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MASTER OF FINE ARTS

ECO BATTERY EXCHANGE SYSTEM

By

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PREFACE

Two years ago when I started my student life in the United States, I encountered many things which were different from my home country, Thailand. The most interesting thing for me was the concept of recycling.
In Thailand, people do not know much about recycling, but rather, the concept of re-use is their strategy. Although that habit can slow down the solid waste accumulation in some areas, it is not enough for a big city like Bangkok. After I kept my eyes on the thoughtful campaign of Americans, I realized the great benefit of recycling. Specifically, that it is not only a partial solution for the solid waste problem, but it can also save energy and money from the production of new materials.

Before beginning this project, I thought about a consumer device which would make recycling easier and more effective than ever before. The question was what object I should consider, and how broad it should be.

Finally, I decided upon the problem of disposing dry cell batteries from a household was an interesting and suitable issue for my thesis project.

In this modern age, electrical products are a fact of everyday life. Children love to play with their automatic toys. Teenagers usually go with a Walkman. And, modern business-men note appointments on digital memos. Since these products cannot reach hard wired electrical systems, portable, pocket-size, or wireless devices need to use energy from an electrochemical power source or dry cell batteries.

All kinds of batteries produces direct current from electrochemical reaction. Some elements in the dry cell can become toxic waste. The majority of heavy metals (lead, arsenic, zinc, cadmium, copper, and mercury) in the household waste stream come from batteries. Heavy metals are toxic and have recently been associated with neurological illness and cancer (Gasbarro 1991, 42).

P R E F A C E

By today's technology, dry cell batteries cannot be recycled. All consumer dry cell batteries are tightly sealed to protect them from chemical leaking which may cause fire or explosion. Therefore, only a small part of a used cell is able to be reclaimed by re-grinding. As the result, reclaiming is not commercially practical.

The initial idea for this thesis project was to: 1) respond to the increasing demand of using batteries in the future, and 2) stop the spread of chemical waste from dry batteries. One possible solution to these problems would be an efficient battery dispenser/ collector system.

INTRODUCTION

INTRODUCTION

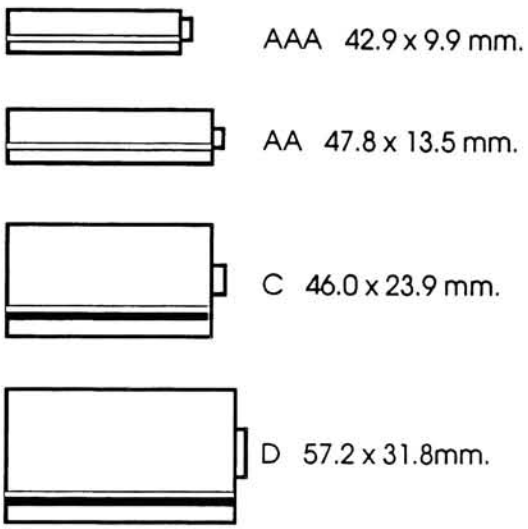


Fig. 1-1 Four Popular Sizes of Batteries

Perhaps the best known of all batteries are dry cell batteries, which are used in a wide variety of portable equipment. The majority of this class of batteries, which are easily found in supermarkets and general stores, are the standard sized cylindrical single cells shown in fig.1-1 . To explain my concept more easily, these four standard batteries will be the principle objects of this project.

There are two types of dry cell batteries: primary batteries and secondary batteries. Primary batteries are disposable. The chemical reaction that supplies current in this kind of battery cannot be reversed. Conversely, secondary batteries are rechargeable, because the chemical reaction which produces electrical energy can be reversed by recharging with a battery recharger (Gasbarro 1991, 42).

Those two categories of batteries have different advantages and disadvantages in both marketing and performance.

Currently, disposable batteries are more popular than rechargeables. Users can easily find disposable batteries in any super-market or convenience store, but they can get rechargeable batteries only from specialty stores. The problem with the rechargeable battery market is that rechargeables are higher priced and poorly promoted and marketed.

Battery sizes	Two-battery pack prices ($)	
	GE rechargeable	DURACELL disposable
D	6.93	1.88
C	6.93	1.88
AA	5.00	1.22
AAA	5.83	1.68

Table 1 Consumer Prices from WAL-MART, Rochester, NY, 92

The initial purchase prices are the easiest numbers to compare between the two products. From table 1, a rechargeable may cost about 3.5 times the price of the same size throw-away battery, plus $10-25 for a battery charger. On the other hand, this situation would be completely reversed if a buyer considered the prices in term of a whole life. According to the advertisement on the back of a GE® rechargeables' package, a pair of their batteries can replace up to 150 pairs of throw-away batteries. This means it is far more economical to replace disposable batteries with rechargeables (see fig.1-2).

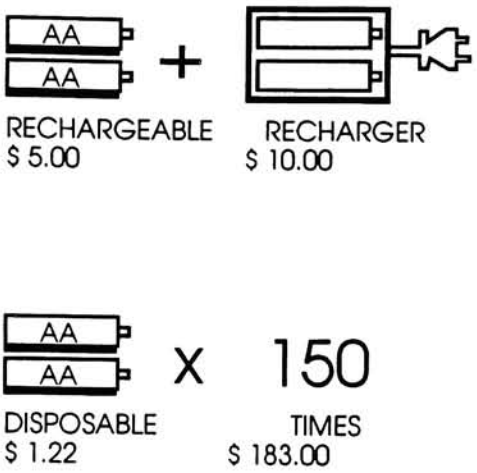


Fig. 1-2 Rechargeable vs. Non-rechargeable

Promotion, another important marketing tool, can create a good image for products, and educate its consumers. Since I have been in the U.S.A., I have rarely seen ads for rechargeable batteries either on televisions or in magazines. In contrast, I always see many good advertising campaigns for the two major disposable alkaline battery brands, Eveready® and Duracell®, through different mediums. Consequently, people are much more familiar with disposable alkaline batteries than rechargeable batteries.

Besides a good Marketing strategy, a successful product must satisfy its user by its dependable quality. Although secondary batteries can be recharged over and over, their discharging characteristic is not as good as primary, alkaline batteries.

The best known rechargeable, nickel-cadmium (NiCd) battery, smoothly releases its energy until it is almost gone, and then it suddenly stops. On the other hand, alkaline batteries lose their energy gradually (Vincent, Scrosati, Lazzari, Bonino 1984, 79, 119).

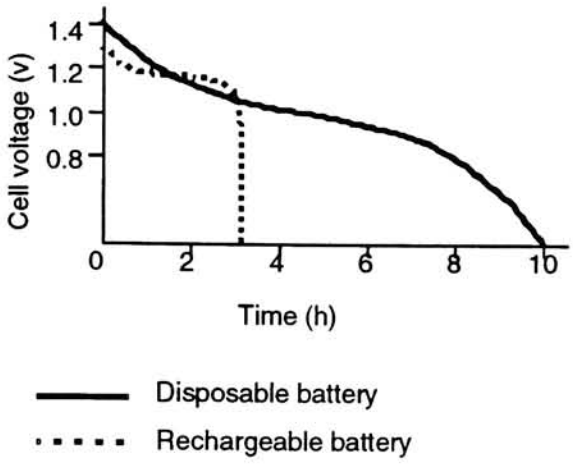


Fig. 1-3 Discharge Characteristics

In my own experiment, two AA alkaline batteries lit a flashlight three to four times longer than NiCd rechargeables did under the same conditions (see fig.1-3).

The important fact, however, is that the NiCd battery is not the only rechargeable battery presently on the market. Last year, Gates Energy Products introduced a brand new rechargeable, "Millennium®" (fig. 1-4). Its advertisement from a catalog declared that users could get up to 33% more use between recharges than with other rechargeable battery brands." Kim Edwards, VP of marketing of the same company, also, pointed out that "We are developing a replacement for NiCd called nickel hydride that we hope to introduce in five to ten years" (Gasbarro 1991, 43).

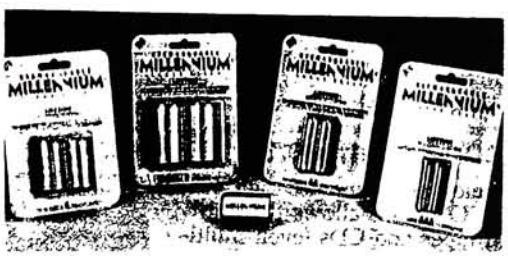


Fig. 1-4 Millennium Rechargeables

Moreover, Mr. Aoki, a Sony Corporation director mentioned that "Everyone knows the ultimate rechargeable battery is made of lithium metal, but it's still unstable" (Thurber 1992).

Since there is a trend that the future rechargeable battery will approch the user's needs more than the disposable battery, this thesis will be based on only rechargeable batteries. The design will be concerned with Marketing strategy, Human need, and Environmental care. The sample situation refers to today's NiCd batteries, but the final solution may be able to apply to other future rechargeables.

THE CURRENT STATE OF RECHARGEABLES

■ Distribution ■

Different from the disposable battery, it is more difficult to find the rechargeable battery in any drug store or convenience store. Rechargeable batteries are available in some specific stores, such as electronic suppliers and toy shops. The reason may be that the rechargeable battery's price is more expensive than the disposable battery. Additionally, every new rechargeable needs the first charge. That means every user should have a battery charger.

According to the charging time, there are two kinds of the rechargeable in the market: the quick charged battery (2-6 hrs.), and the overnight charged battery (8-16 hrs.).
They need different types of battery chargers. The overnight charged battery has more electric capacity per charge, which means the power will last longer than the quick charged battery.
(Catotti and others. 1975).

■ Use ■

Users do not have much freedom to use their rechargeable batteries away from a charger. For example, it would not be a good idea to use rechargeable batteries with a Walkman during a long traveling trip, unless the user brings a charger along so that the batteries can be recharged whenever they are drained and an electric socket is available. Moreover, waiting time for a full recharging is considerable. It takes about14-16 hours to fully charge the standard rechargeable cell, and 3-5 hours for the quick charge battery (Catotti and others. 1975).

Recharging a pair of batteries is very simple. A user need not have to watch recharging, but there is a certain procedure. According to the operating instructions manual of a Panasonic charger, "Batteries can be left in charging unit without harm, but for maximum battery life, remove batteries after fully charging." If a battery is "overcharged" at the 0.3 C rate (quick charging), the cell temperature and pressure will increase, and the cell voltage will drop

down as an interrelationship as presented in fig.2-1. Frequently overcharge temperature and pressure will shorten the cell life. And, continuous charging after being fully charged will drop voltage levels (Catotti and others. 1975).

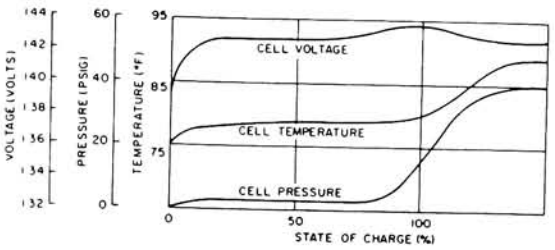


Fig. 2-1 Characteristics of Voltage, Pressure and Temperature Vs. State of Charge of a Sealed Cell at 0.3C Charge Rate

■ Conclusion ■

The rechargeable battery can be charged and discharged hundreds of times. Correct maintenance and use may keep the rechargeable battery in good condition up to 1000 charge/discharge cycles.

The only sign that identifies the poorly conditioned cell is the lower peak voltage that the cell can reach. The power will drain from the full charge quicker than before.

PRELIMINARY SOLUTION

The "tool" that I used to create the beginning solution for this project was the imagination of myself as a rechargeable battery user. I attempted to free myself of all current constraints and perceptions and visualize a scenario that would:

- allow users to purchase, affordably, rechargeable batteries from automatic dispensers that are available in many convenient locations,
- have an efficient recharge service after purchase so it is not neccessary for the user to have a battery charger at home, and
- take care of used batteries; thus, users feel better about environmental care.

After analyzing the above criteria, the problem seemed to suggest that an ideal solution might take the form of a large service "system". This could be similar to those systems provided by Banking institutions, Gas stations, or Food and beverage vending operations. The bigger the service system is, the more convenience the user gets.

3

ECO BATTERY EXCHANGE SYSTEM CONCEPT

CONSTRUCTION

It makes more sense to set up a system for distributing energy than a system for distributing little physical blocks of products. The "Eco Battery exchange system" will circulate Eco rechargeable batteries between users (see fig. 3-1). Users would not permanently own these batteries.

Ready-to-be-used rechargeable batteries are distributed through "Eco exchanging units" without packaging. Once customers purchase batteries from an exchanging unit, they enter the battery exchange system. Users can get the exchanging service through any available exchanging unit. To exchange, they have to deposit their Eco batteries and pay a service charge at a small fraction of the original cost. Then, they receive other Eco batteries freshly charged.

Furthermore, exchanging with different battery sizes is a feature of the system. Users do not have to use the same size of

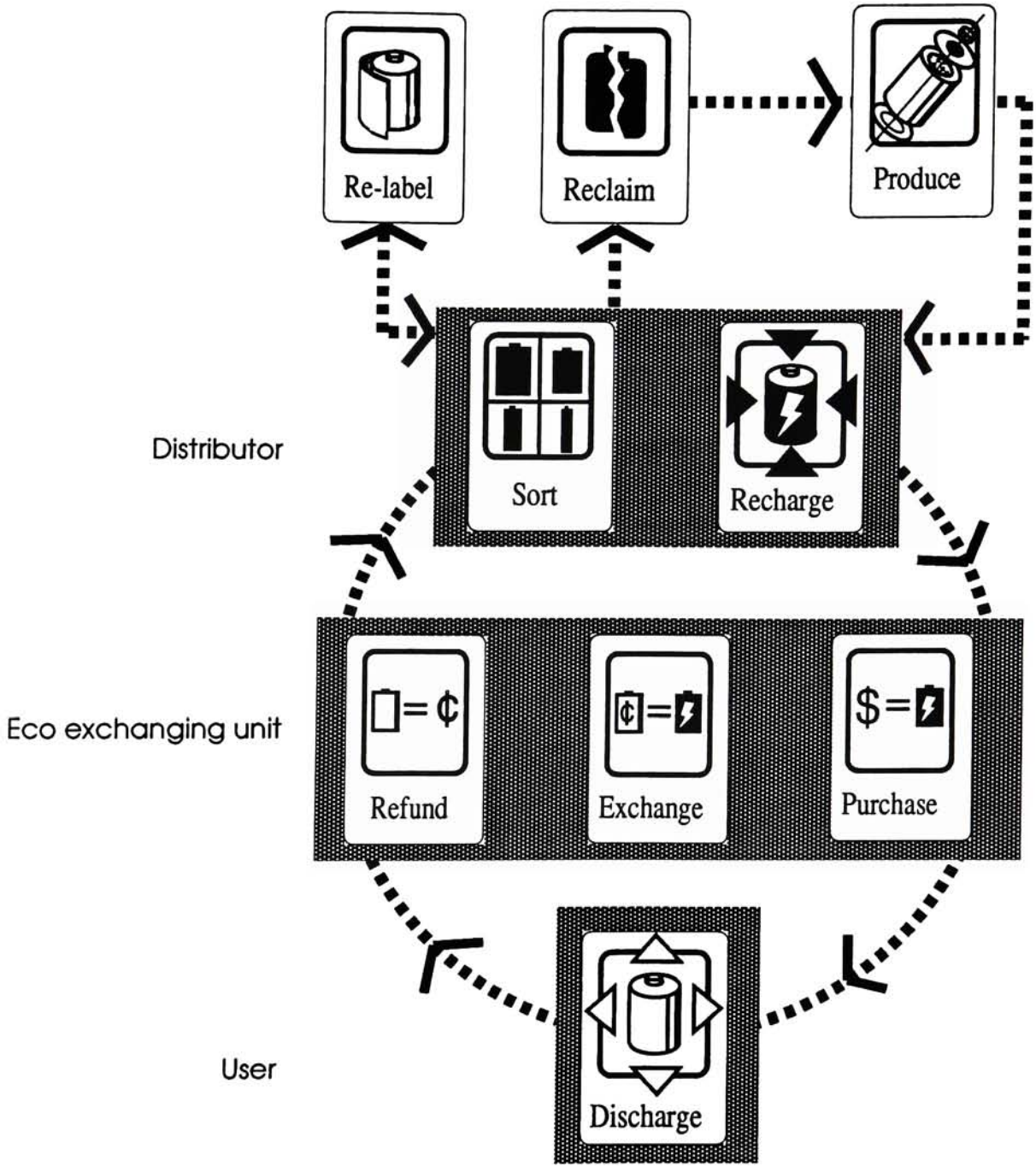


Fig. 3-1 Eco Battery Exchange System Concept

batteries when they need to change them. Also, they can get a partial refund if the battery exchange system no longer fits their needs. By these alternatives, most Eco batteries will come back to the system.

Deposited batteries are picked up by a distributor. Distributors will sort batteries, recharge them, check and remove failed batteries, and return them to exchanging units. This process includes re-labeling, reclaiming, and adding new products into the system, which I will explain in the later sections.

As a result, this is an ideal concept for public spaces and convenient locations. It allows users to use rechargeable batteries without a personal charger. They do not have to take responsibility for throwing batteries away, if they keep using the system. Additionally, by doing so, they will get unlimited service. Figuratively, for the users Eco rechargeable batteries have an unlimited lifetime.

FEASIBILITY

According to the system construction, this project increases not only battery users' convenience, but also business potential. Let me explain how both distributors and users in the Eco Battery Exchange System would benefit.

Rechargeable batteries are expensive long-life products. The users who purchase them may not come back for many years until their old rechargeables have permanently failed. That is not good for business. On the other hand, Eco battery distributers could earn more profit than using conventional rechargeable distribution. The Eco Battery Exchange System offers affordably charged batteries to the users for less than they would pay for new, powerless rechargeables. The users are eligible to use the exchanging service from the system. This convenient system will increase the number of users. As a result, the distributor's profit comes primarily from selling batteries and recharging service.

To keep the battery exchanging business flowing smoothly, the following details are important:

■ Circulation ■

In the early concept, Eco batteries were circulated within each exchanging unit. Returned batteries would be automatically recharged and re-distributed by the machine itself. Since Eco battery users are able to exchange batteries through different exchanging machines, the early idea could have problems. The system needs servicing to balance the number of batteries in each exchanging unit. Circulators bring returned Eco batteries back to a central recharging area. After the recharging process, they proportionally distribute the batteries to every exchanging machine according to the battery needs of each area.

Each exchanging unit can be connected to telephone lines and can signal particular messages to the center for more efficient circulation. Moreover, the machines can monitor not only battery quantities, but also cash status and maintenance needs.

■ Sort and Recharge ■

At the centers, Eco batteries are sorted according to size; so, it is easier for recharging and distributing. Sorting and charging would be done by an automatic machine. Different sizes of batteries will fall into corresponding slots that lead to different battery charging lines. In order to maintain the maximum life of the batteries, they wold be charged over a period of 16 hours (overnight). Slow charging helps maintain the life of the battery (Catotti and others. 1975). After that, the quality of each battery is tested.

■ Test ■

Rechargeable batteries can be tested by measuring the open circuit voltage after charging. The cells remain in good condition for a long time. They suffer only slight capacity degradation with moderate electrolyte loss, but almost complete loss of capacity when a large amount of electrolyte is lost. The effect of electrolyte loss on cell capacity is portrayed in figure 3-2 (Catotti and others. 1975). This diagram shows that

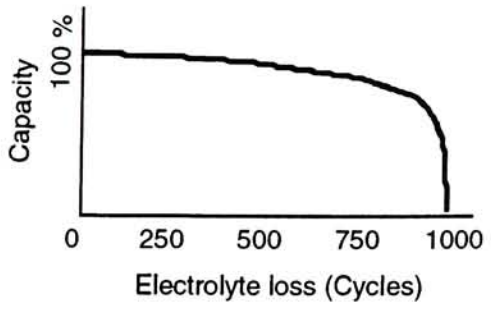


Fig. 3-2 Loss in Capacity as Electrolyte in a Rechargeable Battery is Lost

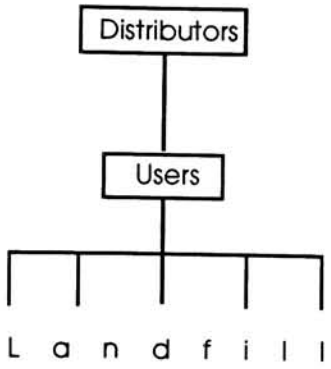
a nickel cadmium battery can be charged and discharged for about 600-700 cycles without disappointing its user.

■ Re-label ■

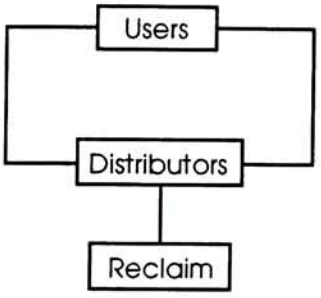
Each Eco battery is wrapped with a recyclable plastic label (PET or HDPE). The labels will be constantly changed: 1) to encourage users to exchange batteries, and 2) to keep the batteries' bodies clean. Besides standard information, there is a bar-code and exchanging date-warning on each Eco battery's label. The bar-code identifies Eco battery eligibility and the label's issue date to the scanners in Eco exchanging machines. The exchanging date-warning tells the users that they may have to pay relatively higher prices for exchanging if they keep the same batteries longer than the exchange date shown.

■ Reclaim and Replenish ■

If an Eco battery could not pass the battery testing process (after charging), it will be removed from the Eco Battery Exchange System. It is the distributers' responsibility to



Conventional Rechargeable



Eco Rechargeable
Battery life

Fig. 3-3 Conventional Rechargeable vs. Eco Rechargeable Battery Lives

send all failed batteries to a separate reclaiming organization (see fig. 3-3). Meanwhile, the exchanging system is replenished with new rechargeables. After being fully charged, old and new batteries are re-distributed at random.

Eco battery distributors would need to invest in exchanging machines, bulky battery chargers, and re-labeling systems.
The investment for innovative machines is always the beginning of every automatic dispenser business. The differences that make the investment for this project more interesting are as follows:

1) Rechargeable batteries are smaller in size but higher in value than other products sold by vending machines.
2) Battery recharging is less difficult than producing or packaging new products.
3) Battery energy is a necessity for most people.
4) The system is safe for the environment.

ECO BATTERY EXCHANGING UNIT

DESIGN OUTLINE

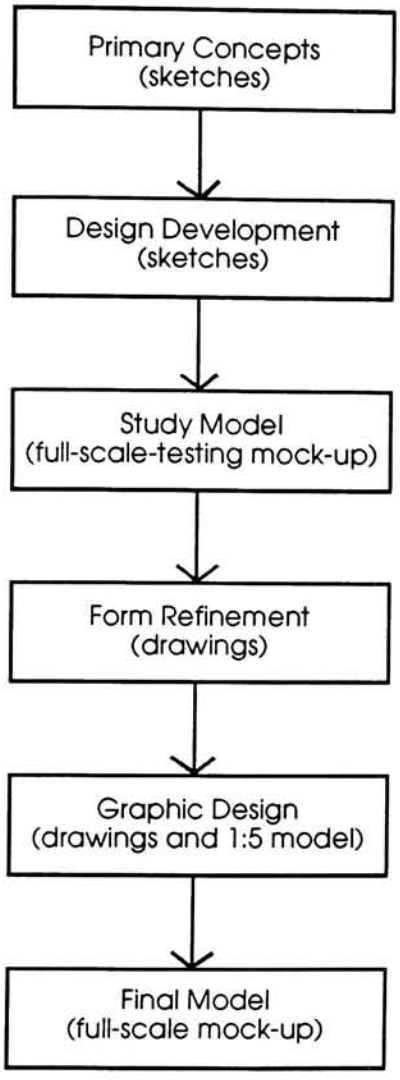


Fig. 4-1 Design Outline of
The Exchange Unit

In the battery exchange system, the key component is the battery exchange unit. This is the connecting point between the operators and their customers. Therefore, it needs a well functioning design with harmony between esthetic of the product and graphics more than any other component in the system.

The Eco battery exchanging unit is a product for public-use. Consequently, designing for untrained users is the major concern.
An easy-to-operate system and easy-to-read graphics for ordinary people from 11 to 65 year-old are the aim of the design development. In figure 4-1 is a scenario that shows the overall design for the Eco battery exchange unit. And, the following is the details of each category.

PRIMARY CONCEPTS

Fig. 4-2 Design with an Internal Battery Charger

According to the system construction (fig. 3-1), a definition for the Eco battery exchanging unit is a machine that distributes Eco batteries, offers exchanging service, and collects Eco batteries from users.

This definition led the beginning concept to the combination of similar products, such as food and beverage vending machines and cash machines. Then, this combination was unified and simplified.

From the first concept to the final concept, there were many changes in the system layout, user interface, and installation of the product. The following is the analysis of those changes:

- From Internal Chargers to The Human Intervention

In the first concept, the battery exchanging machine included an internal battery charger (fig. 4-2) which can charge returned batteries and re-distribute them by itself.

This was an interesting idea but not practical.

Besides the circulation problem that has been explained in chapter 2, the internal charger complicated the design of the exchanging unit. Also, it would cause expensive production and difficult maintenance. Without the internal charger, the appearance of the later designs could be more compact and less complicated.

From The Multi-button Control to The Touch screen Control

User interface is an important issue for the battery exchange service. Each mode of the services - which are purchase, exchange, and refund - needs continuous operation (figure 4-3) like the one in the bank's cash machine.

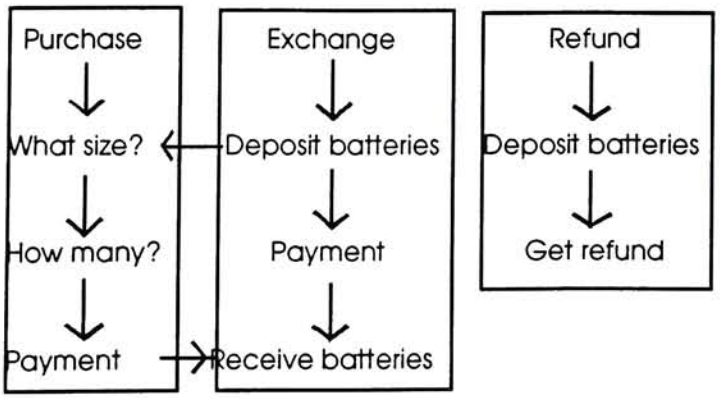
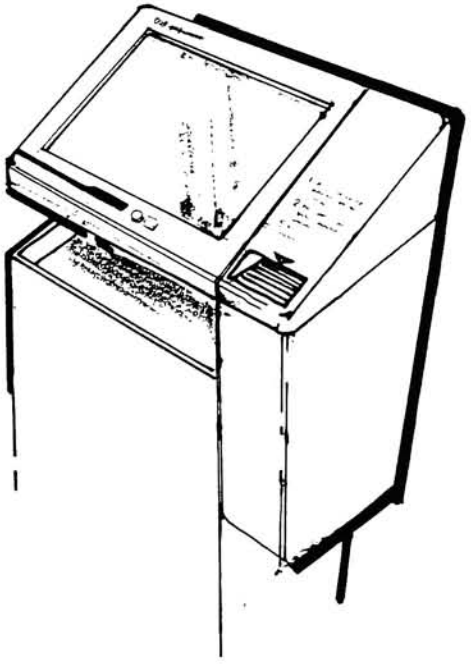


Fig. 4-3 Operation Chart of the Eco Exchang Unit

For instance, users need to identify the size and the quantity of batteries that they want after selecting "Purchase". Then the machine calculates the amount of payment.
Finally, users receive Eco batteries after they complete the payment.

In this case, multi-exposed-button control tends to confuse the user in term of the operation order. A solution for this problem that was applied to later design was using step-by-step-instructions on a monitor with a set of multi-functional buttons.



Finally, the design was simplified by integrating the buttons into the screen (figure 4-4). This represents the touch screen control. The chief advantages of this input device are ease of learning (no training is required) and ease of use. Flexibility is another plus.
For example, the touch-sensitive areas can be redefined via software (Cushman and Rosenberg. 1991). However, the front screen has to be non-glare glass (fine texture surface glass) so it reduces the glare problems that always happens on a glossy surface.

Fig. 4-4 Designs with a Touch Screen Control

Fig. 4-5 Design with Fancy Sculptures

From Fancy Sculptures to Simple Forms

The image of batteries in my mind was something that was sparkling, moving, and had fancy shapes. Some of the concept sketches for this project were purely drawn from that imagination (fig.4-5). However, those "blue sky" designs were not appropriate for the product environment. Since the Eco battery exchanging machine would stand beside other vending machines, supermarket shelves, or building corners, its form must be simple (fig.4-6).

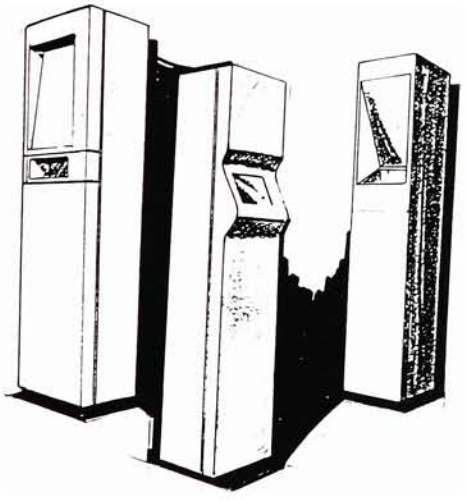


Fig. 4-6 Designs with Simple Forms

With simple tall tower form, this machine would be easier for installation in limited space than ones in the short, wide form with a big foot print. Also, the vertical shape machine looks more elegant and arousing.

Both left and right sides of the machine should be straight. This saves space when the machine stands next to other flat walls. Also, it would not collect dirt and litter where it is difficult to reach for maintenance people.

Figure 4-6 Primary Concepts

The front of the unit should not be deeply recessed so that it would be difficult to recognize when standing between two other vending machines. But, it must not stick out too much to be a "bully" of the narrow way.

DESIGN DEVELOPMENT

The primary concept only refined the original idea of the design. To develop the primary concept to be a stronger design, the Eco battery exchange machine needed exterior and interior details based on Human factors and design sense.

■ Exterior ■

The conclusion from the primary concept does not mean that the design must be too simple. The Eco machine should retain the electrifying image of the battery. A big cylindrical form was a design element that best represented the characteristic of the Eco batteries. Meanwhile, the question was - how to effectively apply it into the design?

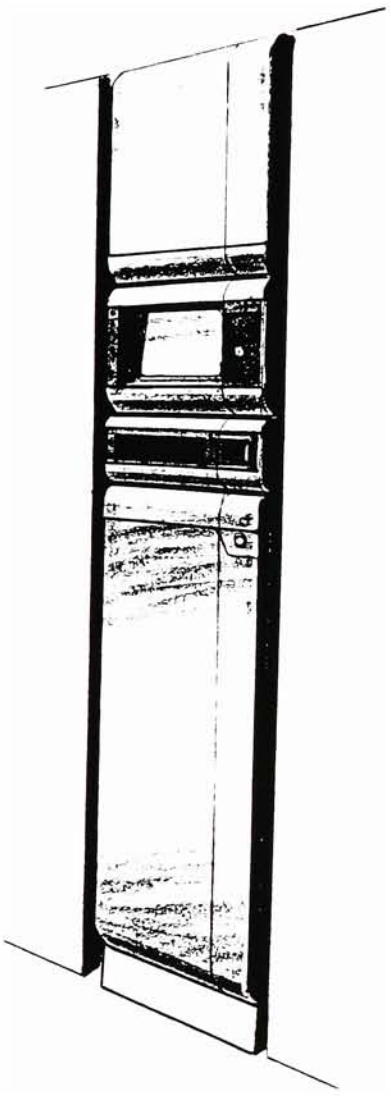


Fig. 4-8 Design with Stacking Forms

Through many sketches, the most interesting design was the one that looked like a set of stacking audio equipment (fig.4-8).
The upper and the lower edges of each component of this design are big round corners. The repetition of this horizontal roundness represents cylindrical dry cells. Yet, it helps emphasize each functional part of the unit: the charged-battery storage, the control panel, the battery gateway, and the discharged-battery storage.

In term of expressive appearance, the curvilinear front of the unit always reflects and creates highlight beams when it is under a light source. This phenomenon also represents the energy products inside. It can even be an attractive spot in a poor-lighting situation (figure B on page 40a).

■ Interior ■

Whole parts of the front of the Eco battery exchange machine can be opened like a single, swinging door. Most maintenance works for the machine are behind this door. The posible detail of the interior is illustrated in figure 4-9.

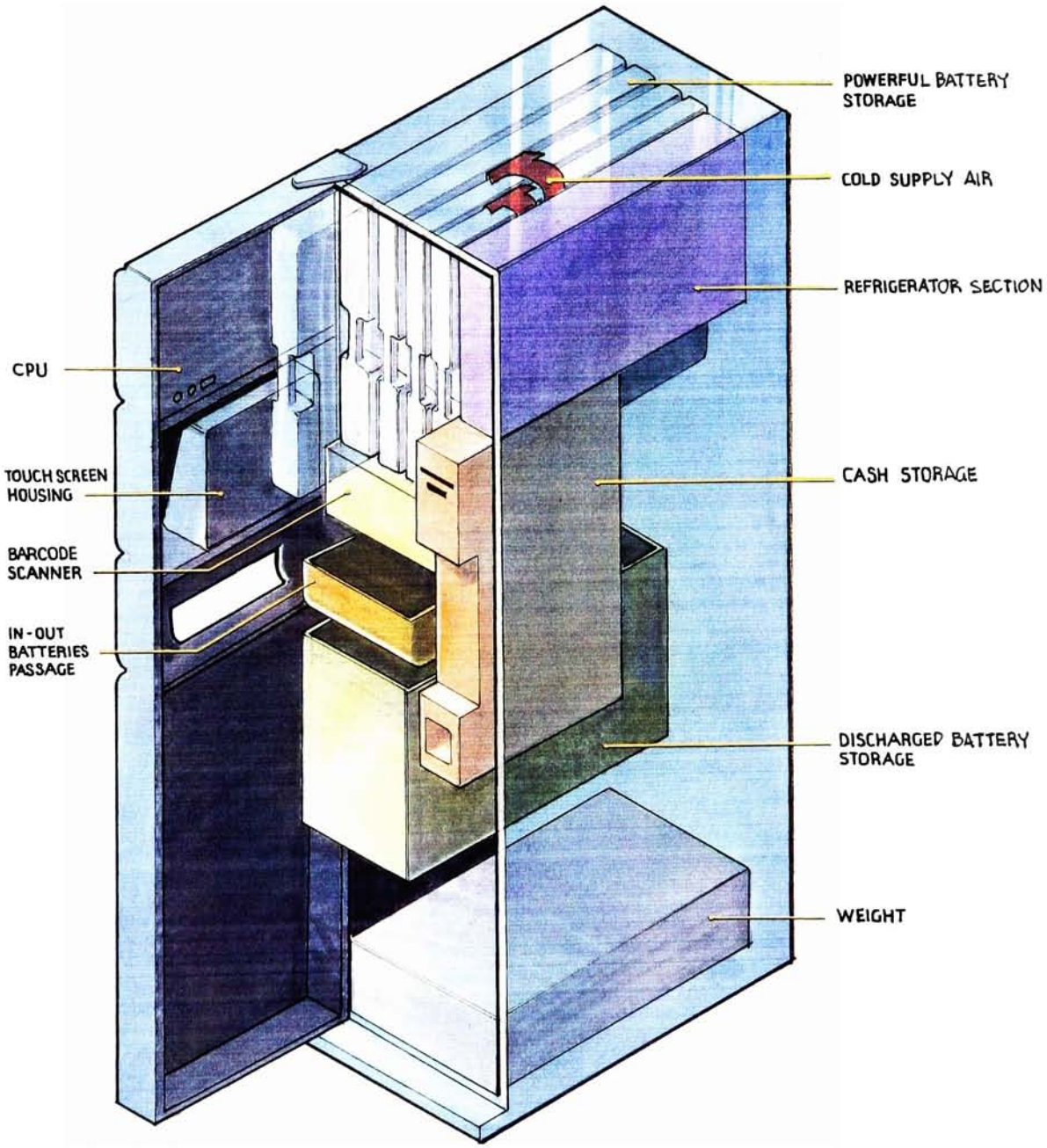


Figure 4-9 The Interior of The Eco Battery Exchange Machine

On the back of the door, there is a CPU that control the whole system in this machine, including the application of the touch screen control. The distributor can reprogram the application software through this CPU like other personal computers.

The recharged battery storage is located on the top-left corner of the trunk. The storage consists of four different magazines for four sizes of batteries (AAA, AA, C, D).
These magazines are the same overall design, but different in battery-lines' dimensions.
The example detail shown in figure 4-10 is a D-size battery magazine. The other magazines for smaller batteries have relatively greater capacity. The range of the weight of each full-loaded magazine would be about 30-40 lb, which is still under the reasonable weight limits for occasional lifting for 18-35 year-old males (max. 55 lb) (Woodson. 1981).

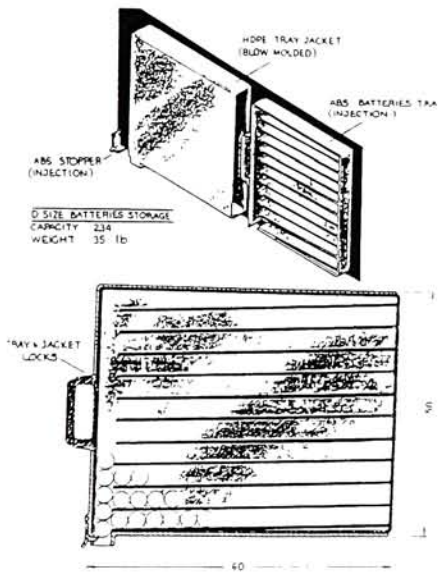


Fig. 4-10 D-size Battery Magazine

Adjacent to the storage on the right-hand side was a refrigerator section. The cold air from the refrigerator would flow around the

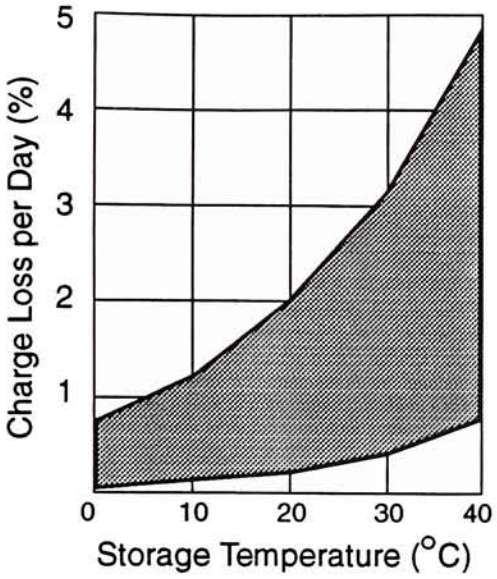


Fig. 4-11 Self-discharge Rates

temperature lower than 20°C. The lower the storage temperature, the longer the battery retains its stored energy. Figure 4-11 shows typical self-discharge rates from 0°C to 50°C for a representative nickel-cadmium cell (Catotti. 1975).

The charged battery storage is connected to a battery gateway (in-out battery passage). Batteries in the magazine are smoothly dropped down from the top to the bottom to the connection by gravity. At the connection, there are four counter valves and a gate controlled by computer as shown in figure 4-12. In the picture, valve 2 is in the position that cuts two bottom batteries from the upper stack. Thereafter, the gate A is opened and only the two batteries fall down to the gateway without a battery jam.

The Eco battery exchanging machine has only one battery gateway. To exchange, users have to deposit and receive Eco batteries through this gateway. Deposited batteries have to be faced up in the gateway, so the bar code scanner can read

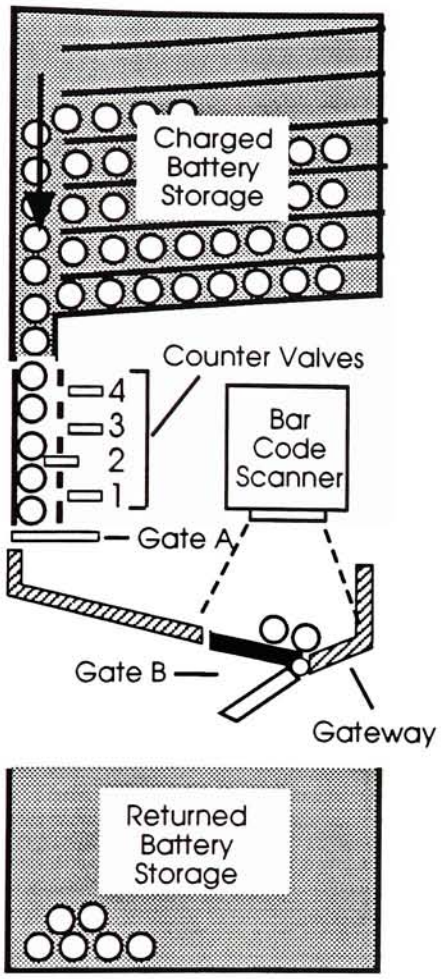


Fig. 4-12 System Scenario

them. If they are qualified, the machine will continue the exchanging process. After the user pays the charge, gate B is opened to remove the old batteries to the returned batteries storage. Then, new batteries fall down from the upper storage to replace the old batteries in the gateway.

The big cash storage is at the middle right-hand side. The battery exchanging machine deals with high priced batteries, so it needs a high capacity cash system. Although an Eco battery is cheaper than a virgin rechargeable battery, it is still more expensive than any other product sold by machines. The Eco cash machine would accept not only coins and one-dollar bills like other vending machines, but include 5$ and 10$ bank notes. This is more convenient for customers who first purchase many Eco batteries but do not have enough change.

The last visible part in figure 4-9 is a mass of weight at the bottom of the trunk. It is an option prepared for stabilizing the unit in case the unit is standing unaccompanied.

The most unstable direction of the narrow, deep, and tall unit are the left the and right sides. Especially, when the top storage is full and the bottom storage is empty, the CG (Center of the Gravity) is too high, and may easily fall over. (fig. 4-13). The bottom weight would lower the CG and keep the unit more stable.

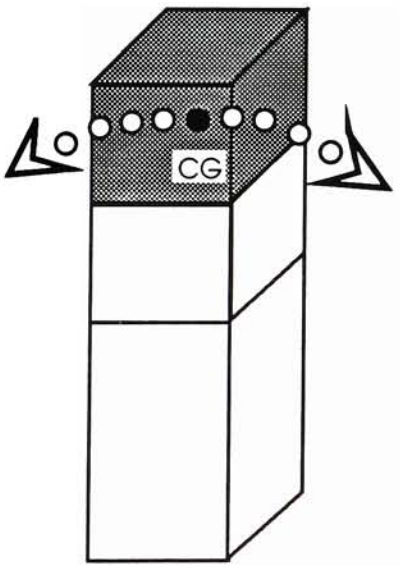


Fig. 4-13 Unit Stability

STUDY MODEL

The front part of the selected design from Design Development was built in full-scale-study model. The purpose of creating this model was to study the following subjects:

■ The User Reaction ■

During the time that the model was standing in the Industrial Design studio at R.I.T., it interested many students who were working near by. Many of them positively commented on the overall form of the model. Some of them had interesting opinions about the details. Some other friends demonstrated their reaction to the model. Every useful opinion and demonstration was recorded for later improvement. For example, figure 4-14 suggested that the control screen was too low even for a 10 th percentile man.

■ The Lighting Effect ■

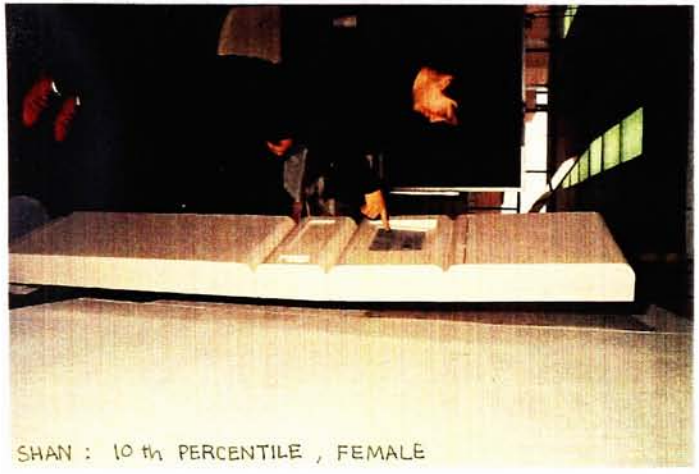
The study model shows its details by the reflection, the shadows, and the dark sides of different levels and angles. Different positions of light source create a variety of lighting

effects, which explains the beauty of its form better than that in the drawing. Therefore, the model is very useful for the later form and graphic refinement.

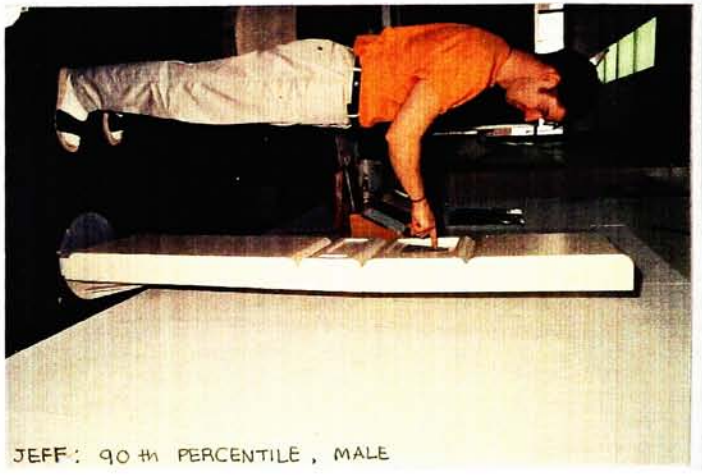
■ Material and Process ■

The last advantage of making this model was to survey materials and techniques that may be suitable to apply to the final model making. This reduced the risk of potential mistakes. 5-millimeter-thick foam core board with melted glue sticks were the only materials used for this model. Foam core panels are rigid enough for the flat surfaces in this design. It also handled round corners very smoothly with V tracks on the inner side of the corners.

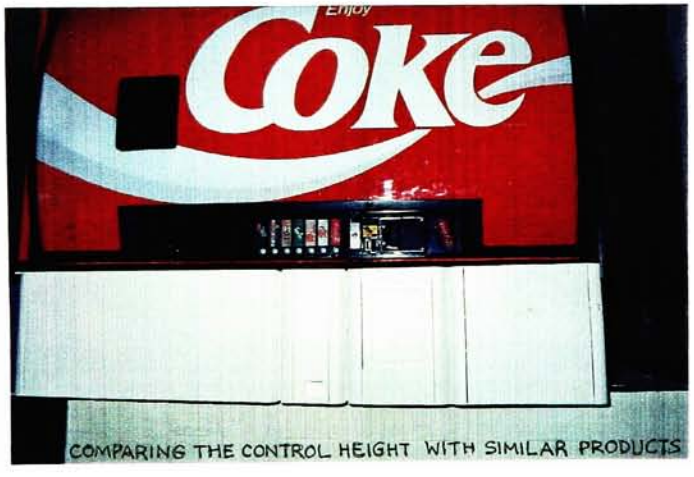
Techniques for making this model were very simple and quick. Heavy machine tools were never required. In contrast, the work was done within 2 days with only basic tools, such as a sharp knife, a metal ruler, and a cutting mat. The output work was the light-weight model which can be lifted up by an index finger.



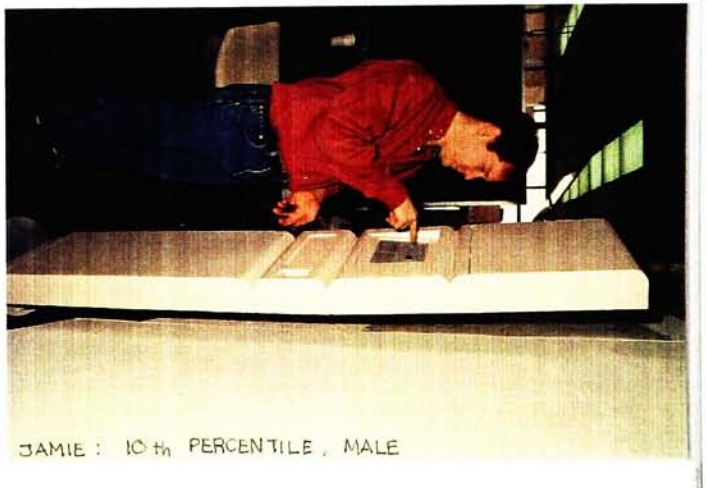
SHAN : 10 th PERCENTILE , FEMALE



JEFF : 90 th PERCENTILE , MALE



COMPARING THE CONTROL HEIGHT WITH SIMILAR PRODUCTS



JAMIE : 10 th PERCENTILE , MALE

Figure 4-14 Study Model

FORM REFINEMENT

The proper-scale drawings in figure 4-15, 4-16, 4-17. and 4-18 are the summary of the Human Factors test, plus stylistic details on the user interface. The details included materials, textures, colors, parting lines, and primary graphics. Detailed drawing and rendering techniques were employed to express the effect of the materials as close to the real thing as possible. The major media used on those drawings was dry pastel over the gray strokes of felt-tip markers.

■ Figure 4-15 ■

The mat black finish unifies and emphasizes the monitor and the battery gateway which are the key components of the Eco machine. There is a rotation lock, at about the middle right side, for the door's security. This kind of lock does not need a key. And, it is in harmony with the rest parts of the design. However, the overall appearance is too delicate and not appropriate for the image of its content.

■ Figure 4-16 ■

The contrast of the materials and the colors make this design simple and strong. The dark gray area is a durable plastic bumper intended for scratch protection. Moreover, it highly contrasts with the gold metallic surface of the upper part of the user interface. Although black and gold colors are a good match, the big gold area on figure 4-15 may make people uncomfortable because it is a warm color.

■ Figure 4-17 ■

After gradual development, there is a revolution in the user-interface design. Many design tricks were applied to the new series of drawings. In figure 4-17, for example, purple and black with split components cause the design look fashionable; but it might soon become out of date.

■ Figure 4-18 ■

This design was developed from the one in figure 4-16, which met most of the design criteria. This picture shows the details and explanation of the user interface.

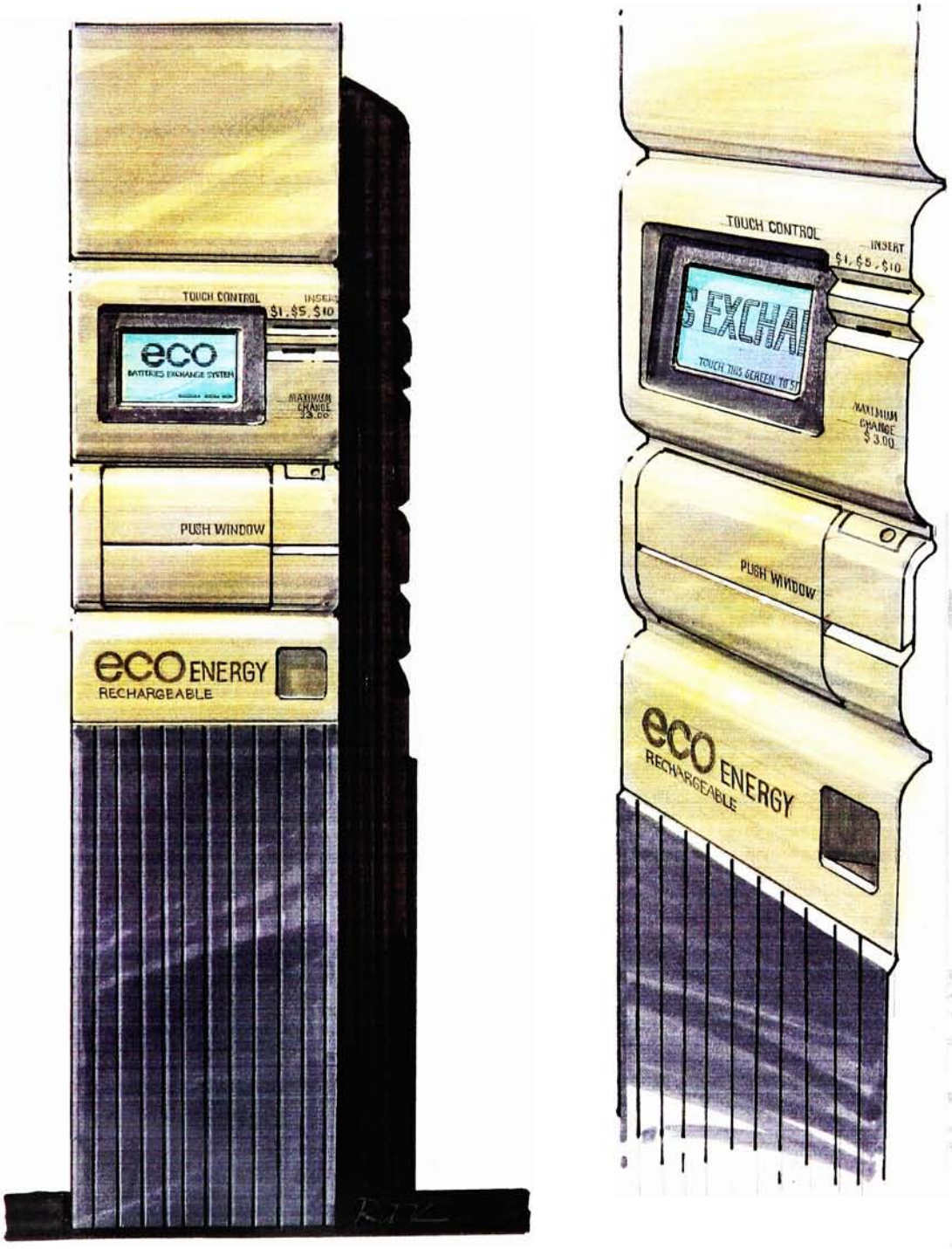


Figure 4-15 Form Refinement

Figure 4-16 Form Refinement

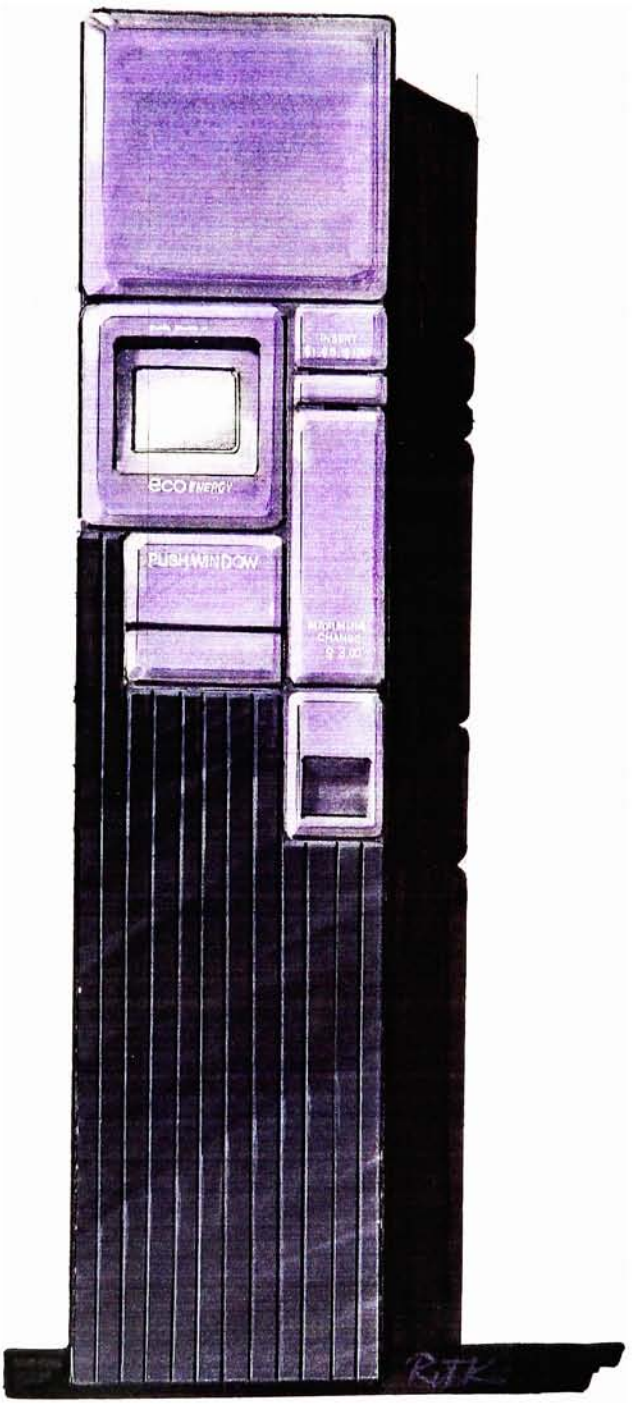


Figure 4-17 Form Refinement

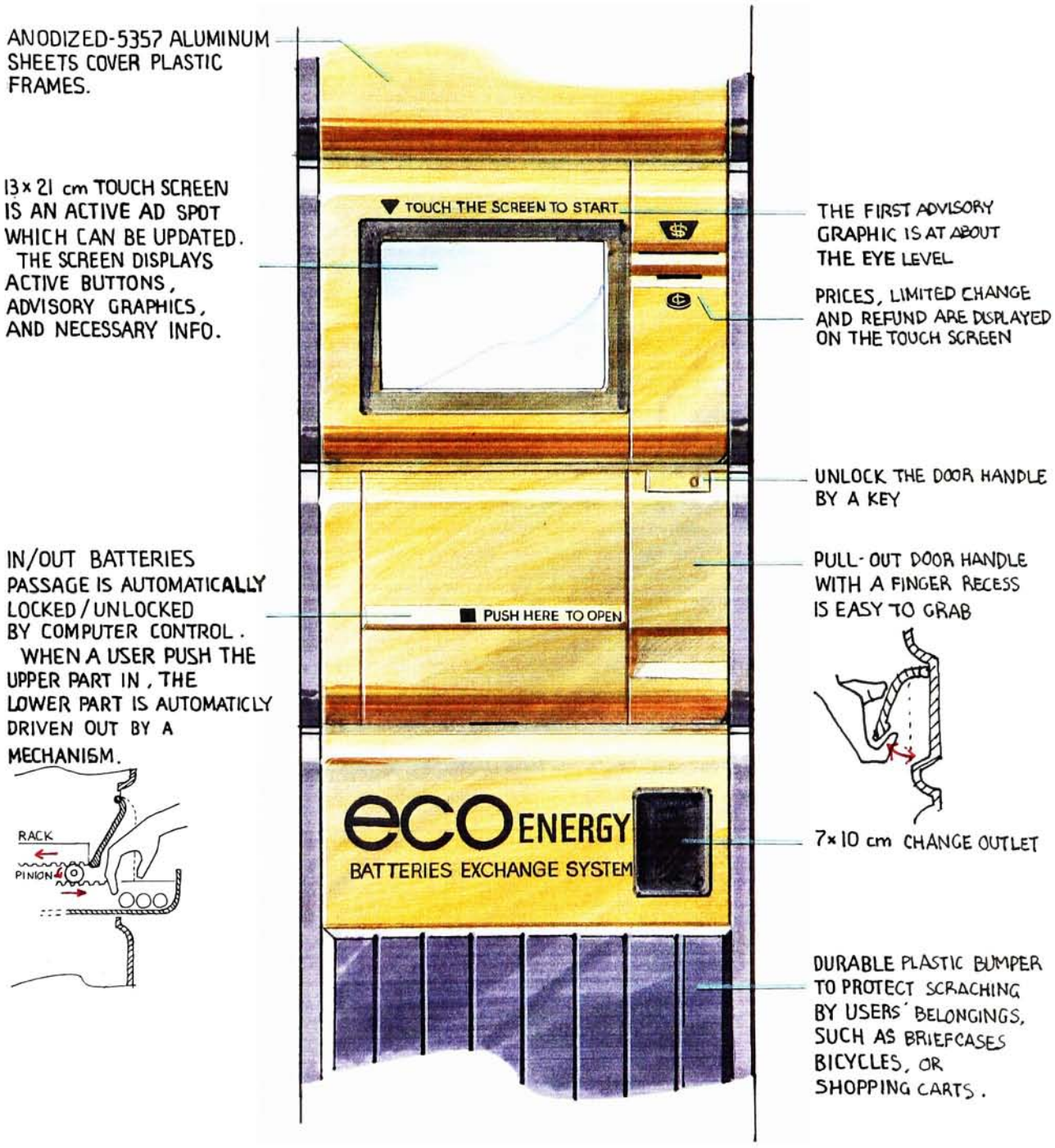


Figure 4-18 Form Refinement

GRAPHIC DESIGN

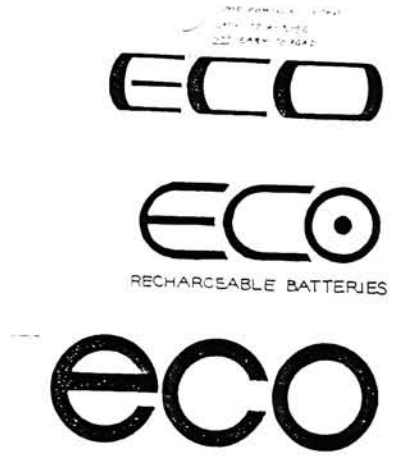


Fig. 4-19 Trademark Designs

■ Trademark ■

The first logotype, Eco, was created during the Form Refinement process to support the designs. It came from the first three characters of the terms "ecological" and "economical", which are what this project aimed for. Figure 4-19 illustrates some parts of the sketches for the Eco trademark.
The circle design is the best one in this category because it simply explesses the cross-section of three cylindrical cells, yet it repeats the stacking appearance of the Eco machine.

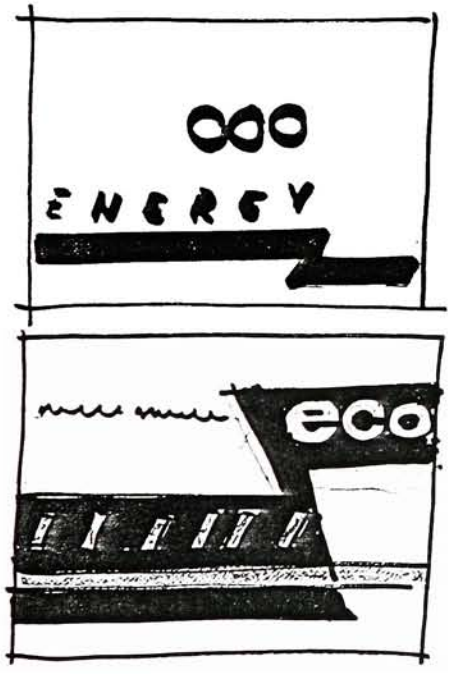


Fig. 4-20 Graphic Design Sketches

Then this trademark was applied onto the product along with some coorperative terms, such as "Energy" and "Rechargeable".
The first step of this process was making such rough sketches as illustrated in figure 4-20. After that, some interesting sketches were refined and applied on the metalic surfaces of 1:5 scale models as shown in figure 4-21.

Figure 4-21 1:5 Scale Models

Finally, the conclusion was reached that: 1) the mat color field stands out best on the shiny surface, 2) the negative letter on the same surface is easier to read than the positive letter, 3) the design with the big trademark is the strongest design for this product.

■ Instruction ■

There are two kinds of instructions on the user interface of the Eco battery exchanging machine: the permanent instructions and the interactive instructions.

■ As shown in figure 4-22, 'TO START please touch screen" and "TO RECEIVE or TO DEPOSIT please push here" are only two permanent instructions of the Eco machine.
Each instruction is a combination of two different type faces. The main term of the instruction is 36 pt.Helvetica Light Italic.
The key words of the instructions are emphasised by using 48 pt. Helvetica Compact in the upper case style.
Consequently, the user could read and understand these instructions quickly.

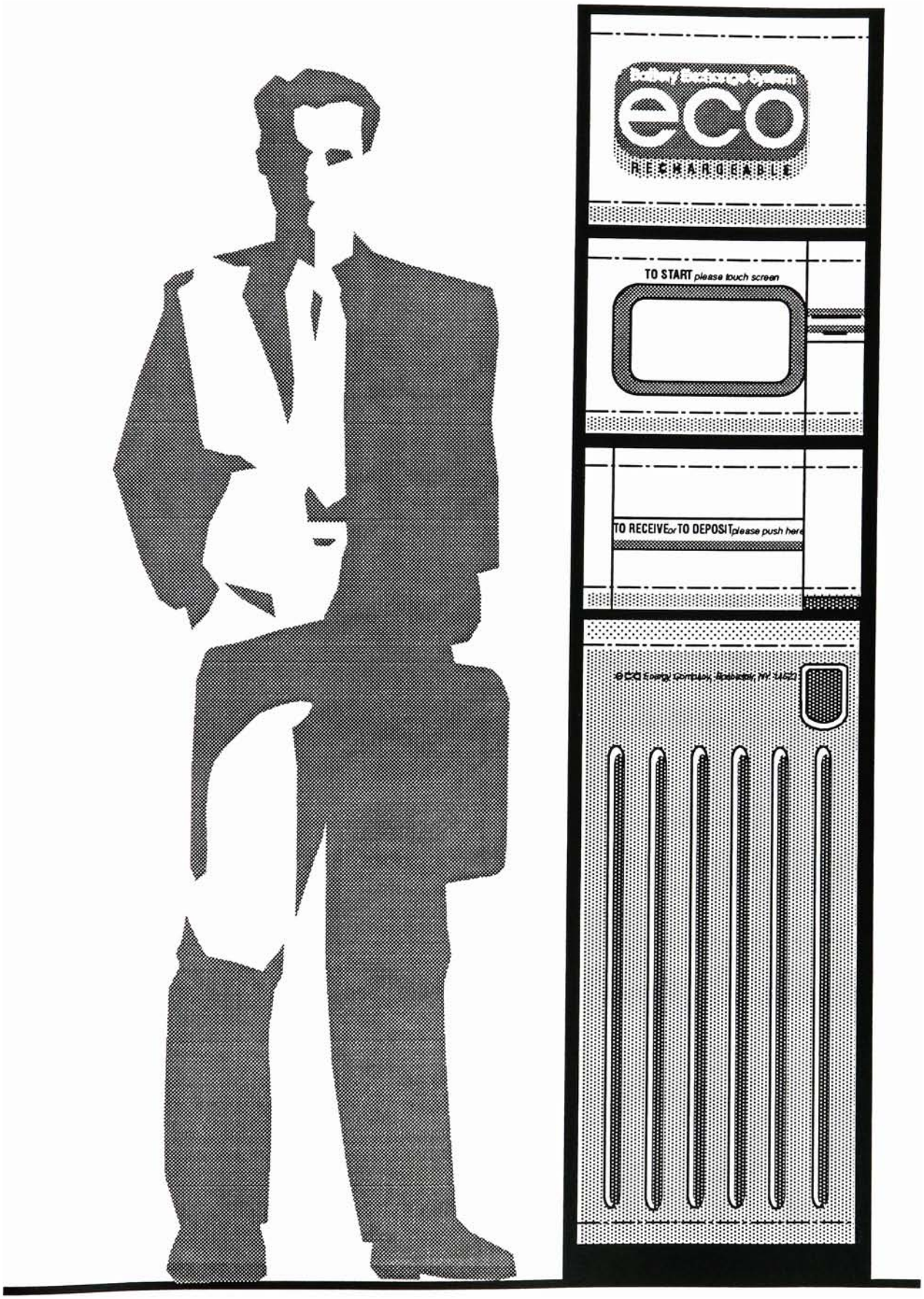


Figure 4-22 Final Design with a 50th Percentile Man

The first instruction advises the user to activate the machine by touching the touch screen. Thereafter, the step-by-step instructions on the screen will lead the user from the first to the final step of the operation. To support the instruction on the screen, the second permanent instruction assures the user of the location and the operation of the battery gateway, which is below the touch screen. This position may be too low for the human's eye level, but the instruction is still easy to read because it is on a turned-up surface.

■ When noone operates the Eco battery exchanging machine, the touch screen displays a standby image which can be an advertising campaign or special information for the period of time, depend upon programing via the software. Immediately when the screen is disturbed, the standby image changes to be the main menu (figure 4-23). The menu invites the user to use one of the three services of the machine which are: PURCHASE, EXCHANGE, and RETURN.

The black fields identify the touch buttons (icons) on the screen. Most of those buttons are at the bottom of the screen, except for the battery selection buttons on the first screen of the "PURCHASE" category. The four battery icons are not the actual size but they are about the right proportion in a smaller scale. So, the user who always forgets the battery code (AAA, AA, C, and D) will be able to recognize the battery he or she wants. Additionally, the required quantity can be increased by one for each time a

Main Menu

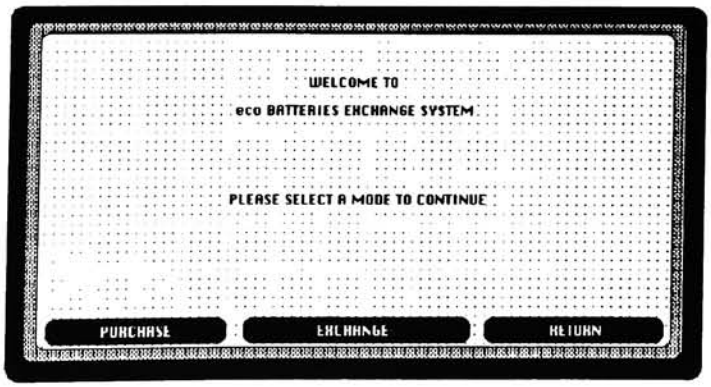


Figure 4-23

Step-by-step Instruction on the Touch Screen

"PURCHASE" Process

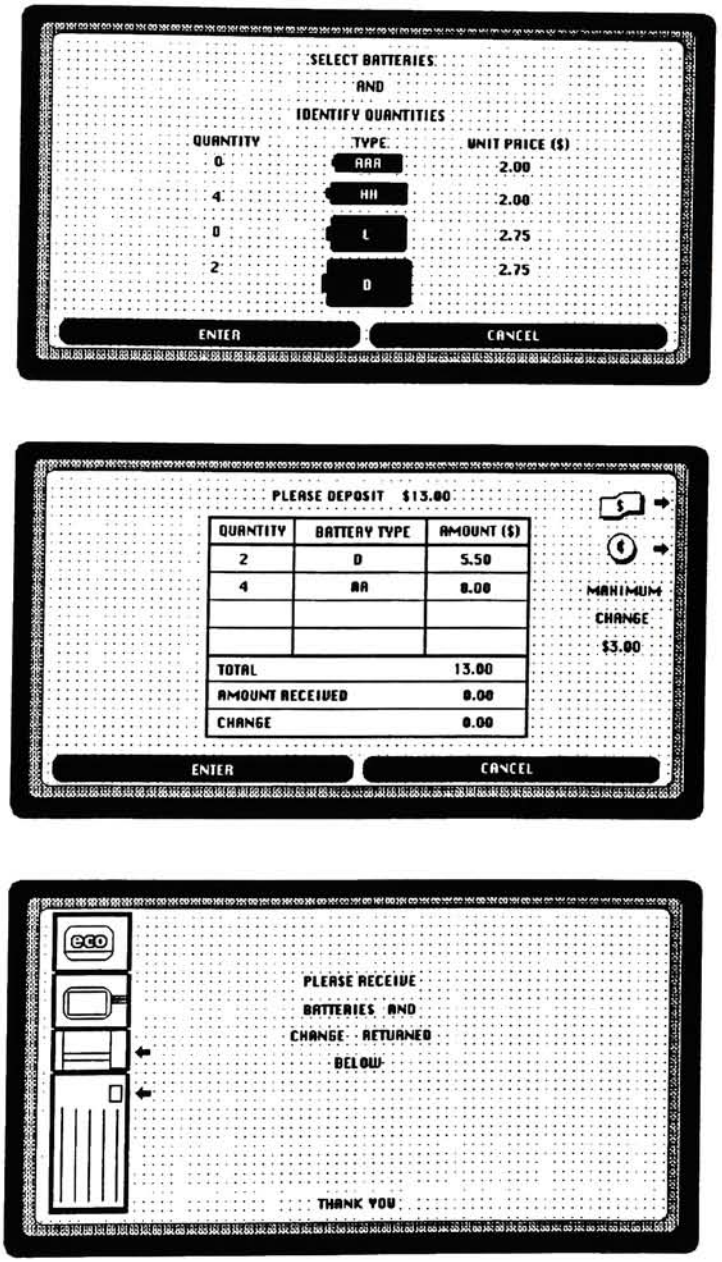


Figure 4-23

Step-by-step Instruction on the Touch Screen

"EXCHANGE" Process

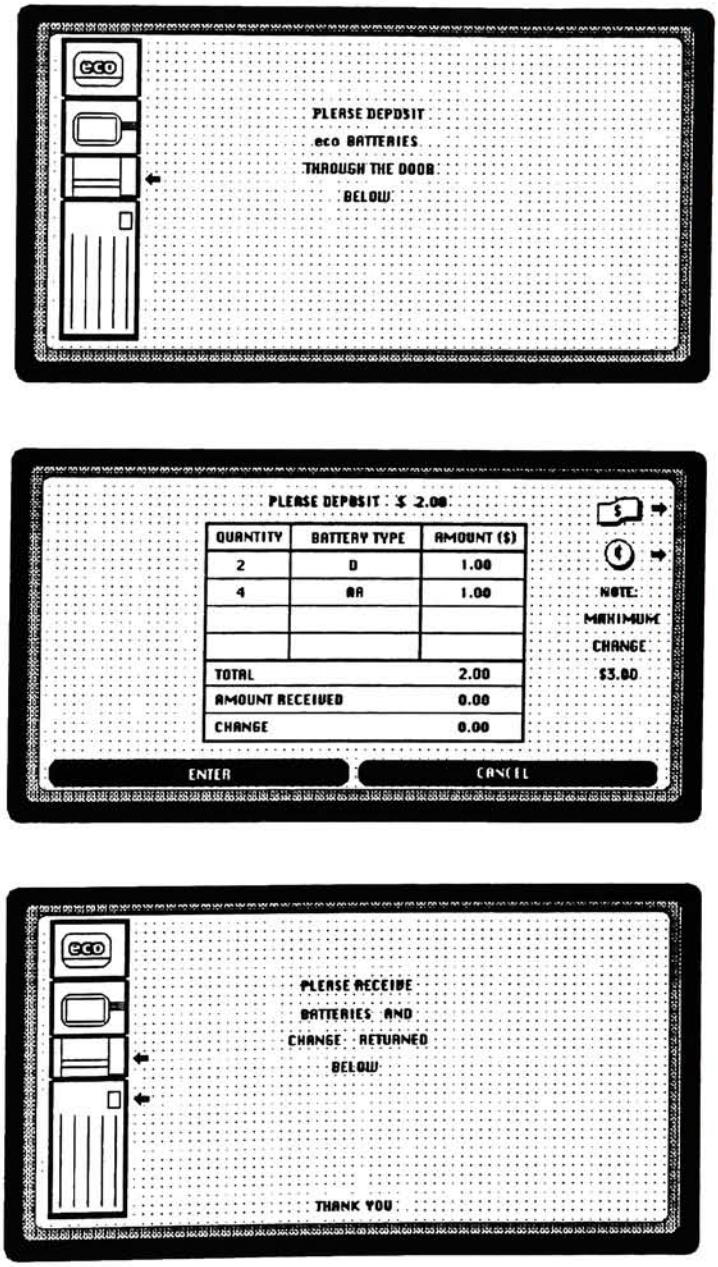


Figure 4-23

Step-by-step Instruction on the Touch Screen

"RETURN" Process

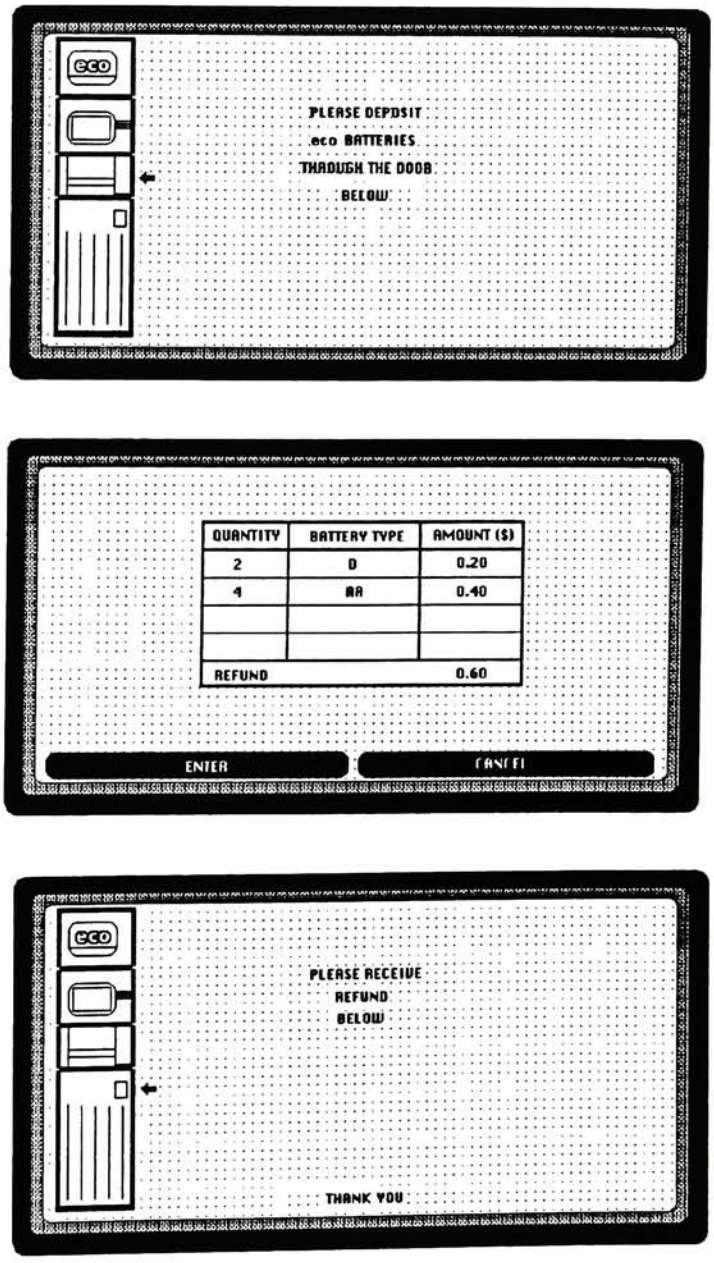


Figure 4-23

Step-by-step Instruction on the Touch Screen

FINAL MODEL

The full scale model shown in figure 4-22 is the final result from blending the two dimensional and three dimensional works together.
The method for making this model was almost the same as that for the study model.
The main structure of the final model is made of foam core board. Only some details such as the monitor, the black frame, and the bumped texture are plastic.

An important trick of the presentation is the light behind the translucent panel which represents a flat touch screen. The light screen helps the model looks like the actual product with power-on.

Figure 4-24 Final Model

CONCLUSION

The battery exchange unit would be different from other vending machines in the consumer market in that it includes a collecting unit. Therefore, the user can return or exchange the drained battery back for recharging. This concept applies not only to rechargeable batteries that are cylindrical, but to ones that are other shapes such as those used in camcorders. If battery exchange units were as ubiquitous as drink vending machines, tourists would not have to carry heavy spare batteries for their camcorders.

Furthermore, considering a battery as refillable power in a reusable case may extend the concept to other products such as music cassettes, color spray paint cans, and anything else. As a result, consumers will have little to throw away, and that reduces the demand on raw materials.

Figure A Project Presentation (Thesis Show)

Figure B Final Model in a Poor Lighting Area

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