Crystal Characters Per Minute (CCPM): Human Energy Harvesting

Fei Liu
Parsons Design and Technology Department
New York, NY
fei.fei2liu@gmail.com

Fig.1

ABSTRACT
This paper describes the breadth and depth of experiments conducted in creating the human energy harvesting system Crystal Characters Per Minute (CCPM). It explains the inspirations, implications and technical execution of the system.

ABSTRACT
Sustainability; DIY; Science experiment; Energy harvesting; Keyboard design; Piezoelectricity

INTRODUCTION
CCPM, as shown in Fig 1., is an exploration in parasitic energy harvesting through the act of typing on a keyboard. People spend increasingly more time on the computer across the globe, using the keyboard as one of the main modes of interaction between the rest of the world and themselves. CCPM proposes an alternative way of looking at the way we use the devices we rely on the most. The energy we expend and "waste" can be harvested and stored into a battery for later use. The battery can then be treated as a designed object which has its own narrative and sentimental purposes.

INCEPTION
The first inkling to harvest human energy came while reading *In The Bubble: Designing in a Complex World* by John Thackara where he discusses the un-sustainability of our current outlook on technology. I wanted to work with an object that was immediately relatable and had a low-barrier threshold for people in my demographic. The idea to use piezoelectric materials with the keyboard and harvest the human power of typing arose from that goal.

Human Energy Harvesting
Energy harvesting is a term used to describe the process by which electric power could be extracted from ambient sources. This technique has its drawbacks in that its sources are usually only capable of generating low and unpredictable amounts of power.[4] This paper focuses primarily on harvesting energy generated by human motion. Other methods include harvesting from natural light, radio-frequency radiation and thermal gradients.

Currently, applications already exist which use motion and vibration to generate enough power for devices with varying power needs. The most successful of these involves the use of rotary motor mechanisms, whether they be taking advantage of pedal power on a bicycle, or attached to a pair of sneakers. So far, harvesting a useful amount of energy from these motions have required the mounting of uncomfortable and clunky mechanisms onto pre-existing consumer items such as shoes.[2] On the other end of the spectrum, piezoelectric materials can be used to generate just enough energy to run low-power and ultra low-power devices such as hearing aids, lasers and micro controllers. Harvesting from ambient vibration requires working with the piezoelectricity of different natural materials. An initial goal was to try and explore systems which allowed their users to generate small amounts of power naturally and slowly. I did not want them to change how they interacted with the device.

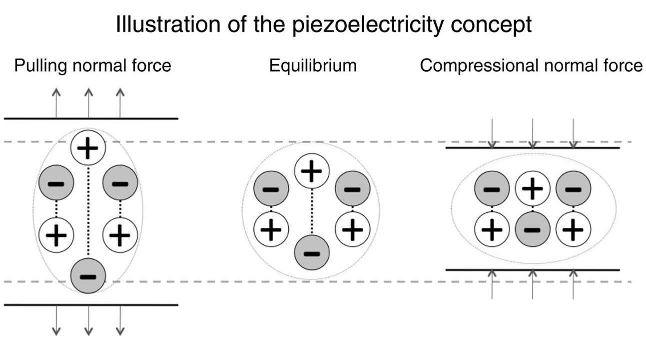

Fig. 2

Piezoelectricity and Rochelle Salt

The phenomenon of piezoelectricity was first noticed by the Curie brothers in the 1880s. It was discovered that certain materials such as crystals, bone, and silk produce electric charge when squeezed or struck (Fig. 2). Since then the technology has used in applications ranging from the facilitation of pressure sensing applications to microphones. [3] I chose to test the piezoelectric effect with potassium sodium tartrate, also known as Rochelle salt. Instead of working with lab-tested and commercially produced piezo ceramics and film tabs, I decided to try and grow my own Rochelle salt crystals for the first time. Rochelle salt has material limitations which makes it hard to incorporate into electronics because of the following reasons: it generates a low AC current which would need to be converted to DC current before it could be used, the crystal as salt which has a liquid state if its environment is hot and humid enough, and the crystal itself with has certain polarities in its orientation.

The first issue became the main focus of my project. From my research, solving it requires a highly intricate and calculated circuit (Fig. 3) which will rectify the AC current and turn it into DC current, store the energy, set a threshold for when the energy can be released, and finally, release it when the previous demands have been met.

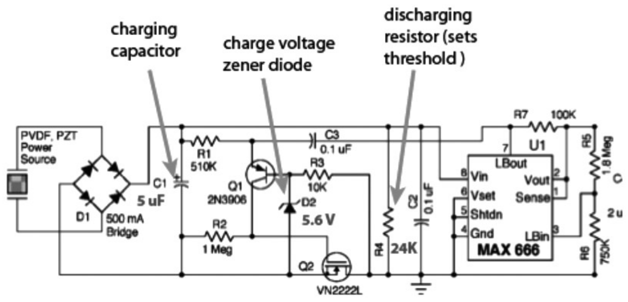

Fig. 3[7]

Interfacing the Keyboard

The keyboard is one of the three only ways we communicate with computers. The mastery of this interface is stressed at a young age from elementary school onwards, and is even a qualification for securing a career. The speed and accuracy in which it can be operated has become the symbol of efficiency. Interfacing the keyboard with piezoelectric materials presents a consistent and dependable way of getting the intended results. Skilled typists average at about 120 words per minute while the average office-worker may be fine with 60-70. Fast typing on a QWERTY keyboard may generate up to 19 milliwatts per second[1]. Multiply that by the number of hours the average office worker spends in front of the computer, and there may be just enough power to be harvested, stored, and used to power everyday devices. For a certain sedentary demographic, there is no other surface that the body comes into repeated contact with more than our keyboards- if we are to shorten our lifespans by sitting and typing too much, why not create some alternative batteries at the same time?

Keyboards using piezoelectricity which currently exist in the market attempt only to address the issue of durability and extreme weather conditions. Stern Switches creates unibody keyboards which use piezoelectric materials for the tops of keys and pressure applied onto them to register each letter (Fig. 4).

Fig. 4

I propose a system which uses uniformly cut piezoelectric crystal keys to replace the plastic ones on our keyboards (Fig. 5). The system will utilize a circuit similar to Jie Qi's (Fig. 3) and collects typing power and stores it in some form of an external battery. The decision to store the electricity in a battery instead of expending it to power itself is because keyboards already receive power from the main computer unit and cannot have no use independent of it. Lights mounted beneath the keys will blink intermittently to alert the user to how much energy has been stored. When the battery has filled up, the system will perform a sort of swan song light-show and the user will then know that they can detach the external battery and start using it.

Fig. 5

UNDERTAKING

The following is a list of steps which I took to actualize CCPM.

- Grow Rochelle salt
- Test Rochelle salt with oscilloscope
- Convert AC voltage generated by Rochelle salt to DC current
- Mount Rochelle salt crystals on silicone keyboard cover

Crystal Keyscape

I used tutorials found online to grow 7 batches of Rochelle salt with soda ash, Cream of Tartar, distilled water, and coffee filters. These items can be found in most grocery and art stores. Each batch creates roughly 10-15 large crystals which could then be broken down into 3-4 smaller crystals each. The first two attempts were unsuccessful due to usage of a cheaper substitute of Cream of Tartar, and an over-sped up cooling process. The boiled down mixture of soda ash and Cream of Tartar needs to cool down very incrementally in room temperature in order for the crystals to form a strong bond. Once the crystals are formed overnight in a

Fig. 6

cool place, it is important to drain out the liquid they sit in and let them dry and harden up. The longer the crystals are left alone, the stronger they become.

I started by testing if the crystals I grew could get a reading on the oscilloscope. After testing, it seemed that they could generate around 1-2 volts of AC current. I still did not know how to "plug in" my crystals and get them connecting to any circuitry. I decided to use the crystals in an alternative aesthetic model, to show what a keyboard of crystals could look like (Fig.6). This model strayed from my original goal to keep the user interaction with the device unchanged and intact but provided an interesting different perspective on the hidden technology I was trying to implement.

Galvanic cell batteries

At this point, I still had not figured out how to convert the ac current of my salt crystals to usable DC current. After much research on the topic, I found some examples which used crystals directly as battery cells[7]. I decided to try t method to melt Epsom salt with the Rochelle salt crystals I already made to create a battery[6]. This type of battery uses the electrochemical reaction between two types of metals and a "salt bridge" between them to transfer and keep the electricity cycling through the cell. As the metals oxidize, one metal which goes through the process faster gives electrons to the other metal. I tried using both aluminum and magnesium ribbon as the faster-oxidizing metal, and copper as the slower. Copper and aluminum or magnesium were placed on either side of troughs in an ice cube tray and the melted Epsom and Rochelle salt mixture poured into the concave area. Within 4-5 hours the salt will have hardened again and would be ready for transportation and testing with a multimeter. Depending on the choice of metal and the size of the cell, two of them linked up in series could reach a standing DC voltage of up to 1 volt at around 0.05-0.2 milliAmps (Fig.7). They were enough to light up a red LED dimly. Including Rochelle salt in this mixture insured the retaining of the piezoelectric effect. Deliberate striking of the cells created a spike of 0.02-0.03 milliAmps over the course of a few seconds. This timing is perfect for a slow to moderate typer and proves that these galvanic cells could potentially be used in substitute of plastic keys. I then etched letters into the salt cells to demonstrate how they could look as keyboard keys (Fig. 8).

Fig. 7

Fig. 8

CONCLUSION

CCPM is an attempt to explore the methods of harvesting power from human energy, specifically from a device we use so frequently to complete our tasks. The system proposes that its users re-consider electricity as a tangible and poetic element of our daily lives, and as an element which we can control and effect. CCPM tries to imbue life into electricity by bringing its creation to the fore. Further development of the system includes connecting the crystals to an energy harvesting circuit and testing and finessing those parameters. The same practice could then be re-configured for touch applications and devices to tap into our interactions with smart screen-based objects.

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