current and past instruments. Safety and ease of use are the most important user requirements. The main functional requirement is that the instrument must trim adult fingernails nearly as quickly as nail clippers. The economical requirement is that the device should be simple to build to keep the price less than a few times the price of fancy nail clippers: roughly \$50-\$100. Furthermore, this device is not intended to be used as a complete fingernail manicuring device, but rather a simple fingernail trimmer. From these specifications the following requirements can be extracted:

¹ Pflanzter, A. "Safety Nail Cleaning and Filing Device," Patent Number 1,604,720. Oct. 26, 1926

² While there are a wide range of professional and consumer manicuring devices meant to be used to shape and smooth finger and toe nails, no simple nail trimming devices were identified during my research.

³ Rosenbloom; William J. "Electric manicure," Patent Number 4,117,854. Oct. 3, 1978

⁴ Tyshenko, Jr.; John A. "Fingernail Grooming Device," Patent Number 6,050,270. April 18, 2000

⁵ Brookstone's Company Info web page indicates sales of \$350 millions dollars a year selling specialty consumer products

http://www.brookstone.com/service/company_info.asp?company_info_id=233&cmid=fr_cmpinfo

⁶ "Sharper Image Corporation is a multichannel specialty retailer that is renowned as a leading source of innovative new products." The Sharper Image had \$540 million of revenue selling "new, innovative, high-quality products that make life better and more enjoyable." http://www.corporate-ir.net/ireye/ir_site.shtml?ticker=shrp&script=700

- Must trim fingernail quickly and effectively
- Needs to include depth guides, wheel guards and other characteristics to prevent possible injury to sensitive tissue under nail
- Must be light and simply shaped in order to be held comfortably in one hand
- Needs a simple design to keep costs low
- Should be intuitive to use
- Does not need to be overly complicated: it only needs to trim fingernail growth to an acceptable length

3.2 Design Characteristics

From the design requirements, several characteristics were identified. The device would be battery powered, preferably by small AAA size batteries or smaller. A small high-speed motor would spin a small cutting or grinding wheel. A thin depth guide would extend beyond the edge of the trimming wheel that would be positioned under the nail. The guide would align the nail with the device, limit the depth of the trimming and prevent non-fingernail tissue from coming into contact with the trimming wheel. From these characteristics several sketches were developed to guide the production of a rudimentary device.

4 Development and Testing

4.1 Parts

Parts were chosen to meet the design characteristics with the least amount of actual manufacturing. Maglite® Solitaires® (See Figure #) were identified as good battery housings because their anodized aluminum casing is strong, aesthetically pleasing and lightweight. Dremel® cutting and grinding bits provided a good match for the size and type of trimming wheels needed. Prof. Blanco provided a small 1.5-3V-hobby motor⁷ originally from Radio Shack® (See Figure 4-1) to spin the trimming wheel and a simple push-button switch.

⁷ Similar but not identical to this newer motor design
<http://www.radioshack.com/product.asp?catalog%5Fname=CTLG&product%5Fid=273-223>

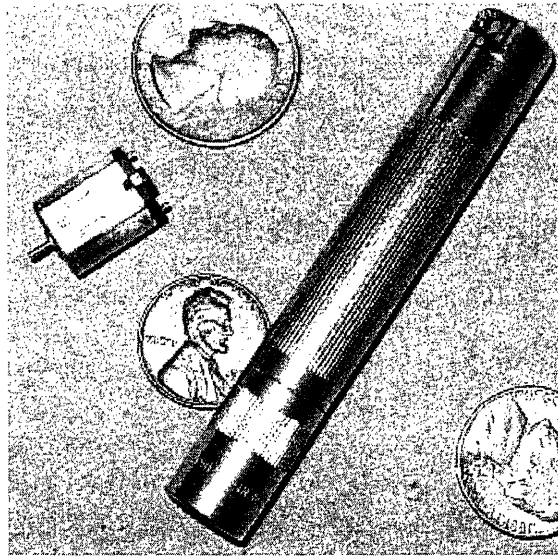


Figure 4-1 Maglite® Solitaire and hobby motor before machining

4.2 First Build

The goal of the first build was to produce a non-functioning device with size, shape and weight matching some of the early sketches. This early device allowed the basic size and geometry of a nail trimmer to be studied without having to spend too much time producing a working model. The initial design was built by machining the bulb housing of a Maglite® Solitaire® (See Figure 4-2) to accept and hold the motor. A piece of ¼" aluminum rod was machined to approximate a casing for the motor.

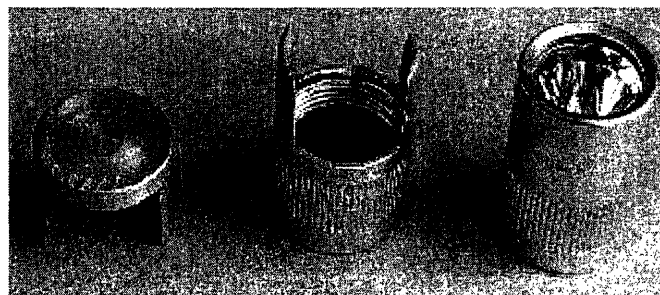
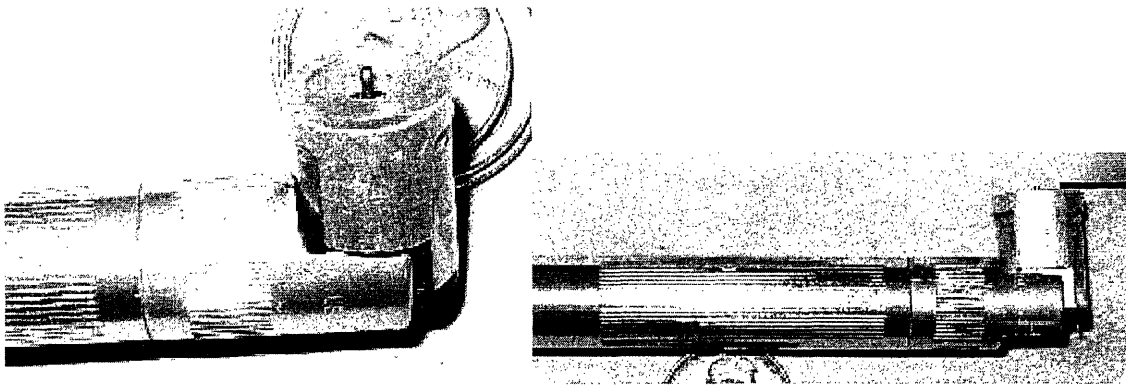


Figure 4-2 First production parts, from left to right: the motor casing, machined bulb housing to hold the motor and new bulb housing

When these pieces were assembled the device looked pretty close to a marketable fingernail trimmer (See Figures 4-3 and 4-4).



Figures 4-3 and 4-4 Different views of the first build. Note the black line in Figure 4-4 indicating the position of the user's fingernail during trimming.

The first build revealed a few points of improvement. The position of the fingernail was inverted so that the depth guide pressed against the quick under the fingernail with the rest of the finger above the device. Also, the trimming wheel needed to be lowered to be in-line with the battery housing, to prevent the trimming wheel from angling away from the fingernail when users pressed it against their fingers.

The first build was pretty close to a functional device. The build could be made to function by wiring the motor and the switch, attaching the grinding wheel and depth guide plate and covering the whole thing in a thermo-formed plastic case. However, it became apparent that it would be advantageous to machine a more solid housing to hold the motor. The bulb housing held the motor in place with a tight fit as opposed to a more stable mechanical assembly. Furthermore, the depth guide would have to be supported by the battery housing and then extend forward, which would allow too much flex in the depth guide. A stiffer housing would allow the depth guide to be more securely attached, adding more rigidity to the device and insuring the depth guide was held at the correct position relative to the trimming wheel.

4.3 Second Build

The second build encompassed three main tasks: machining a sturdier motor housing, attaching a trimming wheel to the motor shaft and wiring the motor shaft to the switch and battery.

4.3.1 Machining the Motor Housing

The motor housing was machined to provide a more stable platform to attach the different pieces of the device. The motor housing had several requirements to be met:

- It needed to attach firmly to the battery housing.
- The motor needed to be held securely in the housing, to prevent rotation, horizontal displacement, but still be adjustable vertically to allow the trimming wheel to be properly aligned with the depth guide.
- Provide a secure attachment point to keep the depth guide steady.
- Have a location opposite the trimming wheel side for the switch to be placed.
- Require minimal machining yet remain aesthetically pleasing and structurally sound.

From these design requirements a two-piece housing was designed. The larger piece serves as the main housing and the shorter piece acts as face plate holding the motor in its channel. Aluminum was chosen for its machine-ability, lightweight, availability and match with the battery housing. Two pieces, 1.3" and 0.2" in length were cut from a 1" square rod of Aluminum.

The larger piece was then shaped into a 0.7" thick 'L', with a 1.3" by 0.6" leg, and a 1" by 0.55" foot. A 0.458" diameter hole was drilled through the center of the leg providing clearance for the neck of the battery housing. Perpendicular to this hole, a 0.40" channel was milled through the center of the foot. The channel was milled 0.475" deep to match the width of the motor. A small hole was drilled through the corner of the hole and channel to allow a wire to extend to the switch pad, while a small channel drilled along one of the inner corners of channel allowed the other wire to extend to the end of the motor. Four 2-56 holes were tapped in the front corners of the piece to accept the screws that attach the faceplate (see Figures 4-5 and 4-6).

The faceplate was a flat 0.13" thick 1" by 0.7" plate with a 0.05" raised ridge running its length (see Figure 4-7). The ridge lined up with the channel to hold the motor in place. Four 0.1" in diameter holes were drilled in its corners to match the holes in the housing piece.

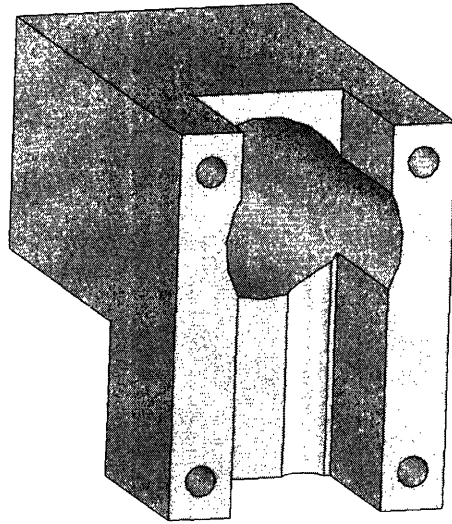
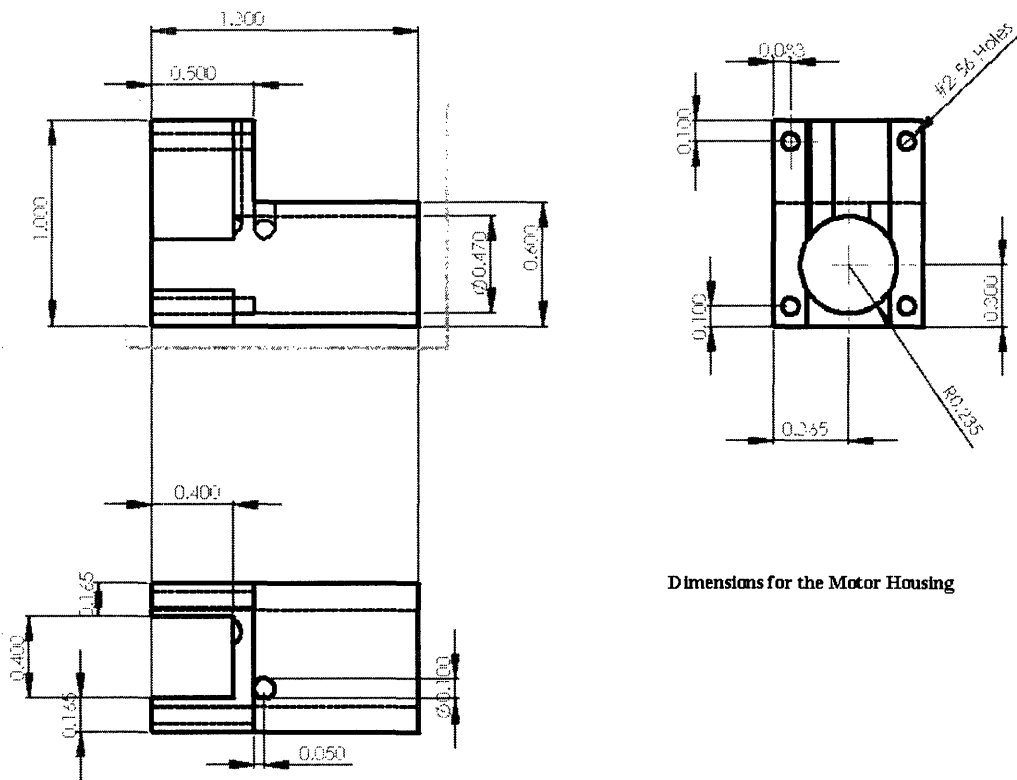


Figure 4-5 Solid Model of Motor Housing.



Dimensions for the Motor Housing

Figure 4-6 Dimensions of the motor housing.

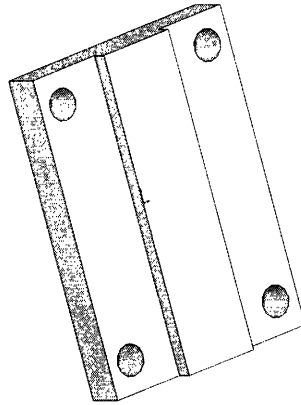


Figure 4-7 Solid Model of Faceplate

The faceplate holds the motor in place, but when the screws are loosened the motor can be moved higher or lower in the channel (see Figure 4-8).

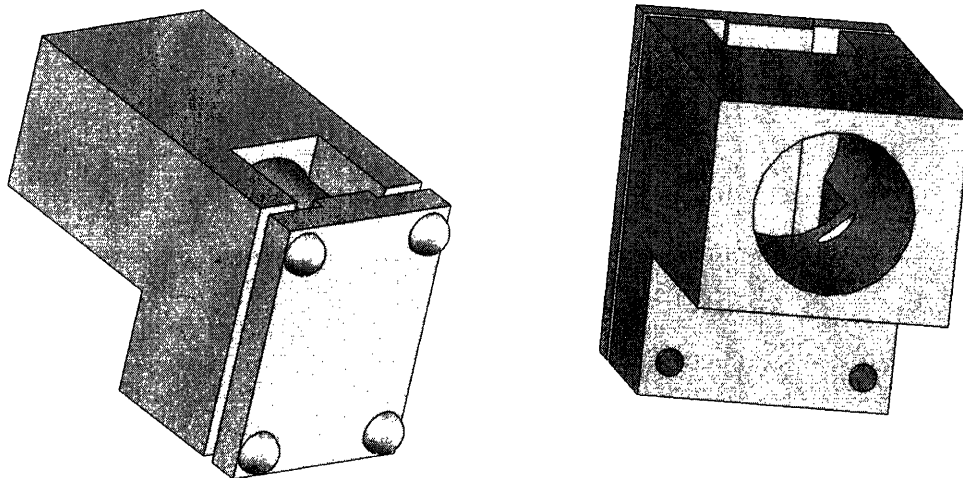


Figure 4-8 Front and back views of the assembled motor housing and face plate solid modeling.

4.3.2 Attaching the Trimming Wheel to the Motor Shaft

Attaching the trimming wheel to the motor shaft proved to be one of the more difficult tasks in this project. The small size of the motor and the Dremel® bits, combined with the strength of the bits versus the fragility of the motor led to a difficult machining task. The motor's plastic bearings prevented the amount of force required for even a close press fit, so that the bit had to be glued to the shaft. However, too much glue and the

shaft could possibly be glued to the motor. Also the shapes of the bits create a problem: the grinding stone is wider than the shaft, preventing the lathe collet from reaching the shaft.

The first choice for the trimming wheel was a saw-toothed blade (see Figure 4-9) because it trimmed the nail the fastest while producing the least amount of heat. However, this bit was composed of hardened steel, and so could not be readily machined. The method of machining this bit required annealing the metal to make it softer machining it, and then rehardening it. The softening and hardening process would probably dull the cutting edges, reducing the cutters effectiveness.

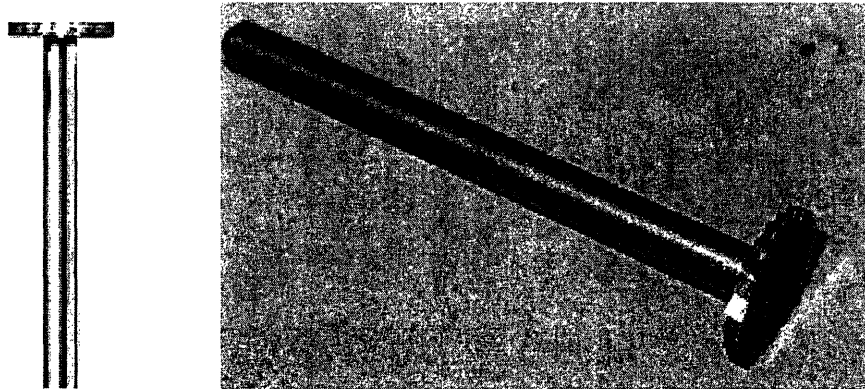
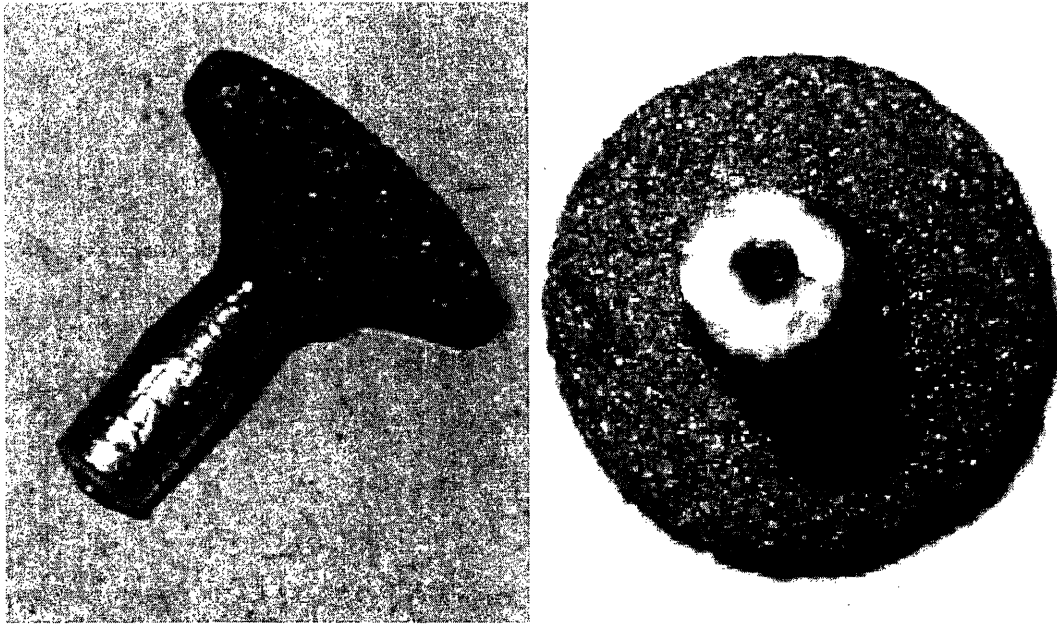


Figure 4-9 Saw-toothed Dremel® bit made out of hardened steel.

The second best trimming wheel was an aluminum oxide grindstone (see Figure 4-10 and 4-11). This grindstone was glued to an aluminum shaft. The shaft had to be held in the lathe, but the grindstone got in the way of the chuck. To get around this dilemma I thought it would be possible to thread the shaft and then screw that into a threaded rod with a diameter larger than the stone. In the search for the right die it was noticed that the shaft fit nicely in a #8 die. The shaft was then cut as short as possible while still leaving enough material to be grabbed by the die and lather. The die, with the shaft screwed into it, was then placed in the lathe chuck. The hole for the shaft was then drilled through the center. However, this hole proved to be too tight and the hole had to be widened. The next size larger drill hole was still too tight, so that the hole had to be drilled a third time.

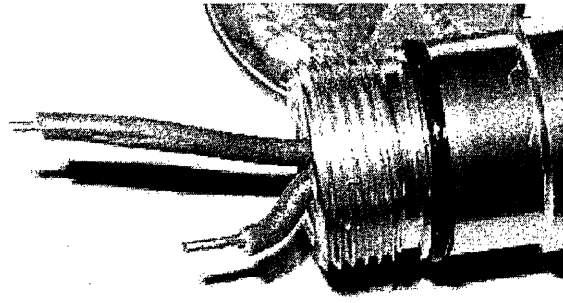
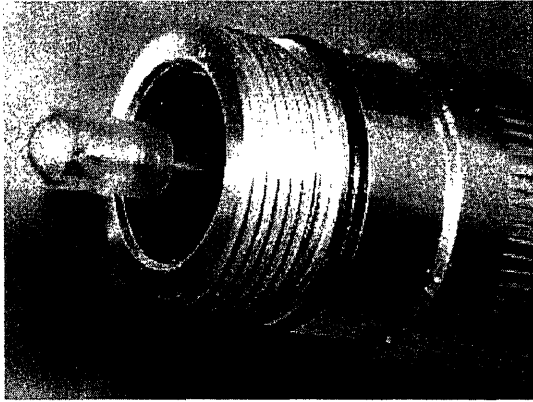
The last hole proved to be too large so the motor shaft glued was off center in the grindstone shaft causing it to spin eccentrically. The eccentricity caused the stone to grind against the motor housing. This was corrected by raising the stone above the channel. Also, because the grinding wheels shaft was longer than anticipated when designing the motor housing the grinding wheel extended beyond the top of the housing when the motor was at the bottom of the channel.



Figures 4-10 and 4-11 Aluminum Oxide grindstone side view and looking down at the shaft hole. Note the glue mounting the stone to the shaft, which is the shortened, final length in this photo. Also note the thread marks on the shaft left by the die. While difficult to see in Figure 4-11, the motor shaft was glued off center in the hole.

4.3.3 Wiring the Motor, Battery and Switch

Wiring the motor to the battery and the switch was a relatively simple process. To wire the battery the light bulb was removed and stripped 22-gauge electrical wire inserted in the bulbs connection sockets (see Figures 4-12 and 4-13).



Figures 4-12 and 4-13 Figure 4-12 shows the battery housing with the light bulb partially withdrawn exposing its connection wires. Figure 4-13 shows the bulb connection wires replaced with 22-gauge electrical wire.

One wire was then fed through the hole in the motor housing to the switch platform and soldered to the switch. The other wire was fed up along the small wire channel in the motor channel and soldered to one of the motor terminals. Another wire was then connected from the other motor terminal to the other switch (see Figure 4-14 and 4-15).

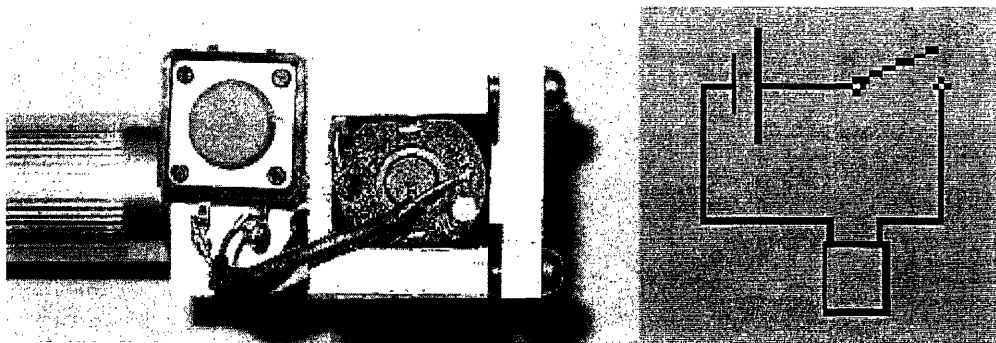


Figure 4-14 and 4-15. Figure 4-14 is the bottom of second build showing the wire paths from up inside the motor housing to the motor, then from the other motor terminal to the switch and from the other switch connection back down into the motor housing and to the battery connection. Figure 4-15 shows the basic circuit path of the wiring.

4.3.4 Assembling the Second Build

The three machining steps completed, the second build was then assembled (see Figures 4-16, 4-17 and 4-18).

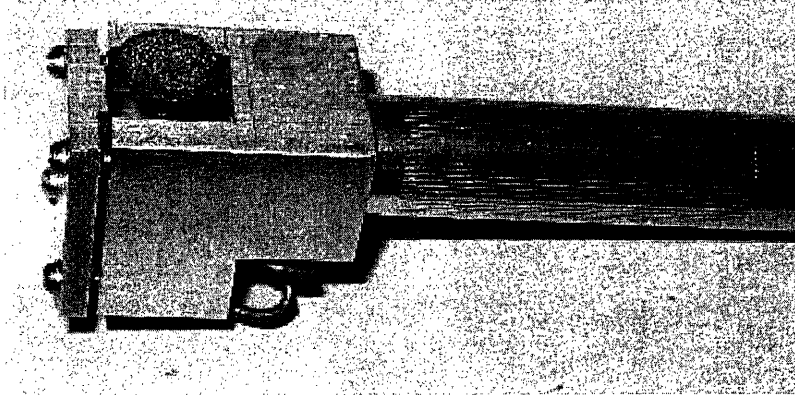


Figure 4-16 Top view of second build.

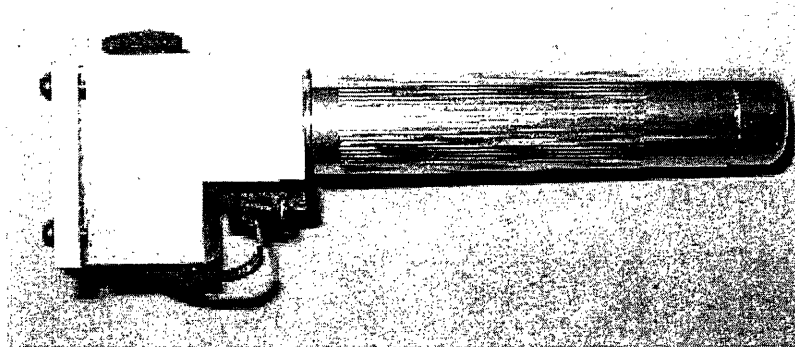


Figure 4-17 Side view of second build.

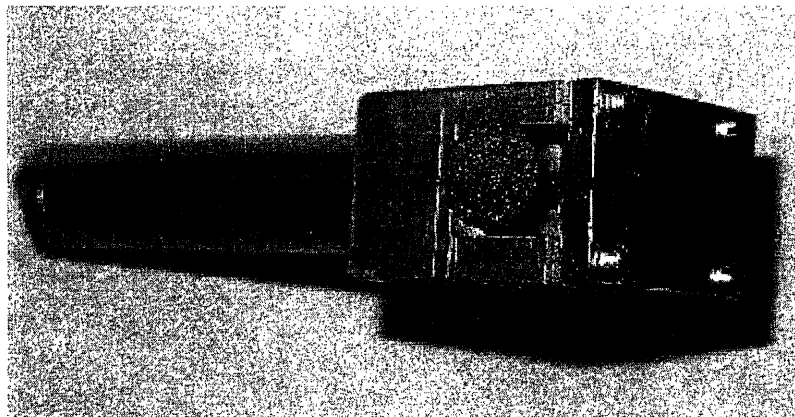


Figure 4-18 Front view of second build.

The second build functioned well until a few problems were encountered. A motor terminal broke off at the motor edge preventing the wire from being resoldered. As already mentioned the grinding stone spun eccentrically. Lastly the glue holding the grinding wheel to the motor shaft sheared and the grinding wheel came off. Before these problems occurred the device functioned as intended, except for the grinding wheel sticking out above the motor channel. The device ground away fingernail for a minute or so, until the glue sheared.

4.4 The Third Build

After the problems with the second build, a third build was required. This third and final build corrected the problems of the second build, attached the depth guide plate, the switch and the battery housing to the motor housing.

4.4.1 Correcting the Second Builds Problems

The problems of the second build were corrected by replacing the motor with a new one, redrilling and attaching the grind wheel, shaping the eccentricity out of the grind wheel and wiring the new motor to the switch and battery. The source of the grind wheels eccentricity was checked by placing the shaft of the grind wheel in a 1/8" collet and spinning it in a lathe. The wheel spun true, but an important discover was made when taking the piece out of the collet: it had been crushed slightly. It was then realized that the grinding wheel shaft could be crimped onto the motor shaft. The glue was then drilled out of the hole with a bit slightly larger than the motor shaft and the grinding wheel placed on the new motor's shaft. Then the grinding wheel's shaft was crimped tightly around the motor's shaft. When the motor was placed in the motor channel and rewired, the grinding wheel spun with less eccentricity than before. A dressing stone was then pressed against the side of the grind stone as it was spun by the motor to shape the stone until there was no more eccentricity. The top of the stone was then pressed against the dressing stone until it was flattened.

4.4.2 Securing the Switch, the Battery Housing and the Depth Guide to the Motor Housing

With final wiring and machining completed the switch and the battery housing were super glued to the motor housing. Prior to this they were loosely held in place by the wiring.

Then the depth guide was fashioned and super glued in place. The depth guide was composed of a soft tin-plated metal. One edge of the guide was folded back on itself and hammered flat, providing a smooth edge that fits nicely under fingernails against the quick. Ideally the depth guide would lie flat on the motor housing with the grinding stone right below the guide. However, the grinding wheel extended beyond the motor channel above the top of the motor housing because of the difficulties encountered in mounting the grinding wheel. The guide plate had to be bent up and over the top of the grinding wheel. The shape of the bend was developed using pliers and trial and error. When the guide plate was in the correct shape, it was glued to the motor housing so that the front edge of the guide plate extended 1-2 millimeters beyond the front edge of the grind stone. With the guide plate glued in place, the device was complete (see Figures 4-19 and 4-20).

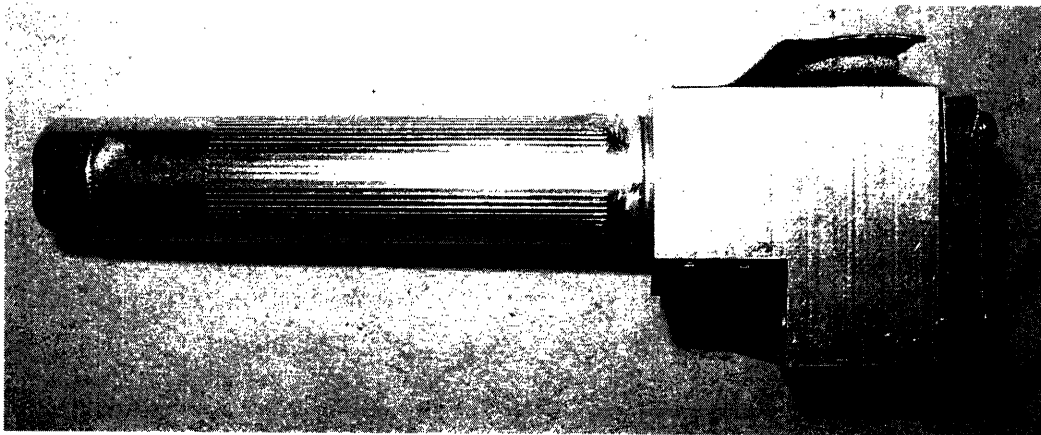


Figure 4-19 Side view of the completed prototype nail trimming device.

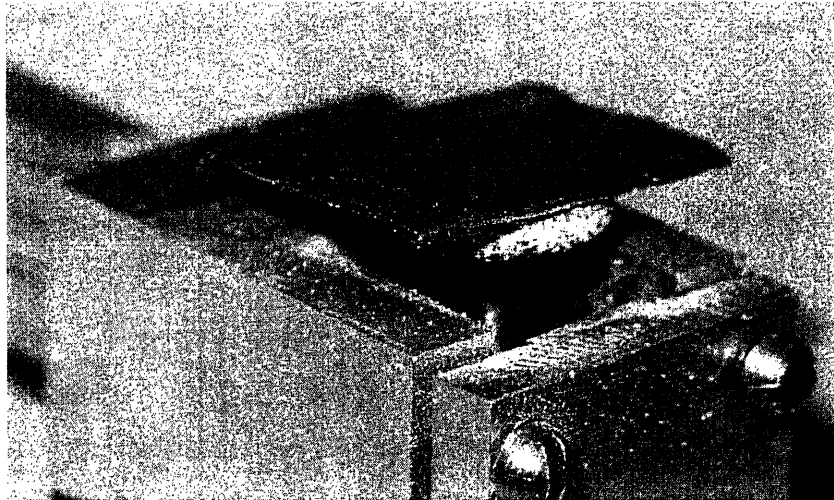


Figure 4-20 Top angle view of the grind wheel and depth guide. Notice the fingernail dust around the top of the motor channel, the small overhang of the depth guide in front of the grinding wheel and the rounded front edge of the guide as a result of bending and hammering the plate.

5 Results

The prototype device meets all of the design requirements except the first and most important. The combination of the motor being too weak and the voltage supply too small results in not enough torque to quickly grind away fingernail. Trimming my thumb nail took close to 2 minutes. Despite this problem, the device is well suited to perform as a nail trimmer. The weight, general shape and function match the design requirements for a marketable device (see Figure 5-1). The depth guide, though not ideally positioned, fits well underneath the fingernail, preventing the grind wheel from hitting the quick while allowing the fingernail to be trimmed.

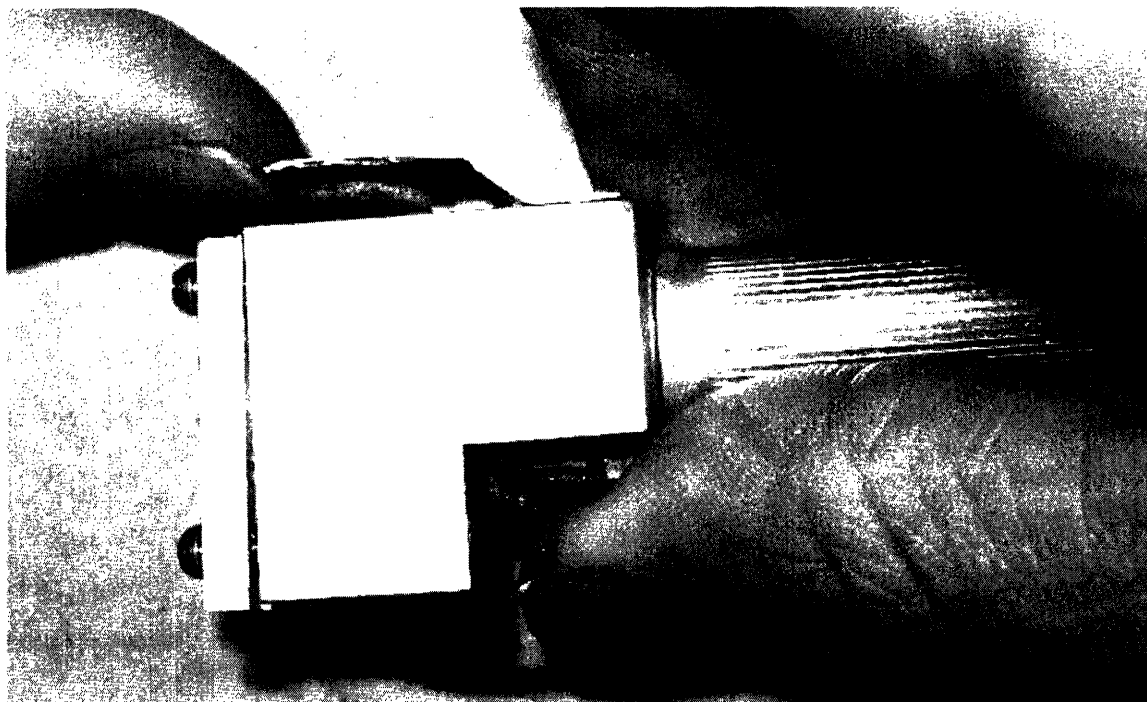


Figure 5-1 The prototype improved fingernail trimmer in action, grinding away at my thumbnail.

6 Discussion and Conclusion

The prototype device proves the concept to be valid, but fails to meet all of the expectations. The device could be greatly improved with a stronger motor and a higher voltage battery. These improvements would not significantly affect the basic characteristics of the device, just its rate of fingernail trimming. The entire device could be composed of low-cost plastic or for a sharper look, anodized aluminum. A marketable device would benefit from more rounded corners and edges giving the device a sleeker look (see Figure 6-1). The wiring would also be completely encompassed within the device, as opposed to the exposed wires of the prototype.

The saw-toothed wheel identified as a good fingernail trimmer during testing is still an appealing trimming wheel. While the saw-toothed wheel trimmed faster than the grinder wheel, it left a flat cut with almost sharp edges that would probably need to be filed. This problem could be alleviated by designing a wheel with the teeth curved in the shape of 'u' so that the trimmer would produce a rounded cut with smoother edges.

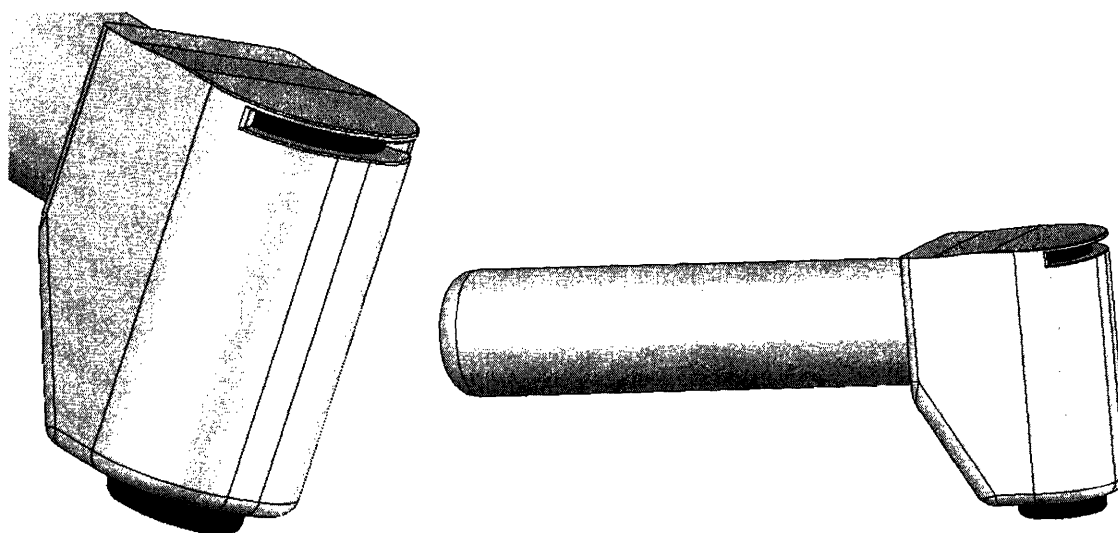


Figure 6-1 Artistic modeling of a more marketable device.

Once a more robust fingernail device is produced it will probably become evident that the device needs some sort of fingernail dust gathering compartment. A chute leading to a container could be set up similar to the bag on a lawn mower. This could be incorporated as part of the housing, so that the dust gathered in the compartment and could be emptied into the trash.

The main differences between this device and other patents and devices designed to groom fingernails is the focus on simple fingernail growth removal and the recent advent of small powerful motors and better batteries. With a little more design work and some successful marketing this device could become a successful product. The next step for this device to reach the marketplace is the production of a faster grinding device to trim fingernail growth in a more timely fashion. Once that is accomplished the device could then be patented and then marketed to production companies. Another venue could be to start a small corporation to begin the process of producing, marketing and selling the product with a long term goal of raising the interest of a larger corporation and then selling the rights to the product to them.