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Product design's influence upon business management.

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THESIS

Product Design's Influence Upon Business Management

by

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I - Introduction</td>
<td>1</td>
</tr>
<tr>
<td>A. Importance and Growth of Industrial Design</td>
<td>1</td>
</tr>
<tr>
<td>B. Benefits Obtainable from Good Design</td>
<td>2</td>
</tr>
<tr>
<td>C. Goal and Scope of Study</td>
<td>3</td>
</tr>
<tr>
<td>II - Background and Growth of Industrial Design</td>
<td>5</td>
</tr>
<tr>
<td>A. Historical Developments</td>
<td>5</td>
</tr>
<tr>
<td>B. The Influence of Art</td>
<td>6</td>
</tr>
<tr>
<td>C. Art and Industry Join Forces</td>
<td>8</td>
</tr>
<tr>
<td>D. Reasons for the Unification of Art and Industry</td>
<td>10</td>
</tr>
<tr>
<td>E. Development of Some Common Products</td>
<td>11</td>
</tr>
<tr>
<td>F. Elements of Product Design</td>
<td>13</td>
</tr>
<tr>
<td>G. A Typical Example</td>
<td>14</td>
</tr>
<tr>
<td>III - Product Design: Basic Considerations</td>
<td>18</td>
</tr>
<tr>
<td>A. Determine Range of Company Activity</td>
<td>18</td>
</tr>
<tr>
<td>B. General Types of Business Activities</td>
<td>19</td>
</tr>
<tr>
<td>C. Adding or Changing Products Presents Problems</td>
<td>21</td>
</tr>
<tr>
<td>D. Decide Whether to Buy or Make</td>
<td>23</td>
</tr>
<tr>
<td>E. Determine Size of Output</td>
<td>24</td>
</tr>
<tr>
<td>F. Determine Quality of Output</td>
<td>25</td>
</tr>
<tr>
<td>IV - Product Development</td>
<td>27</td>
</tr>
<tr>
<td>A. The Need for Research</td>
<td>27</td>
</tr>
<tr>
<td>B. Conflicting Interests in Product Design</td>
<td>29</td>
</tr>
<tr>
<td>C. Economic Considerations</td>
<td>31</td>
</tr>
<tr>
<td>D. Organization for Product Development</td>
<td>32</td>
</tr>
<tr>
<td>E. Fundamental Considerations in Product Design and Development</td>
<td>37</td>
</tr>
<tr>
<td>F. Satisfy Consumer Desires</td>
<td>37</td>
</tr>
<tr>
<td>G. Costs of Research and Development</td>
<td>39</td>
</tr>
<tr>
<td>H. Coordination of Various Interests</td>
<td>40</td>
</tr>
<tr>
<td>I. Procedure in Product Design</td>
<td>41</td>
</tr>
<tr>
<td>J. Product Design Department Aids Other Departments</td>
<td>44</td>
</tr>
<tr>
<td>V - The Industrial Designer</td>
<td>48</td>
</tr>
<tr>
<td>A. Scope of Activity</td>
<td>48</td>
</tr>
<tr>
<td>B. A Typical Procedure</td>
<td>49</td>
</tr>
<tr>
<td>C. Another Typical Case Study</td>
<td>52</td>
</tr>
<tr>
<td>D. The Client Must Perform Certain Duties</td>
<td>55</td>
</tr>
</tbody>
</table>
### TABLE OF CONTENTS (Con't.)

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>VI - Utilizing the Industrial Designer</td>
<td>56</td>
</tr>
<tr>
<td>A. Recommended Procedure</td>
<td>56</td>
</tr>
<tr>
<td>B. Conflicting Views</td>
<td>51</td>
</tr>
<tr>
<td>VII - Product Design Reduces Costs</td>
<td>64</td>
</tr>
<tr>
<td>A. Means of Reducing Costs</td>
<td>65</td>
</tr>
<tr>
<td>B. Material Cost Reduction</td>
<td>70</td>
</tr>
<tr>
<td>C. Tooling Costs</td>
<td>74</td>
</tr>
<tr>
<td>D. Labor Cost</td>
<td>76</td>
</tr>
<tr>
<td>E. Summary and Review</td>
<td>77</td>
</tr>
<tr>
<td>VIII - Design Cost Control</td>
<td>79</td>
</tr>
<tr>
<td>A. Role of Cost Engineers</td>
<td>79</td>
</tr>
<tr>
<td>B. Organizational Status</td>
<td>80</td>
</tr>
<tr>
<td>C. Functions of Cost Control Engineers</td>
<td>82</td>
</tr>
<tr>
<td>D. Duties</td>
<td>82</td>
</tr>
<tr>
<td>E. Qualifications</td>
<td>83</td>
</tr>
<tr>
<td>F. Operational Policies</td>
<td>85</td>
</tr>
<tr>
<td>G. A Typical Analysis</td>
<td>86</td>
</tr>
<tr>
<td>H. Development of Case Histories</td>
<td>89</td>
</tr>
<tr>
<td>IX - Product Design Increases Sales</td>
<td>90</td>
</tr>
<tr>
<td>A. Greater Use of Industrial Designers</td>
<td>90</td>
</tr>
<tr>
<td>B. Competitors Turn to Design</td>
<td>91</td>
</tr>
<tr>
<td>C. The Professional Designer: Examples of His Work</td>
<td>92</td>
</tr>
<tr>
<td>D. Examples of Sale Increases Due to Design</td>
<td>97</td>
</tr>
<tr>
<td>E. Design Revives a Stagnant Industry</td>
<td>98</td>
</tr>
<tr>
<td>F. Good Design Aids Sales</td>
<td>99</td>
</tr>
<tr>
<td>X - Summary and Conclusions</td>
<td>105</td>
</tr>
<tr>
<td>Bibliography</td>
<td>110</td>
</tr>
</tbody>
</table>
CHARTS

Figure I - Organization of Development Department (10 Technical Men) . . . . . 35

Figure II - Organization of a Product Design and Research Department . . . . . 36

TABLE I - Comparative Data 94-95
Chapter I

Introduction

A. Importance and Growth of Industrial Design

In recent years the importance of industrial design has greatly increased. A number of factors have contributed to this growth. First of all, the desire on the part of the consumer for style and beauty in commercial products has steadily mounted. This desire for sleekness and beauty in products has increased the importance of company designers and independent industrial designers.

Quantity selling and competition have also increased the need for efficient style-wise products. The continued acceptance of a standard product has resulted in progressive changes in the outward design of the product. These changes in the appearance of the product have not in most instances been the result of overt attempts to improve this aspect of the product, but have been the outgrowth of engineering efforts to improve the functional operation of the product. By means of simplification, standardization and the use of new materials, engineering staffs were automatically improving the external appearance of their products and giving them a modern look, so appealing to a design conscious public.

The typewriter is a typical example. The first typewriters were extremely bulky and awkward looking. Gradually, as the demand for the product increased, major
changes were made and the machine became progressively smaller, more efficient and businesslike. The demand for increased versatility in the machine required an increase in parts but through better engineering the machine became more compact and stylish. The same has been true for a great number of other standard machines now in daily use both in homes and in industry.

An increasing demand for a product results in a great deal of competition among manufacturers of this product. This competition considerably aided the growth of product design. Competitors became aware of the fact that only through efficient design of their product could they make it more appealing to customers. At first, functional design was of prime concern but gradually style design grew in importance so that today these two, together with production design, are of equal importance.

B. Benefits Obtainable from Good Design

Today every consumer product and many industrial products have incorporated in them the fruits of painstaking work and thought developed by the engineering departments of manufacturers. However, the ultimate consumer has not been the only party to benefit from all of this effort. The manufacturers themselves have realized many benefits. Increased sales, lower manufacturing costs, more efficient use of men, materials and equipment have resulted from the use of efficient product design.
C. Goal and Scope of Study

The problem of determining a complete and definite picture of the role of industrial design in business management today is the goal of this project. The impact of efficient design and style design is felt throughout industry today. Various methods are employed in manufacturing concerns to achieve the desired design of their product. Although the methods may vary somewhat, nevertheless, it is possible to compare them and discover the points which are common to all. By comparing and analyzing these common features it will be possible to develop an over-all picture of the place and influence of product design in industry today.

Much has been written about industrial design but each written work has taken a narrow view of the subject. Various books have been written about the professional industrial designer and articles have glamourized this newest profession. Still other articles have pointed out the benefits derived from company designers.

All these written passages have covered a limited area of the over-all problem. Each has been concerned with its specific topic and has not related its topic with the others that make up the complete picture. The relationship between these topics will be indicated and their importance will also be noted.

This study will cover all the important phases of
industrial design. General principles of industrial design will be illustrated by discussing general conditions prevailing in industry. The more specific aspects of industrial design will be brought forth in the discussions of specific case histories of manufacturing firms.

Upon presenting these general and specific aspects of product design, a section of the thesis, entitled Summary and Conclusions will be presented. This section will present a summary of the complete project and certain conclusions and convictions of the author will be presented.

It is the goal of this endeavor to present a survey and discussion of the increasingly important field of industrial design and its past, present and future impact upon business management.
Chapter II

Background and Growth of Industrial Design

A. Historical Developments

Since the turn of the century such rapid progress has been made in product design, development and research that we are prone to belittle the contributions of the past. Considering the limited techniques and equipment previously available, one marvels at the accomplishments of our forefathers.

Before the discovery of America the natives of Guatemala were using fast vegetable dyes. The early Egyptians processed copper in a manner which even today defies duplication. Early history reports the use of gunpowder by the Chinese. Five thousand years ago the Mongolians were using tea leaves to treat trauma; in 1925 the Henry Ford Hospital of Detroit announced the modern counterpart of this remedy, the tannic acid treatment for burns. Modern scientists are constantly striving to unlock the past. The Rockefeller Institute has sent an expedition into the jungles of Brazil to study the herb treatments used there, hoping to discover in them valuable principles which are as yet unknown to the rest of the world.

* 3, p.100-101
Man is dissatisfied with the inherent state of many materials; they are heavy when he would prefer them light, soft when he wants them hard, and solid when they should be liquid. The more exact scientific methods of the nineteenth century have rectified these conditions. Schoenbin nitrated cotton and obtained nitrocellulose, which Hyatt discovered how to plasticize into a pliable product. Du-Chordonnet completed this nitrocellulose cycle by spinning the first filament. Despite the fact that rayon is often thought of as a modern product, its early beginnings appeared in the middle of the last century. Today, American chemical research in rubber and synthetic fabrics ranks second to none in the world, as does our medical research. World War II brought forth the development of synthetic rubber on a commercial scale and unlocked the secret of atomic energy. Future developments in the field of chemistry and atomic energy stagger one's imagination.

B. The Influence of Art

Man has always desired beauty in anything he possessed. Even primitive man, centuries ago, felt this need, for archaeologists have found weapons, vessels, and tools of many tribes and many cultures which have

* 3, p.101
rare beauty of design and perfect adaptation of form to function.

These artistic remains of ancient peoples have drifted into modern museums where they are classified as "decorative arts", to distinguish them from painting, sculpture and architecture. Many a visitor to a museum will casually pass them by in favor of the more obvious attractions of painting and sculpture. Yet these relics are the artistic ancestors of our present day utensils, appliances, and furniture.

Today, one finds in museums; the gorgeous wine bowls of the Han and Chou dynasties in China, cast in bronze and covered with intricate symbolic designs; ancient Egyptian amphorae and pottery from Cyprus; Scythian bronzes and the handsome burial bowls from our own Mimbres Valley in New Mexico. After viewing these relics it is soon realized that many designs we have today had their beginning in the dim past of civilization.

About the fifteenth century the artistry of man began more and more to be separated from useful ends. Art developed for art's sake, without thought of applying it to everyday life.

*4, p.5
C. Art and Industry Join Forces

This distinct separation between art and industry continued until the Industrial Revolution. The Industrial Revolution brought forth an increasing number of mechanical contrivances. They grew and developed without the benefit of artistic design. At the outset their inventors were so concerned with their functional aspects that they did not bother with such trivial matters as balance of form and color harmony. This was as it should be. The survival of such mechanical devices as lawn mowers, iceboxes, typewriters, washing machines, telephone sets and automobiles depended upon their ability to prove their usefulness. Finally, the manufacturer had to turn to the artist to help improve the appearance of these devices and appliances. At last art and industry joined forces and combined their talents to bring both beauty and functional efficiency into modern industrial products.

Today, we are chiefly interested in articles made by mass-production methods, this automatically shuts out several fields where artists have been traditionally an important factor in manufacturing, namely, in ceramics, glassware, textiles, silverware, jewelry, wall paper and furniture. These have always been sold largely on appearance, whereas, in the manufacture of engineered products like typewriters, usefulness and price were of prime concern of manufacturer and purchaser alike.
The artist-craftsman of the past usually spent most of his life working with a single material: gold, silver, porcelain or crystal. The modern designer now must work with a great number of materials in order to create articles for use today. For every material used, a number of different processes are available and must be considered to arrive at the desired finished product. However, these materials might generally be divided into two classes: the baser metals such as iron, steel, zinc, and aluminum which ancient designers neglected, and the synthetic plastics which were virtually unknown twenty-five years ago.

The sharp division between the old and the new, however, has not been merely in materials, but in basic techniques and approach. Master silversmiths and potters produced their products with their own hands: the feel of the metal or clay was in their blood and the resulting object, whether it was a coffee urn or vase, contained a part of the maker embodied in it. In mass-production industries, however, there is quite a difference. For example, kitchen ranges or vacuum sweepers must be perfected on paper, in the model shop and in the experimental lab. From then on, the designer never touches the actual materials again. The process of reproducing the product by the
thousands is the work of cold steel, guided by alien and indifferent hands.

Every product of the craftsman bore the maker's personal representative mark or symbol. The products of modern industry carry only the impression of the designer's mind. The close contact between product and initial creator is lost in modern industry employing mass-production methods. Though this closeness is lacking in the actual production, the ideas and imagination of the designer are incorporated in the product. Although modern industry does not utilize the archaic methods of production used by the old time craftsman, many of their artistic ideas are now employed. Not only the ideas of these craftsmen but also the very basic and more elaborate principles of art in general are now utilized in industry to enhance the beauty of many mass-produced products. Art and industry did not join together by mere chance, there were definite reasons for their unification.

D. Reasons for the Unification of Art and Industry

Two prime causes of this unification were: mass sales of identical objects and competition. Mass sales tended to increase the acceptance of a product and increased acceptance, by its very nature, had a natural tendency to

* 4, p.8
** 4, p.6
induce better appearance. This situation developed slowly, previous to any concerted action to improve the outward appearance of products. Although engineers were not aware of it, their continual efforts toward functional improvement and simplification of operation for the user, tended automatically to develop a smoother, more modern look in their company's product.

E. Development of Some Common Products

The typewriter is an excellent example of such a development of a commercial product. The first machines were incredibly awkward. Gradually, as volume of sales increased they became smaller and more business-like. Although later, parts were increased to meet the demand for greater versatility, the machine became more compact, more appealing to the eye and better engineered.

Another example of this development is the icebox or refrigerator. When mechanical refrigeration was first introduced, compressors were so large and so noisy that they were placed in the basement, and cabinets were little more than a crude metal box on stilts. Today with millions of units sold every year, the refrigerator has become a sleek, sanitary product with a great deal of eye appeal.

As long as any new device was still a curiosity

* 4, p.11
the public was chiefly interested in how it worked and what it would perform. When the device became commonplace, the public then demanded that its appearance be improved and its functional kinks ironed out. Today, industry is aware of the sales benefits of good looks so that styling and mechanical development of new products are more likely to go hand in hand.

One might ask about the Model T, stating that Ford continued to build cars along the same lines year after year without change. This is not exactly true, for a visit to the Ford rotunda at Dearborn will indicate the gradual evolution that took place in the Model T over a period of years. Although no directed attempts to streamline the car were made, the old high body was lowered so that the car began to hug closer to the ground. The high tops were reduced in height, and the old brass lanterns replaced by simpler headlights.

Ford's production, however, was so large that any radical changes in design became progressively more difficult to make until he was forced to by the competition offered by better styled competitive models. Since he took the step, the Ford Motor Corporation has been a leader in design for appearance.

The entire process of product evolution has been
greatly aided and abetted by cause number two: competition. When a manufacturer has a field all to himself he can easily dispense with good appearance; it is only considered a luxury. But when the field becomes crowded and the functional and technical differences between competitive makes become increasingly more difficult to discern, then good appearance becomes the distinguishing feature and now a necessity. The intelligent manufacturer must use every device at his disposal to gain a legitimate advantage over his competitors and design has proved to be a new and rather potent device with which to squeeze out those last few sales that may mean the difference between profit and loss. Just how design is utilized and the benefits derived from so doing will be illustrated later. Our attention now will be centered on the general picture of product design.

F. Elements of Product Design

Product Design has grown and developed until at present it is composed of three distinct yet integrated aspects of the complete problem. These three points of view are called, functional design, form design, and production design. We have seen how the first two, functional and form design, developed and joined forces. The third element, production design must also be considered in order to effect a sound product design. In considering the development and unification of functional and form design, it was assumed throughout, that the manufacturer was mechanically and economically
able to produce the product. This was a valid assumption, for in the past a manufacturer usually produced one or possibly a few items and in not too large quantities; therefore, his production layout was not very complicated and if another item was to be manufactured, suitable rearrangements could easily be made without seriously hampering the output of established products.

Today, with companies manufacturing hundreds of items, the situation is quite different. The present day product must also be designed to fit into the existing operational setup of a firm with as little trouble as possible so that production costs can be maintained at reasonable levels. Modern products must be efficiently designed from all three points of view to effect a product that will perform what is required of it, appeal to prospective consumers; and be economically feasible to produce.

G. A Typical Example

A simple illustration will demonstrate the necessity of an agreeable balance among these three elements of product design. Consider the design of a modern lawn mower. If a new lawn mower were being designed consideration would be centered, first of all, upon the ability of this new design to perform what was expected of it, namely its ability to cut grass. The person or persons in charge of the design would make certain that the lawn mower would cut evenly and cleanly, and would endeavor to have it cut everything in its
The mower would be designed for easy manipulation and durability. The mower should continue to operate for great lengths of time without losing its effective cutting action and ease of operation. Additional aspects of the design pertaining to its functional duties might probably be considered; these might include provision for lubrication, amount of noise made by the mower when operated, ease of cleaning and similar characteristics of the machine. Function design as we have noted has to do with performance in use and therefore is of primary importance when planning a new product.

Today, more than ever, it is not sufficient that a product merely do well the work which is required of it, in addition it must appeal to prospective buyers, it must incite consumer demand. A great deal of "streamlining" has been done to bring about this consumer demand. Form design seeks to create a demand that is based upon the physical appearance of the product. Streamlining a lawn mower certainly does not improve its ability to cut grass but might create a sale if its appearance appeals to a customer. Recently "deluxe streamlined" lawn mowers have come on the market; they have a more attractive appearance than the orthodox models. At least one manufacturer of lawn mowers included in a recent line several models featuring "centralized lubrication."
mowers had but one point to be oiled; pipes and ducts carried the oil from the central reservoir to the various friction points of the mowers. It is doubtful if centralized lubrication improves lawn mowers functionally but it may be an important feature if it increases the competitive appeal of this manufacturer's products. Many competitive products are indistinguishable from the point of view of their operating characteristics and therefore their sale is largely due to their physical appeal. Designing products to increase their buyer appeal apart from superior functioning of the product is familiar practice and an important requisite of a well-designed product.

Excellent functional and market design are of no greater importance than design in terms of production cost. Cost of production is greatly influenced by product design. It usually costs less to punch holes than it does to drill them. Thus good design from a production point of view will, if at all possible, permit the punching of such holes as are required. In addition, the fewer holes needed, the lower will be the cost of making holes. Few products designed in terms of function and market appeal are suitable for profitable production until they have been thoroughly redesigned in terms of manufacturing ease. Changes in design to simplify processing must not sacrifice excellence of functional

* * *
and market design. Occasionally some compromise between the three is necessary, but design excellence aims at a maximum of all: functional perfection, consumer appeal, and low cost of manufacture. It is the combination of the three that puts design on a business basis.*

* 1, P. 479
Chapter III

Product Design: Basic Considerations

A. Determine Range of Company Activity

The company's range of business activity must be determined by a firm before the design of products can be formulated. This may, on first glance, appear to apply only to firms which are new, but consider how this would apply to an established concern. One of the country's prominent airplane manufacturers found itself after the war with surplus plant capacity. One of the firm's plants was well adapted to the manufacture of light air-cooled gasoline engines. The concern obtained a contract to manufacture small air-cooled gasoline engines for a company that was introducing a small rotary-plow garden tractor to the market. When this program subsided, the firm again found itself with an empty plant. After investigating a number of possible business ventures, the company decided that what this world needed was a good power-driven wheelbarrow, and thereupon, launched itself into the power-driven wheelbarrow business. This program eventually failed. Doubtless one important reason for this was that the plane manufacturer had strayed too far from his own business and was not familiar with the problems of manufacturing and selling contractors' equipment.
B. General Types of Business Activities

There are manufacturing firms whose manufacturing is purely incidental to their main corporate purpose. Lever Brothers is in the business of making and selling soap. Liggett and Myers is in the business of making and selling cigarettes. For companies of this nature which have very high selling and advertising expenses as compared to manufacturing costs, manufacturing is primarily carried on because the item which they wish to sell can be obtained more cheaply or with more regularity of supply from a source they themselves own rather than from a purchased source. Companies like these may easily add new products to their lines if they require the same sales techniques or salesforce, and do not concern themselves too much with manufacturing techniques, for this is more of a service to them.

Some firms are in the business of supplying a trade group. Thus the Auto-Lite Company makes anything electrical to go into an automobile. This firm's product design is concentrated upon supplying the automotive electrical parts business, and the firm undertakes any type of manufacture needed to meet the requirements of this business.

Other firms are in a business which requires them to offer a full line of products. Certain hardware companies, although originally in the brass business, find
themselves fabricating many different types of materials in order to supply a full line of hardware for their salesforce to distribute. There are firms which are in a business which revolves around a specific process. Metal stamping firms, plastic producers, textile bleacheries, dye houses, electro-plating firms, and many others are examples of this type of business. Here, the main concern of the firm is performing a certain type of process, although the products may go into items sold in many different fields. Some firms of this type offer for sale no particular product but the skill of a certain group of employees or the use of a certain type of machinery which they may possess. A number of firms have carried this type of business to the point where they do not own the material which they process. Electro-plating firms typically own no material in process and merely offer their services to electro-plate somebody else's product.

There are other firms whose business revolves around a certain type of material. Leather firms are in the business of processing hides, aluminum companies make aluminum. The Bridgeport Brass Company handles brass and the United States Steel Company makes steel. Products of these firms may go into many different fields, but the firm itself is in a business revolving around a certain type of material.

Some firms are in the business of producing some sort of individual product. Thus some firms are in
the shoe business, some are in the novelty hat business, and some may be in a broader field such as that of cotton textiles. These firms may perform only one operation involved in making cloth, or they may be vertically integrated to such an extent that they process cloth all the way from cotton bales to finished shirts.

C. Adding or Changing Products Presents Problems

Determining the scope and extent of business activity to be conducted by a firm is extremely important in the field of product design. It is the decision to abandon one type of business or to broaden out into a different type of business which is the rarely made, but highly important product design decision. The decision of Henry Ford at one time to make a three-motored airplane; the decision of one machine tool manufacturer to enter the road machinery building business; the entrance of a mid-west lathe manufacturer into the loom business; the decision on the part of the officials of the Fairbanks Morse Company to go beyond their original business, which was that of making scales, and to enter the diesel engine field and the pump field; and the fairly recent venture on the part of the Gillette Safety Razor Company into the field of home permanents, exemplify decisions which have been made to enter an alien field of business.

If a firm makes a new product which involves the same manufacturing field with which it is familiar and the
same selling field with which it is familiar, the product decision and the whole problem of product design is one which is suitable to fairly accurate sales estimating, relatively simple design engineering, and not too unfamiliar production engineering to start operations, and relatively small risk. If the new product involves a new manufacturing field but selling in the same field, as might be the case should an automobile manufacturer decide to produce a 1951 model with a plastic body, there need be no major difficulty, save that the firm must make a great number of mistakes in a new field which will be costly, and during this period might compete with firms that know this particular business better.

As a rule, the next most radical move in the field of product design is to produce a new product which involves similar manufacturing techniques, but selling in an unfamiliar territory. Here again, the firm must compete with those who are experienced in selling in this different field and may often be surprised by the time it takes to get a marketing foothold in the new area.

Very seldom do we see an established manufacturing firm producing a new product which involves entirely different manufacturing techniques, equipment, or personnel, and selling in a different field. Rather, most firms add to their product line or develop new products in
a curious step-wise fashion. Selling in one line may result in the expansion of manufacturing activities in order to supply a full line of products. This may result in the widening of sales activity into different fields in order to keep the newly developed manufacturing facilities busy. Selling in this new field may involve new manufacturing in order to supply a proper line of products in the new selling field, and so forth. There are many examples of firms which have been over-extended beyond their natural or effective size by this process.

Thus far, we have been discussing the problem of what to design and surely this is the basic problem of product design. Implicit in this problem are the problems of simplification, standardization and diversification. We shall not discuss these problems here, but may note that the center of thinking in these areas must revolve around the firm's decision as to what is its natural or most effective type and size of manufacture and distribution.

D. Decide Whether to Buy or Make

Assuming that a decision has been reached as to what product to make, perhaps the next problem is that of buying it ready-made or making it, or its components, one's self. Most manufacturing firms like to manufacture their own products, but if the firm is a firm whose primary business is selling, such as a soap firm or a cigarette firm
it may be that the firm can purchase the item cheaper than make it itself. It is a phenomenon of good times that firms tend to make products which they might in normal times purchase more inexpensively. In good times the problem is that of being sure one has the product on hand at the right time, of the right quality, and in the right quantity. Many firms make products at higher cost than they may buy them so that they will not leave their sales force stranded.

E. Determine Size of Output

The problem of buy or make is often resolved as a result of the decision or the estimate by the firm of how many products will be made. If the sales forecast indicates that the product will be sold in high volume, naturally the firm may expect a more effective manufacturing operation. More important, the design of the product itself may be radically changed. It may be designed for die-casting instead of being made by a sand-casting. It may be a plastic molded item rather than a turned wood item. It may be a piece which is designed to be manufactured more easily upon an automatic screw machine than upon a lathe. The product may be designed so that it lends itself to line production assembly techniques, and so forth. This is a critical decision, for it is tragic in many instances, to observe firms which have invested large amounts of capital in dies, fixtures, and manufacturing setups.
only to achieve a low sales volume. It is also discouraging to note some products which are not designed for volume manufacture which are being manufactured by these means. A basic difficulty in ordnance manufacture during the war was the fact that most guns and other pieces of ordnance equipment were designed during peacetime when only a few were to be manufactured and the basic design was not by its nature easily adaptable to high-volume war production.

F. Determine Quality of Output

The "how many" decision is closely allied with the decision as to "how well" the product shall be made. Quality in itself is not necessarily a good end. The product design problem is that of producing the best possible product within a given price, quality, or marketing range. This decision is of vital importance because it may sometimes take a firm out of its established field. The decision of the Packard Motor Car Company in 1935 to produce a medium-priced car had many long-run implications for the firm. It meant a basic re-tooling of the entire manufacturing plant. It meant a re-casting of the firm's entire sales efforts, development of a different type of dealer, and inevitably meant a decline in the public eye of the quality associated with the hitherto high-priced Packard Car. The product design problem here is that of determining the quality level and of designing a product which meets that level.
This may often be difficult. In the low-priced radio field, for instance, the important design problem is that of balancing cabinet cost, which is a surprisingly high percentage of the manufacturing cost of the radio, against component cost. The quality variables here in finish of cabinet, durability, size and style, as compared to excellence of electrical circuit, quality of component, quality of wiring job, life of electrical circuit, make for a very interesting product design problem.

Having reached answers to these questions, a firm is now ready to undertake a specific design of a product. Year by year this problem becomes more interesting because of the widening area of choices in industrial processes which occurs as all manufacturing technology becomes more advanced. Our concern here, however, has been to indicate that the decision as to basic area of business, the decision to buy or make, the forecast as to how many will be made and its effect upon design, and the decision as to how well to make the product are the basic questions which must be answered before a design may be undertaken.
Chapter IV

Product Development

A. The Need for Research

In the preceding chapters there has been indicated the necessity of achieving a perfect balance among the three elements of product design and of carefully selecting the product which is to be manufactured and distributed. The department, or departments, within an organization concerned with the development of company products will now be the object of some attention.

In the past, when many firms were small, the responsibility for product design was assigned to the engineering staff of the company. As manufacturing concerns grew in size and complexity another department; the research department, was formed to aid in the development of company products. Today, the departments of product engineering and research have such closely related objectives that we shall consider the two as one distinct entity concerning itself with product development.

Any business of substantial size operating in a competitive market is faced with two types of situations demanding technical research: (1) the need to solve problems relating to current operations, and (2) the need to develop new products, to improve the present product, or to find new uses for existing products. Regardless of
how smoothly an industry may be operating at a given time, new problems are constantly arising that require research to overcome. New products or improvements in old products are demanded in our competitive economy. Some small enterprises in their early stages may not be financially able to conduct elaborate research activities, but as they become well established they can no longer depend upon the leadership of others, they must display leadership of their own to remain in a competitive position. Most companies grow slowly and enter research as a natural part of that growth. This statement, of course, would not be true of a new enterprise conducted by a large concern, such as the General Motors Corporation or the E.I. du Pont de Nemours & Co., Inc., which has at times conducted intensive researches in its main laboratories and then built complete plants with the newest equipment to develop the findings of its researches.

One might define research as the search for new information by the experimental method. Pure or extensive research seeks truth for its own sake without regard to its possible utility, whereas applied research seeks to solve certain problems with consumer utility as the final goal. Intensive research strives to increase

*3, p.100
our knowledge about certain things so as to enable us to improve them or reduce their cost, or both, as well as to create new uses or service. Both types of research have their proper place within our social structure, one cannot claim any superior status over the other. Industry, however, is primarily interested in research in the economic and social sciences and in materials, equipment, and processes. Industrial management is chiefly concerned with research in materials, equipment, processes and the product manufactured. Industry makes greater use of intensive research but extensive fundamental research serves as a stimulus to more effective intensive research.

B. Conflicting Interests in Product Design

There are many conflicting interests which have great influence upon the ultimate design of a product. The sales division tends to work towards diversity, whereas the production group strives for standardization. The sales division might offer the following factors which favor diversity:

1- The necessity of meeting the needs, desires, and purchasing capacities of various consumers.

2- The gain in sales appeal through product changes so that the merchandise appears to be up to date.

3- The need to meet price competition by changing

* 3, p. 101
construction of the product in minor details so that the price may be slightly reduced.

4- The necessity of meeting several competitors' products of varying design or varying materials.

5- The limitations imposed by process or design patents of the particular company or its competitors.

6- The desirability of developing several competing but dissimilar lines to enlarge the number of retail outlets.

7- The continued development of technical processes and equipment and adjustments to take advantage of the possibilities of these developments.

The design engineer that can effect diverse-appearing products from standard materials and processes is usually the leader in his field. Certain products cannot be constructed from standard materials and processes. This situation would then require careful consideration on the part of management, for the factors which exert an influence toward standardization present a strong argument. These factors would include:

1- Lower investment in plant, equipment, materials, and finished inventory.

2- Resultant price reductions, so that the market for the product is enlarged.

3- Interchangeability of parts if product is mechanical.

4- Possibility of development of automatic equipment or standardized chemical or mechanical controls.

* 3, p.102
The nature of the product will greatly influence the decision management must make regarding the problem of diversification vs. standardization, however, if such a problem exists management must be extremely cautious and careful. A misstep might result in ultimate ruin for the concern.

C. Economic Considerations

Before deciding to undertake a research project or to utilize the results of past research, it is necessary to analyze the economic considerations. Investment in machinery and equipment must be compared with the immediate savings which will be made, by the necessity of reducing production costs to meet competition, by the possibility of new processes replacing the processes which will use the equipment whose purchase is being contemplated, by the life of the equipment, and by the prospective length of life of the design of the product on which the contemplated new equipment will be used.

Research and analysis inform the plant owner that he can improve his product or cheapen its price by improving his production facilities, but in times of depression he knows that he must maintain the most liquid position possible, that he must utilize the old-style
machine or the old-style process a little longer, no matter how dissatisfied with it he may be. Enterprises in a strong financial position do not lay off their research workers and do not stop process development; they keep at work, and when conditions improve, produce products which are demanded by the consumer. Therefore, we must consider product development as a project that continues under all economic conditions, if this is not done, a firm will soon realize that its competitive position is lost.

D. Organization for Product Development

Bearing in mind the above-mentioned problems, we will consider the nature and composition of the organization devoted to product design and research. Many phases of design and research require painstaking preparation and exhaustive investigation. Active participation in production routine is not conducive to this type of work. It will often be neglected entirely unless a particular executive has a special personal liking for it, and in this case, production frequently suffers from lack of attention. It is doubtful if there is any phase of organization where specialization gives greater returns than in the field of design and research. Any type of creative work takes time.

The mistake is often made of laying the major emphasis on buildings and equipment, but in reality the
buildings and equipment are not as important as maintaining the right state of mind and providing the necessary amount of time to pursue the inquiries. The factors that foster efficient product development and research are: time to pursue the investigations, an inquiring state of mind or experience in systematic investigation, and the facilities necessary to carry on the research.

The product engineer should occupy a position of trust and responsibility in the organization. In many of the larger enterprises he is a vice-president on an equal status with the sales manager and the factory manager. The research division may be a section of product engineering; product engineering may be a division of research; or the two may be entirely separated. Where the two are united in the same organization, there is more likelihood of a closer tie-in with actual production problems. If research is really to function, it must be allowed to work on its primary objective and not have to direct its attention to tasks that rightfully belong to the producing departments or inspection. It is an ever present temptation, particularly in highly technical processes, to call upon the development and research department when production encounters difficulty. Regard-

* 3,p.103
less of the position in the organizational structure of the product engineer, if he is to be effective he must work closely with the production, purchasing, and sales departments.

Figures 1 and 2 illustrate the organizational structure of research and development departments, depending upon the number of men in each. In Figure 1, the department is composed of ten technical men. Groups 6, 7, and 8 are primarily concerned with product development and are responsible to the director. Groups 1 to 5, working under the assistant director, will handle both process development and pure research, with primary emphasis on process development. Patents in such an organization are usually handled by the director in consultation with outside attorneys. Figure 2 illustrates an organization having one hundred technical men, hence the higher degree of specialization.

* 3, p. 104
FIGURE I. ORGANIZATION OF DEVELOPMENT DEPARTMENT (10 TECHNICAL MEN)
FIGURE II  ORGANIZATION OF A PRODUCT DESIGN AND RESEARCH DEPARTMENT
E. **Fundamental Considerations in Product Design and Development**

Regardless of who is actually charged with the responsibility of product design, certain basic fundamentals should be followed in order to insure sound results. These fundamental considerations are as follows:

1. The desire of the consumer for utility, quality, style, and color within a given price range must never be ignored.

2. The cost of product development must be kept within the capacity of the business enterprise to pay.

3. Due regard must be given to the effect of introducing the new product upon the rest of the company's products, both from a selling and manufacturing point of view.

4. There is need for coordinating the various departments interested in design, such as the methods department, the manufacturing division, the purchasing department, the sales department, and last but not least the finance division.

F. **Satisfy Consumer Desires**

The main objective of a business concern is to satisfy the customer in order to achieve a profit on the operation. A great deal of production is done in anticipation of demand, therefore, it is necessary to anticipate the consumer's desires in marketing a new product or an improved one. The consumer desires not only style, color and utility but also ease of maintenance. The

* * 3, p.105
product engineer should strive for accessibility for maintenance and bear in mind that the product will be repaired in the field where facilities are not the same as in the manufacturing plant. The feature of low maintenance cost provides a strong selling point for a product.

Many concerns have devised means whereby they might find out from the consumers themselves what they want in a product. General Motors developed an interesting technique for this purpose. The firm sends out thousands of attractive booklets that show current and possible designs, colors, upholstering materials, improvements, and other features. These are conveniently arranged so that persons receiving them may easily check their preference and place the booklet in a return envelope. These replies provide a basis upon which the corporation can determine consumer desires. There are special market-research corporations that will conduct a consumer study for a fee. They may use a questionnaire or send out representatives to interview a representative sample of customers. The sound business enterprise will seek to determine future consumer desires, the method that is used will depend upon the nature of the product, ultimate consumer and financial position of the firm. The method is not important; the fact that
some medium is being used to determine consumer wants, is.*

G. Costs of Research and Development

The development engineer seldom can estimate accurately the cost of a given program at the time of his initial request for funds. If it is a relatively simple program and he knows exactly what has to be done, his initial cost estimate will be fairly accurate. Cases of this mature are rare in real development of a new product or process. Usually there are so many unknown factors that an accurate estimate is impossible. The sound procedure is to budget developmental and research costs and to keep an accurate record of all expenditures for each project. This type of a program will tend to keep costs in a balanced relationship to each other and prevent all available funds from being spent for one purpose when other problems also demand attention.

The question of what percentage of profits or sales should be spent toward research and development is continually raised. Some answers state that this estimate should be ten percent of profits or two percent of sales. These estimates are of no use. When a company is confronted with a number of problems requiring solu-

* 3, p. 105.
tion, the budget may be easily in excess of the estimated two percent of sales, provided of course that the firm is financially able to meet this demand. No set ratio can be established; each case will be different and the budget should be established according to the needs of the development program.

H. Coordination of Various Interests

If a new product will compete directly with a product now in the line, management must decide in advance just what policy to follow. Should the product be marketed by the same sales group or have a different sales organization, such as is used by General Motors in marketing the Oldsmobile and Buick automobiles? Will the present manufacturing facilities be adequate for the old products as well as the new? If the new product is the same in type but different in quality from the regular line, what effect will producing the new one have upon the production of the old line? Will the new product tend to lower or to raise the quality of workmanship on the old one if both are to be produced by the same workmen? These and similar questions must be answered by management in advance of production if disastrous results are to be avoided.

The logical method of resolving the various

* 3, p.106
conflicts of interest is to have all interested divisions partake in the final decision. Usually the design engineer will consult the methods department and the manufacturing division as he develops the design of the product in question. This coordination may result in changes in the design that do not interfere with the basic operation of the product yet makes possible the use of existing equipment, and thus avoids any unnecessary expenditures for new equipment. The design engineer, by working closely with the sales department, will have the benefit of practical customer reaction as well as the enthusiastic support of the sales group in marketing a product for the design of which they feel some responsibility. The purchasing department may render valuable suggestions regarding economies in buying certain materials or parts that may be specified especially in terms of standards and dimensions that are used in the trade.

I. Procedure in Product Design

The original request or initiative for a given product design or a research project may come from a customer, the sales department, an officer of the company, or the major executives as a group, or as the logical result of evolutionary product development originating in the problems facing the business. The development of the product may arise from the company's purchase of an invention, patent
or incompletely research; however, the work more generally develops from internal investigations carried on within the firm.

The management of an automobile firm, for example, may decide that it wishes to present to the public a car that will sell in the $900 class. This stipulation will then be the controlling factor. Since there is a fair relationship between the selling price and the weight of the car, the total weight of the car can be approximated to a fair degree of accuracy. The next decision could concern the wheel base, here the sales department may agree merely to meet current competition; in this event the over-all dimensions are already established by trade standards.

Since there are many specialized parts in an automobile, the chief product engineer would then assign to each special group its particular task with proper requirements pertaining to the weight and cost of the units. These special units might be listed as the frame, lubrication of chassis, the engine, ignition system, clutch, transmission, spring suspension, wheels, tires and body. Each of these major divisions may have several subdivisions; the body, for instance, will at least have body contour, paint, trim or upholstering, and body hardware. Since nearly all cars give satisfactory performance, the actual mechanical working parts are fairly well standardized, and may be easily adapted to the current design with minor improvements that may reduce
costs or increase efficiency.

The general appearance of the car will greatly influence the popularity of the current design; therefore, attention must be given to the design of the body proper, cowling, and radiator. A design specialist may work on the rear, another on the side view, another on the windshield, another on the hood and cowling, and still another on the front. The completed results of these specialists may then be put together into one drawing to give the general picture of the projected product, which may have to be revised to obtain a harmonious result.

Another method might be utilized. In this method, which incidentally has become increasingly popular in recent years, an artist sketches the completed design and then makes changes until it meets with the approval of the major executives. The specialists are then assigned their segment of work to harmonize with the artist’s approved design.

A temporary wooden or plastic model will then be made, painted, and possibly upholstered to serve as a complete model. This will probably be changed a number of times until it receives final approval. The dimensions of the final model will then be transferred to an aluminum sheet to avoid any distortion that might develop due to temperature changes in the room. Body dies will be built from this metal sheet and production will later begin. Any major mechanical changes that have not been previously
tested on the road will receive extensive road tests before the car is marketed.

J. Product Design Department Aids Other Departments

The product design department may reasonably be expected to offer certain special services to the other departments in the organization from time to time, especially to the sales department, manufacturing department and top management.

The product design and research division’s first responsibility to the sales department concerns the existing products. They must keep the products which the sales department is selling at the top of the list of competing products within a given price range. In the automobile-tire industry the research laboratories are constantly making complete and detailed chemical and structural analyses of competitors’ products. The research and design division must not be caught napping by competitors.

A sales division has the right to expect from its product design and research group a reasonably constant flow of new products within their field of operation. A reservoir of potential products should be available for

* 3, pp. 107-108
** 3, p. 110
addition to the current line when needed. These potential products should be developed beyond the laboratory stage and should have had some minor field tests conducted under the supervision of the product design group. On the other hand, it is the responsibility of this group to separate from sales consideration those new products which are technically weak.

A third responsibility arises in connection with the interpretation of technical data and results so that they may be utilized to the greatest advantage by the sales department. Technical help of this nature can greatly aid the effectiveness of the sales effort. The advertising function can be appreciably aided by a close relationship with a cooperative and sympathetic scientific group. This relation should imply that a state of reciprocal responsibility, mutual interest and intelligent cooperation exists.

The product design group must have a close relationship with the manufacturing department. This is needed to insure the efficient production of prospective undertakings. Through this cooperation the design group may be able to suggest changes that will result in the improvement of processes. This does not mean that the work of the mechanical department charged with methods

* 3. p. 110
improvements will be supplanted but rather supplemented by any work carried on by the design group relating to this subject.

Management benefits from the design and research group in a number of ways. This group evaluates the many new scientific discoveries emerging upon the scene in terms of the organization's products. The newer scientific equipment also falls within this category as is evident in the adaptation of the principles of the radio to the determination of noises in automobile transmissions and the use of X-rays in detecting defective castings.

Whenever scientific meetings are held, reports of such meetings are scrutinized by the design and research divisions to discover any latent possibilities of new products or processes. Management should expect such aid from this group if the organization and financial structure of the concern permit.

Another responsibility of the product design and research departments to management lies in the field of patents. Although the actual patent litigation is handled by the legal staff, much of the original data used by the legal division must be provided by someone else. Research and product design result in patents. The laying of a firm

* 3,p.111
foundation for a patent policy goes all the way back to the laboratory notebooks and the records of the product design department, where intelligent and adequate notations should be made and samples and models developed and carefully filed away for later reference. The writing of patent specifications is a cooperative task between the product design representative and the patent attorney. In subsequent litigation a great deal of the success of the firm will depend upon the presentation of adequate and proper records dated during the period of development and research.

* 3,p.112
Chapter V

The Industrial Designer

A. Scope of Activity

When industrial designers initially made their appearance upon the business world all of their talents were not exploited by patronizing firms. The designer's attention was forcibly focused on the external appearance of the product or structure only. All the preliminary phases of economics and production were determined before the designer was summoned. This short-sighted view was all right for the late twenties for at that time there was much room for improvement in machine-made articles. However, with each succeeding design project, the designer encountered increasing sophistication, both the public's and manufacturer's. There were more and more questions requiring precise answers. Many of these queries touched on subjects, such as, economics, production and distribution which hitherto were solely management's concern. The designer had to explore these areas in order to effect sound designs. Today, the industrial designer does probe into the subjects of economics, production, distribution and the like, to answer questions that will direct him to the design that will be best suited for his client. The clearest way to prove that this procedure is currently followed is to examine a typical procedure.
B. A Typical Procedure

A vehicle for public transportation, for instance, presents a good case. With minor variations, such a program would be followed for either train, bus, air transport, or steamship. The systematic procedure as a whole could be applied to any product worthy of consideration. The files of the noted industrial designer, Raymond Loewy, yield a record which can be considered representative of a thorough investigation into a product under consideration. This typical procedure is as follows:

Step I- A new type of service is to be offered the traveling public. This is the problem which the client presents to the Loewy organization. Perhaps the project may have started with only the consciousness that a new type of service is needed, present facilities proving inadequate or antiquated. The company asks the designer to explore possible solutions. Therefore, a study may be made of existing types of motive power, physical limitations and potentialities of the company system, the possible passenger reaction to new service, etc.

While the vehicle itself is the prime factor, all other considerations affecting the service system

* 9, pp. 31-32
must be understood, that is, personnel requirements, uniforms, terminals, waiting rooms, baggage accommodations, food services, ticket offices, signs, and feeder routes. On the basis of these findings, the design organization submits a preliminary report and a first broad conception of an over-all program.

Step II- At this point the designer examines certain aspects of the problem which may need more careful study. Although his preliminary presentation is in the hands of the client, he is not idle. Engineering, traffic, operating and sales departments of the company discuss the designer's presentation with him to arrive at a clearer conception of specific problems to be solved. The problem is re-presented to the designer for refinement after the elimination of such features as the company deems impractical or inconsistent with its aims.

Step III- In collaboration with the engineering and operating departments of the company, further studies are made of motive power, structural form, and interior arrangements of the proposed vehicle. During this stage usually a full-scale mock-up of the vehicle is built under the designer's direction. Within this model alternate arrangements are tested. Considerations of structure, seating, comfort features, main-
enance, dimensions are checked and re-checked to achieve the best possible three-dimensional form.

To augment the mock-up, renderings are made of the vehicle as it might appear in operation; details and perspective drawings are prepared for presentation to the company. Perhaps, also, a small-scale model is made so that exterior styling may be demonstrated. This model, in soft clay, may be revised to comply with successive changes of exterior design. Reports from the designer's engineers and estimators are attached.

At this point the management must make the decision that commits the further course of the company. On the basis of the findings and recommendations, to date, it is possible for the company to predict within a margin of safety the practicality of its undertaking. If the decision is to proceed, the company now assigns the designer to the task of seeing his design through to reality.

**Step IV**—The dimensions, capacity, construction, and arrangement of the vehicle having been decided, the design organization now studies design details, such as, seating, berths, lavatories, lighting, wall and floor coverings, upholstery materials, color treatments, galleys, hardware, accessories—testing as many as he can in the mock-up built previously.
Step V- After approval of specifications, working drawings are made, and the designer now moves into the builder's shop to check work progress. Contractors may bid for the various jobs at this point, either through the designer's office or the company, as the case dictates.

Step VI- Throughout various stages of construction, and installation, the designer supervises so that he may advise on interpretations of design to insure accurate reproduction.

Step VII- Even after the vehicle is in service, the designer's organization usually inspects or actually supervises its maintenance. In the case of major design projects, such as a ship or a train, the designer protects his own company's interests by establishing a permanent maintenance schedule on the unit. As time elapses, the consultant can recommend redecoration, alteration or new equipment.

Once a train is streamlined, the company may want a modern station to match it, modern ticket offices, and then some work on feeder lines connecting with the new route. There is nothing like a new clean design to make old-fashioned equipment look so outmoded.

C. Another Typical Case Study

The case history just presented does not suffice to cover the new role of the designer in all fields. It
was presented to give the reader a sample of the techniques an industrial designer might utilize to solve a particular design problem. In product design, packaging, department store design, more and more is being required of the designer. Department stores illustrate the point strikingly. At one time, no designer did more than design the sales area, fixtures, display and decorative treatments. The same forces that made it necessary in the case of transportation to reach further back into economics and planning have made it equally necessary in the case of stores to investigate market centers, potential volume, transportation and communication, city planning, mechanization and personnel.

Consumer polls and market analysis are the work of specialists. The findings of such surveys, however, are important to the planning agent in determining layout and structure for any type of retail store. Therefore, the industrial designer must participate, at least in an advisory capacity, in these preliminary investigations.

Today a typical development might be pursued by the designer in the following sequence:

Step I- Analysis of market to determine geographic dis-
tribution and potential volume.

Step II- Analysis of competition.

Step III- Study of buying habits from which lines of merchandise and price ranges are determined. (These considerations are major in deciding the form of the building to house such goods.)

Step IV- Prepare merchandise plan and fixture layout for sales and service areas. A study is made of mechanization to increase efficiency and to reduce handling operations.

Step V- Design of structure to house accepted features. Interior and exterior design, lighting treatments, etc., are presented in finished drawings for decision of client.

Step VI- Preparation of detail and working drawings in blue print and section drawings. Color schemes, furniture construction, samples, etc., are prepared for final approval. At this point plans are in a stage for awarding contracts.

Step VII- Supervision of construction and installation.

Similar efforts are being made in the design and merchandising of non-consumer goods. Not only the department store, but chain store systems, and some new entrants into the retail field are using the designer to correlate their programs.

Until recently, the products alone had been the
subject of the design study; no previous attempt had been made to "sell" these effectively. It was found that some of the advantages of the products were lost when they were placed next to other products of the company which had not been modernized or when they were displayed with competing products by other manufacturers.

D. The Client Must Perform Certain Duties

We have thus far witnessed typical procedures followed by an established industrial designer to effect a sound design for his client. However, a design problem can not be completely solved by an outside industrial designer; much must be done by the client himself. The client and the consultant design firm must work together; cooperation and mutual understanding must permeate the undertaking from start to finish. A great deal of work must be accomplished within the organization of the patronizing firm. Regardless of the scope and nature of the design problem under consideration, a number of activities and decisions must be attended to by the client. What must be accomplished by a client to efficiently utilize the services of a consultant design organization is the topic of the following chapter. A noted industrial designer, J.F. Barnes, illustrates a number of steps which a client should follow in order to insure the realization of sound results to a design problem.
Chapter VI

Utilizing the Industrial Designer

A. Recommended Procedure

If a firm hires a designer to rejuvenate its product a number of rules should be adhered to in order to give him full opportunity to effectively utilize his specialized skills. Product design and styling are so universally proved sales stimulants today that practically every manufacturer is design-conscious. However, awareness of the importance of design is not enough; how to effectively use your designer is also necessary. J.F. Barnes, President of Barnes & Reineck, Inc., Designers & Engineers of Chicago, suggests the following steps be used to obtain the most out one's product designer.

1- Appoint a design committee

In your company, who is responsible for the styling of products and packages? Is this individual qualified for this important assignment? Does this person have the time to investigate the many phases of your business which will be affected? Is this individual qualified to guide product development from the angles of merchandising, advertising, sales, engineering, production, packaging?

* 17, pp. 94-98
All too often the manufacturer is tempted to let someone in the advertising department handle this job because he studied art for two years. Others may turn it over to a member of the engineering department because of his artistic abilities.

Product styling and design is much more than art. It is art, plus the knowledge of merchandising, manufacturing techniques, the ability to forecast future trends, and the knowledge of what other industries are doing.

Experience with hundreds of clients has proven to Mr. Barnes that the soundest approach to product styling is through a design committee. Such a committee should be made up of all executives who are directly or indirectly concerned. These should include engineering, sales, production, advertising, export, general management, and the company secretary to represent the legal trademark and patent aspects. Within such a group, decisions can be made in advance which can save costly delays, unnecessary experiments, and impractical attempts.

2- Give the committee the authority to act

Their job is to make all plans, set schedules, make appropriations — to direct and improve designs. Make certain they have the authority needed to accomplish the objective.
3- Decide objectives

Avoid the mistake one manufacturer made when he engaged a designer to style a new stove. He wanted a stove design that was ultramodern. But before going into production he pointed out that the handles that had been designed, though entirely practicable and easily produced, were more expensive than stock handles. The stock handles he referred to were eight years old, and had been used on competitive stoves for several years. His objectives were not clear - he wanted a new design, but at the same time he wanted to use stock parts that were eight years old.

4- Investigate carefully

Certain limited basic information about designers is in the classified directory. It is important to talk to others in your field who have successfully used design. Ask the designers themselves what clients they have served, and specifically what they designed for those clients. Be certain that the designer you select knows more than mere esthetics. Find out if his practicality adds up to the "know how" necessary to produce your product at a minimum cost, the "know how" to appeal to the masses, coupled with "smartness" that inspires successful merchandising.

5- Give your designer complete information

There is a lot more to his work than just esthetics. He should know company policy and objectives;
what your competition is; your distribution set-up, real or proposed; your competitor's plans, in so far as you know them; your production facilities.

Often it is necessary to begin preliminary design discussions by pointing out objectionable features of the product as it stands, and specifying specific improvements wanted.

6- **Place full confidence in the designer you choose.**

Turn over your problem to him with adequate information, and leave him to do the thinking about the design. That's what you're paying him for. It's to his advantage to keep your products styled to meet the ever-changing standards of the market. He wants you to call on him again and again.

7- **Give your designer the greatest possible latitude in the selection of materials.**

Do not choose materials simply because of your own inventory situation. It is possible that those materials you have on hand can be diverted to other products. If the designer does not specify them it is because he is sure your product will enjoy better sales acceptance with other materials. The competent designer resists this pressure. He knows the three M's of product design - mass appeal, merchandising and manufacturing methods. He knows, for example, that a juke box should be designed with all
the practical razzle-dazzle of chrome and plastics to make it a winner; but that a motion picture projector must be designed in a more sedate manner.

8- Don't select a design just because you like it

Too many clients merely wish the designer to use his hands instead of his brains and expect the designer to interpret their ideas as the (the clients) want them interpreted. Often they think in terms of tinsel and fake glamour, believing their ideas on design are so sound and ful of merchandising sense that a designer is merely employed to fulfill their lack of drawing ability. This should never be the case.

9- Try to add new selling features.

Whether you're starting from scratch in a new field, or simply trying to strengthen your position where you're already established, try to get something better, something brand new, something your competitor doesn't have and something the public wants. The fact that you have it, and your competitors haven't, is a powerful sales argument.

10- Don't turn down a design solely on impracticality

It is possible that new materials or new methods would make these designs practical. The Wright brothers were impractical, too. So was Leonardo da Vinci when he built a flying machine. At some stage of creation, every
important new development seems impractical.

11- Don't reject a design only because it's harder to make

You will sometimes find that engineering and production will want to make a product in a certain way because that is the easier way. They aren't trained to think in terms of sales appeal.

12- Insist upon models before starting production

The designer doesn't necessarily want to engineer the job, but he should give your engineers the exterior contour details and assist in supervising the work so that no major departures are made from his design. It is advisable in most instances to have a wood mock-up, scale model or working model made of the newly designed product. It can prevent costly errors.

13- Make certain that all the design values are actually built into the product

Make sure that your engineers do not make production drawings from the designer's preliminary sketches. Disastrous results have occurred when manufacturers have tried to rush into production before the design was completely engineered. When this has been tried, the original design usually has been so distorted that the merit of the designer's idea has been lost.

B. Conflicting Views

It is well known that the days of the "better
mousetrap" axiom are gone forever. The best product will not sell in profitable volume without an equally good marketing and merchandising plan in the hands of a well integrated, hard-hitting sales division, supported by adequate advertising. Therefore, in the design committee, the voices of those responsible for distribution should carry the greatest weight. If sales management agrees that it can do a good job with the new product, even though it is harder to make or costs more or requires new equipment, the sales manager should have the authority to carry out his responsibility. Naturally, if the production costs and equipment costs are extremely large, then any contention on the part of the sales manager to produce the product should be weighed with considerable thought. However, if these costs are within reason the sales manager's view must predominate, providing it is substantiated by sound reasoning and factual evidence.

In a competitive economy, as we have just noted, the sales manager's view with regard to the addition or elimination of company products must be given a prominent position in the discussion of such matters. However, if a partially or completely controlled economy prevails, such as, in times of national emergencies or wars, the sales manager will have little or nothing to say concerning the products to be produced. Vital materials, such as, steel
and aluminum will be scarce and the design of products will have to be modified to compensate for this lack of materials. If government contracts are obtained, the very nature of the products will be dictated by the rules and regulations stated in the contract. If consumer goods are to be manufactured, some products will have to be removed from the company's line, and those that remain will in most instances be redesigned to account for materials that cannot be obtained. In times of national stress when controls are exercised over a number of manufacturing materials, the sales manager must take a back seat with regard to the products that a firm will produce.

How product design influences the above mentioned production costs will be discussed in the following chapter.
Chapter VII

Product Design Reduces Costs

It must always be borne in mind that profit is a primary purpose behind any venture taken in business. The more efficient a concern is, the more profits will be realized. Many firms operating today will have to gain some added efficiency in order to survive and grow.

It is easily seen that all principal components of product cost are affected either directly or indirectly by engineering and design. In the effort to achieve customer approval and satisfaction, experimentation with design is necessary, but this must not be carelessly performed. The responsibility for customer satisfaction is jointly shared by both the sales and engineering departments. The sales department is responsible from the standpoint of proper application of the product to its use in the hands of the ultimate consumer. Engineering is responsible for the design of an item that will offer the desired performance and sell at a competitive price. If both sales and engineering perform their duties effectively, the result will be satisfied customers and profits. The particular relationship between design and cost can be effectively illustrated if we examine separately some of the components of the selling price of a product.
A. Means of Reducing Costs

The first of these components consists of the company's items of purchase cost. These include products of other manufacturers as well as established raw materials. When it is considered that all materials are purchased to the specifications set forth by the engineering staff, it is then clearly seen that the engineering department (assuming that the design function is an integral part of this department) alone is responsible for the type of material which is used in company products. In view of this fact, there are a number of points which, if carefully considered, will do much to hold down the cost and, therefore, the selling price of a product.

First of all, we must consider the use of regular materials wherever possible. The more places a regular piece of stock can be utilized, the larger the quantity which can be purchased and the lower the purchase price due to volume discounts that might be obtained. To greatly assist this procedure, a list of all standard items of inventory will be desired. This list can be published by the purchasing department in book form and thus made available to all interested departments. Upon examination of this list, a number of materials will be indicated which by slight specification changes will be

* 20, p. 1358
suitable for many different uses. This is particularly true of bolts and nuts and similar items. Action taken in this direction will greatly reduce the number of items carried in inventory. In addition, in the event of a model or design change in one product, a better opportunity will be available to divert the inventory of purchased materials of the old model or design to another product instead of disposing of the stock on hand at a low price. *

Special items, because of their inherent features, must be purchased in small quantities from jobbers, this situation is unavoidable. Multiple usage as has been indicated permits the purchase of larger quantities and provides some protection in the event of a model or design change. When it becomes apparent that a design change may take place in the near future, common sense dictates that the purchasing department be notified so that, as the time for changeover approaches, the inventories of materials which will become obsolete can be reduced to the lowest point that the manufacturing schedule will permit. Thus, when the design change does occur, only minimum stocks will be left on hand to meet replacement parts need. It should also be kept in mind that every piece of unnecessary material used in a product increases costs and places the company in a poorer competitive position. ** Since the amount

* 20,p.1358
** 20,p.1359
of time required to perform an operation determines its direct labor costs, it is extremely important to hold operation time to a minimum. This may be realized in a number of various ways. One such way which is now utilized extensively throughout industry is the elimination of handwork, wherever possible, through the use of progressive dies, drill jigs, electric and pneumatic nut runners and other similar means. A second way is to design toward the usage of interchangeable parts. This will permit longer runs on operations and will result in lower operation time, and therefore, lower direct labor costs. The wise application of sound motion economy principles plus the use of Time and Motion Study will greatly reduce wasted effort on the part of workers and thus reduce labor costs.

New designs should be directed toward the utilization of existing tools and equipment wherever possible. If a design can be modified slightly to use existing dies, jigs, or fixtures, this will eliminate a great deal of hand work and save the expense of new equipment. Another source of direct labor saving which has its roots in product design procedure is to give as much detail as possible on the blueprints given to workers. Whenever a shop worker has to check on detail, it may very well hold up several other workers, thus increasing the labor cost of the product. In other words, engineering can be done much better
and more cheaply by the engineering department than by a manufacturing department. For example, two men working on a power brake formed 58 pieces of standard box channel in an average time of 4.75 minutes each. On the same day these two men laid out and formed 17 pieces of special channel at an average of 21.2 minutes each, due in part at least to lack of detail on prints. It may be helpful to work a general design into the form in which specifications are prepared thus making it easier to work with a familiar layout.

Manufacturing cost includes both labor and material costs. Indirect costs are closely related to direct costs and any attention given to the effects on product design with respect to material and labor will result in overhead savings also. This would not be true, however, if the tooling required to lower direct labor cost increases the overhead rate by too large an amount. Since tooling charges will tend to increase overhead costs, it will be wise to utilize existing tooling whenever possible. However, whenever new dies or jigs are designed the condition of flexibility must be borne in mind and applied to the new designs wherever conditions permit. If a die or jig, with some added cost can be made adaptable to different dimensions, it might save the construction

* 20, p.1359
cost of several other dies or jigs. *

Another saving in overhead charges which can be realized occasionally is in the utilization of blank slugs which would otherwise be scrapped. Slugs which are blanked from one part may occasionally be used in fabricating a smaller part. Standardization to a general design was mentioned in the discussion of direct labor as a point at which cost savings might be realized. This point, if followed, wherever possible, simplifies to a very great extent the problem of flexible tooling. This fact is true, not only in connection with the part itself, but also in related and component parts. Also, multiple usage of materials, which was mentioned in the discussion of raw materials, will be made much easier. **

Specific methods by which material, tooling and labor costs can be reduced will now be considered. Lower costs through designing for economy in material, tooling and labor are under the control of the design engineer. It was practically impossible to keep costs at a minimum during the war years as many design changes were necessary without interrupting the production schedule. Getting into production quickly and maintaining high production rates were necessary at any cost. However, cost is of greater

* 20, p.1360
** 20, p.1360
importance under today's more normal conditions.

A successful company's product must be produced in the most economical manner consistent with an established standard of quality. While designs must be quickly prepared, as we have previously noted, careful consideration should be given to the feasibility of the product from a production standpoint.

B. Material Cost Production

Material cost varies between the raw material necessary to make an article and the material in the finished part. In cost comparisons of similar parts, the actual part shown on the drawing may be cheaper if made from one material than from another, although the raw material cost may be greater. Since it is the designer's prerogative to specify the material on the drawing, he partially controls material cost. The design engineer may call for a forging costing 75 cents a pound, or a piece of sheet steel costing 6 cents a pound.

Material cost tables have been found most useful as a guide to the design engineer in selecting the proper material. Tables pertaining to the cost of raw and semifinished materials can be compiled to apply to any industry. The values represent relative costs to the company rather than actual costs and are based upon average basic cost for normal production orders. For example, normal
production orders of tubing are assumed to be from 500 to 999 feet. The cost increases considerably for smaller quantities, being twice as much for 25 to 100 feet and about two and one half times as much for less than 25 feet. If large quantities, 5000 feet or more, of the same size tubing are ordered at one time, reductions up to 20 percent are possible.

Actual cost records show a wide variation with the prices in many tables. For example, for bar and sheet, much of this variation is the result of the intricate method of determining prices with extras and/or deductions for quantity, gage, width, length, tolerance, finish, analysis and treatment. Quantity is the major reason for cost differences, especially for tubing and extrusions. Where the quantity required is large, the relative cost per unit is low. Most tables are compiled to show the true cost relation when all factors remain equal.

Adjustments must often be made in cost data for castings and forgings because design, type of equipment and schedules all modify cost. Castings and forgings are often bought by the piece instead of by the pound. Forgings as a rule are priced per unit.

Die castings are also bought by the piece, but

* 15, p. 132
** 15, p. 134
the vendor usually does the machining as well. The designer should not overlook this item when comparing relative costs. Many comparative estimates on die and permanent mold castings versus sand casting or bar stock show that die and permanent mold castings are more practical only if production is to exceed a thousand pieces. Few dies used for forgings, die castings and permanent mold castings cost less than 500 dollars.*

Relatively few tables will give the designer a good coverage of cost data. If desirable, more tables can be compiled, one for each material, but too many tables serve no useful purpose. The idea is to supply concise information to guide the designer in selecting materials where the differences in cost are appreciable - not to burden him with minor differences.

The cost of the finished parts will not necessarily reveal the same comparison as the cost of raw materials, because of different methods of fabrication. The estimated costs might also differ from the true costs. Unit costs instead of dollars costs are preferred by some companies.*

Weight to volume ratios of the various materials are often needed when comparing costs. The following re-

* 15, p. 134
lations are satisfactory for all cost calculations:

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (lb per cu in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenolic plastic</td>
<td>0.050</td>
</tr>
<tr>
<td>Magnesium alloy</td>
<td>0.065</td>
</tr>
<tr>
<td>Aluminum alloy</td>
<td>0.100</td>
</tr>
<tr>
<td>Steel</td>
<td>0.284</td>
</tr>
<tr>
<td>Brass and bronze</td>
<td>0.315</td>
</tr>
</tbody>
</table>

Standard parts or parts already in production can often be used or adapted to new designs. As we have mentioned previously, they should be used wherever practicable, since they are more economical to manufacture and also save time and effort of the designer.

Simple parts need to be analyzed for cost as well as heavy, complex parts. Although a few cents saved on a single piece may appear trivial, substantial savings can be realized when thousands of pieces are required.

Under the modern assembly line system of manufacture, purchased parts have become increasingly important and it is necessary to purchase these parts on the basis of quality, delivery and price. Many parts are specified on the drawing from a favorite manufacturer's catalog without investigating the possibility of an avail-

* 15, p.135
able substitute that is less expensive. For example, an aircraft company purchased a heat-treated, chromium-molybdenum steel at a cost of $3.37 as a part of the engine mount bushing assembly. The high cost brought about an investigation that revealed that a high strength nut was not necessary. A 14ST aluminum alloy, hollow, hexagonal extrusion was used and the nuts machined from it at a cost of 30 cents each. Since each airplane required 10 of these nuts, this one substitution showed a saving of $30,700 on a thousand planes, plus a substantial saving in weight.

C. Tooling Costs

Tooling costs can be kept at a minimum by properly designing parts. This is apart from the fact that a small amount invested in tooling will result in high labor costs, or conversely, low labor costs can be achieved by spending an adequate sum on tooling. The amount of tooling can be adjusted to the expected volume of production. This fact is sometimes overlooked, but it is of great importance in planning tooling and the method of making the part.

A simple example will illustrate this point. Consider a small fitting that can be machined either from

*15,p.135
an aluminum alloy sand casting or from bar stock. An analysis of the comparative costs of the parts manufactured by the two methods is as follows:

<table>
<thead>
<tr>
<th></th>
<th>Sand Casting</th>
<th>Bar Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>$0.20</td>
<td>$0.13</td>
</tr>
<tr>
<td>Machining</td>
<td>0.69</td>
<td>0.74</td>
</tr>
<tr>
<td>Cost each</td>
<td>0.89</td>
<td>0.87</td>
</tr>
<tr>
<td>Pattern and tooling(pro-rated over 1000 parts)</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>Total cost each</td>
<td>$0.99</td>
<td>$0.87</td>
</tr>
</tbody>
</table>

In addition to the 12 cents saving in using bar stock over the sand casting, there is another factor favoring the bar stock design, namely, that a fine surface is more easily attained by using bar stock.

Another example concerns a wing attaching link. Originally this part was designed to be rough machined from an SAE 4140 steel bar measuring 1 3/4 x 2 5/8 x 4 1/8 in. and subsequently heat-treated to a strength of from 160,000 to 180,000 lb. per sq. in. The design was replaced before going into production by a copper furnace brazed assembly. This example illustrates the saving that can be made despite higher initial tooling costs and

* 15, p.135
is shown by a cost comparison of the two designs:

<table>
<thead>
<tr>
<th></th>
<th>Copper Furnace Brazed</th>
<th>Bar Stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>$0.32</td>
<td>$0.94</td>
</tr>
<tr>
<td>Labor and Burden</td>
<td>2.53</td>
<td>2.83</td>
</tr>
<tr>
<td>Cost each</td>
<td>2.85</td>
<td>3.77</td>
</tr>
<tr>
<td>Tooling (pro-rated over 1000 parts)</td>
<td>0.64</td>
<td>0.35</td>
</tr>
<tr>
<td>Total cost each</td>
<td>$3.49</td>
<td>$4.12</td>
</tr>
</tbody>
</table>

The lower cost of material and labor more than offsets the increased tooling cost for the copper furnace brazed design, making a saving of $630 per 1000 planes.

D. Labor Cost

Labor cost can also be controlled by the designer as well as material and tooling costs. Any reduction in the number of operations necessary to make a part will result in a corresponding saving in labor.

For instance, the advisability of using 24ST clad aluminum alloy instead of 2480 for sheet metal parts has received a great deal of study throughout the aircraft industry. Results from various reports are conclusive

* 15, p.135
** 15, p.136
*** 24 - Clad aluminum alloy
    S - Wrought
    O - Fully annealed
    T - Fully heat treated
in favoring the pre-heated material 24ST, provided the
part can be successfully formed in this condition. When
there is doubt as to whether or not the tempered material
can be used, as for example on convex flanges or heavy
gage hydropress parts, it is advisable to contact produc-
tion design personnel.

The following example is typical of the savings
that are possible by using 24ST material instead of 24SO.
A cost comparison between making a 6 feet long bulkhead
from material in the "SO" and "ST" conditions is given
as follows:

<table>
<thead>
<tr>
<th></th>
<th>24SO</th>
<th>24ST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material cost</td>
<td>$4.35</td>
<td>$4.75</td>
</tr>
<tr>
<td>Labor and burden</td>
<td>2.94</td>
<td>2.06</td>
</tr>
<tr>
<td>Cost each</td>
<td>$7.27</td>
<td>$6.81</td>
</tr>
</tbody>
</table>

The saving of 46 cents per part would represent
an appreciable sum when totaled over a contract for a
large number of such parts.

E. Summary and Review

It is now in order to review briefly the three
factors of manufacturing cost and the manner in which
they are affected by engineering and design. First of

* 15, p. 136
all, design and specifications determine the type of material which is used. Secondly, the amount of tooling necessary is controlled to a very great extent by the design and the type of material which is being employed. In addition both the type of materials used and the tooling available, heavily influence the direct labor cost.

Standardization to a general design wherever possible will promote the multiple usage of raw materials and aid in the design and application of flexible tooling which, in turn will assist greatly in the reduction of direct labor cost. It will also help avoid excess employment of special material. More time and thought spent on the basic production design will lead to manufacturing efficiency and cost savings which will in turn result in lower selling prices and a better competitive position in the consumer market.
Chapter VIII

Design Cost Control

A. Role of Cost Engineers

The increasing complexities of modern design requires the services of a new group of engineering specialists to assist the design of quality products that can be sold in today's competitive markets. This group of design cost control engineers specialize in producibility and costs. They collaborate with the designers to develop economical design procedures and techniques.

How closely the factory can approach minimum cost of fabrication will be determined by the controlled effectiveness of manufacturing, tooling, purchasing and planning. But the most efficient manufacturing methods, tooling designs, planning procedures and purchasing techniques cannot lower the cost of fabrication below the basic design established by the design engineer.

Since design cost control is the efficient application of comparative manufacturing techniques affecting size, weight and functional design to obtain economical production, the design cost control group's basic functions should include:

* 16, p. 81
** 16, p. 81
1- Cost-analyze engineering designs and initiate production design principles to obtain the most economical design decision for manufacturing.

2- Promote cost control by the issuance of design bulletins presenting the design cost reduction procedures.

3- Develop the standardization of designs for economical manufacturing.

4- Initiate and cost analyze new manufacturing procedures.

5- Encourage and develop a cost conscious attitude toward design problems.

The operational techniques of design cost control take time and money, and may at times slow down the pace of designing. However, at the Glenn L. Martin Company there is no doubt that it is a good investment; particularly when design cost control decisions indicated a yearly saving of over $1,600,000 in 1948. The cost of maintaining these cost control engineers amounted to only $30,000 for this same period of time.

B. Organizational Status

The functional relationship of the design cost control group with the engineering departments may be illustrated by considering the organizational set up within the Glenn L. Martin Company. This group functions in a consulting capacity through the production design section,

* 16, p.82
which in turn reports to the senior design engineer.

The design cost control group is divided into two units.

The first unit composed of design cost control engineers located in the various design and department sections, is primarily responsible for providing "on the spot" design cost information. Since this function is the most important one of the cost group, it is under the personal supervision of the senior cost control engineer. Specialists in their fields, the personnel in this unit collaborate with design engineers to achieve economical design releases for manufacturing.

The second unit, composed of cost engineers under the assistant cost control engineer, is responsible for the basic development of standards such as cost bulletins, dollars cost conversion factors, time data and basic analyses. This unit furnishes the design cost control engineers with supplemental data and assists in the evaluation of comparative cost analyses requiring development or lengthy investigations.

Group concentration is thus established on design problems that results in many suggestions to achieve economical solutions. Also, the detail duties of the design cost control engineer are minimized so that daily con-

* 16,p.82
** 16,p.83
*** 16,p.83
tacts with design personnel can be carried out with maximum efficiency. The personnel of each unit are specialists in the fields of manufacturing processes, cost accounting, production design engineering and industrial engineering techniques.

The operational functions, duties and qualifications of the design cost control engineers are:

C. Functions of Cost Control Engineers

1- Maintain design economy by routine check of design layouts in his division

2- Evaluate controversial designs by determining the most economical designs through the use of design bulletins covering cost reduction principles.

3- Initiate, Develop and Cost Analyze: (a) design economy standards, (b) comparative cost studies, (c) new manufacturing procedures, and (d) economical engineering designs.

4- Control design changes to keep scrap loss and manufacturing costs to a minimum.

5- Maintain constant surveillance of possible production "bottle necks" caused by insufficient design study.

6- Maintain a cost savings schedule.

D. Duties

* 16, pp. 83-84
1- Study and evaluate design layouts to determine whether a cost investigation is necessary and justify the expense of making an analysis.

2- Determine the analyses that may be analyzed superficially and those that need detail coverage.

3- Provide the basic cost development group with all necessary information pertaining to design studies and coordinate between design and development group.

4- Perform satisfactorily the duties of the basic development cost engineer, which include: (a) Detail manufacturing operations, (b) application of standard data, (c) conversion of time values to standard dollars, (d) summarize and execute a comprehensive report, (e) develop standard data by compilation or time study, and (f) develop standard dollar factors by evaluating fatigue allowance, take-away rate, overhead percentage and learning cycle curves.

5- Be responsible for the execution of superficial on-the-job analyses.

6- Maintain an up to the minute knowledge of latest practices in production, tooling, manufacturing, accounting, industrial engineering and cost control.

E. Qualifications

1- Fundamental knowledge of engineering principles with the ability to suggest practical design improvements and to understand the principles of stress and weight analyses
that may be required to bring about such improvements or recommendations.

2- Specialist in the application of production design principles and the solution of producibility problems.

3- Excellent judgement in the use of standard time data per operation and labor cost factors to cope with the many variables in development of cost analyses.

4- Ability to understand the techniques of cost accounting in the use of wage rates, burden charges and cost procedures.

5- Thorough understanding of the function of all types of machines and tools required in manufacturing.

6- Excellent engineering English to compile clear readable reports and make understandable recommendations for cost developments.

7- Good mathematical abilities to develop cost factors, quantity cost curves and statistical records of design costs.

8- Excellent aptitude for presenting visually the development of cost breakdowns and design simplification principles.

To obtain men with these qualifications on the open market is almost an impossibility. However a design cost control group can be successful with men who have fundamental engineering knowledge and sufficient practical shop experience. With these two basic requirements,
men can be trained in the fields of industrial engineering, cost accounting and report writing.

F. Operational Policies

Operational policies of the cost control engineer are of paramount importance, since he functions in a consulting capacity throughout the engineering organization. He must, therefore, be able to:

1- Cooperate and coordinate his efforts with those of the project and group engineers in the basic design sections.

2- Convince others that cost ideas, attitudes, designs and philosophies are basically sound and essential to economical manufacturing procedure.

3- Avoid dominance, argument and forcefulness in presenting cost problems.

4- Present or convey cost problems and suggestions in a manner such that the designer or draftsman acquires the impression that he has solved the cost decision by his own volition or initiative.

Fundamentally, the design cost control engineer sells his wares by dollars and cents - cost figures usually sell any article no matter how nicely a salesman may expound. The habit of comparing dollar and cent values of

* 16, p. 84
one design with respect to another can solve many costly design problems, which are so often prevalent throughout engineering organizations.

Coordinating the development of comparative cost analysis with the various plant departments is another specific function of the cost engineer. Depending on the nature of information required to determine cost decisions his contacts are with these departmental groups: Tool engineering planning, manufacturing processes, purchasing equipment and material, production schedule control, standard parts and processes, and inspection control.

G. A Typical Analysis

After a satisfactory functional design has been established and the amount of material needed to manufacture it has been determined, the designer refers to the material cost tables and charts to select the most economical material. Depending on his judgment of the design factors, he can specify a forging at a dollar a pound or a sheet metal fabricated design at fifty cents a pound.

The next step in the analysis is to develop the manufacturing cost by means of an elemental breakdown of set-up and labor time in machinery or fabricating each design. To develop these elemental breakdowns requires an experienced man who knows all types of machines in the

* 16,p.34
shop as well as the techniques used in producing a part from these machines. The design cost control engineer on the floor has at his fingertips the knowledge and techniques to analyze the design as to its elemental breakdown.

The time value for each operation is evaluated from the standard data books compiled by the cost control group. Standard data is a time value developed from a series of time studies of each individual motion that a man or machine performs in fabricating a product. These time study values are correlated, summarized and modified with variables into a unit standard value for specific operations. Since each time value is an average, its application to shop operations must be applied with sound judgment to achieve correct values for each elemental operation.

Adding the elemental time values for both setup and run time establishes the total operation time sequence for each type of part. Normally this total in minutes is changed to hour values for conversion to dollar costs.

The evaluation of the dollar cost conversion factor requires the incorporation of cost accounting data for re-work and rejection allowances, workers' fatigue.

* 16, p.36
** 16, p.37
allowances, direct labor immediate supervision adjustment factor, and average departmental efficiency percentage. The application of these percentage factors to the unit standard data time value develops into the actual performance factor.

Then by applying the average direct labor rate and burden percentage, the complete dollar hour conversion factor is evolved. This figure when multiplied with the amortized set-up and multiplied directly with the run time standard hour time will give the final dollar cost of fabrication.

After the material and fabrication cost of each part has been determined the next step is the consideration of the tooling cost to complete the total manufacturing cost.

Tooling has an important effect in the cost of manufacturing a product. When production quantities are small, the unit tooling cost can be a major portion of the product cost. Tooling cost alone at times can be the deciding influence in making a design decision without going into a detail analysis of the fabrication cost. For large production quantities, however, the unit tooling cost is often a negligible amount of the total manufacturing cost.

* 16, p. 87
ing cost because the tooling cost is directly amortized over many parts.

Combining the tooling, material, and fabrication cost will give the manufacturing cost for a simple product.

H. Development of Case Histories

The cost control group by continually analyzing designs can develop a series of case histories covering all types of design problems. These histories can be a valuable asset to the design engineer as reference material to aid in making wise decisions on future model designs. Also, they stimulate the search for efficient low cost production methods. The application of design cost control techniques are thus developing design engineers with a new version of basic production thinking.

* 16, p. 38
Product Design Increases Sales

A. Greater Use of Industrial Designers

Many products have a much wider sales potential than realized. More sales appeal and lower costs are often possible when the right industrial designers and engineers put their ideas into products. The margin of excellence among competitive consumer and capital goods is shrinking at such a rate that many manufacturers are relying more heavily on the industrial designing profession to provide competitive advantages.

Many concerns in the retail field, such as Sears, Roebuck and Co. and Montgomery Ward & Co., which sell products manufactured to their special requirements based on customer preferences, depended for years on their own staff designers. Today, these firms are utilizing outside design talent to supplement the work of their own staff. These mail-order houses are stressing design mostly in home appliances, many of which are produced and marketed with each firm’s special brand names.

Capital goods manufacturers, especially firms like Kearney & Trecker Corporation, are doing an outstanding job in creating sales appeal for their line of punch

* 5, p. 13
presses, hydraulic lifts, and other heavy machinery. In the past such manufacturers relied on the utility and price factors to compete in the market and depended on their production engineers to develop the product, with little attention paid to the beauty of the design.

Dave Chapman, a Chicago designer with several large accounts in the appliance field, modestly contends that design of the product is no more than a 15 percent advantage in the final sales result - all other factors being equal. "Increasing numbers of industries have felt that design has become a necessary part of the total sales plan," he said. He has offered as an example, the battle for a niche in the public favor being waged by the washing machine makers.

B. Competitors Turn to Design

Bendix Home Appliances, Inc., came out with the first automatic washer in 1937 and before rivals could enter into the market the war had curtailed materials. The war years, however, built up the demand with millions of new families with babies and extra cash to spend and with domestic help scarce. This lucrative market attracted many manufacturers who sent designers to their drafting boards, keyed to a high pitch.

At present there are at least a dozen manufac-

* 5, p. 18
turers who are producing and introducing new models in competition with Bendix - Westinghouse with Laundromat; F. L. Jacobs Co. with the Launderall; General Electric; Frigidaire Div., General Motors Corporation; Sears Roebuck with its Kenmore; Blackstone Corporation; Gamble-Skøgmo Inc. with its Coronado; Electric Household Utilities Corporation with two models, one, the Thor Automagic, convertible to a dishwasher; Altorfer Bros. Co. with the ABC-O-Matic; Apex Electrical Mfg. Co. with its Apex Automatic; Norge Division of Borg-Warner Corporation; Hotpoint, Inc.; 1900 Corporation, which makes Sears' Kenmore, with its own Whirlomatic; Landers, Frary & Clark with Universal; and Barlow & Selig Mfg. Co. with Speed Queen.

Design will clearly play an important part in determining which of these manufacturers achieves the largest sales volume. Other factors, of course will exert influence; these factors which are subordinates to economy, are integrity and engineering abilities of the manufacturer, plus use features and utility.

C. The Profession Designer: Examples of His Work

Today's industrial designers, and there are too few competent ones, are gaining more confidence from industry since the days when they were little more than drawing board prognosticators. Now their creations can be readily

* 5, p. 18
adapted to assembly-line production and they have, and must have, an extensive conception of engineering, merchandising and many other phases of mass production.

Raymond Loewy Associates of New York City, recognized as a leader in the designing field, produced an outstanding example of design combined with engineering "know-how" when it shaped a new model perforator for the Cummins Business Machines Corporation of Chicago. The table on pages 94 and 95 shows what the firm accomplished for Cummins, with the new Model 300 perforator, which replaces the Model 75 produced until 1945. Both machines have equal capacities in the electrical cancellation of checks, bills, documents, and stamps, and several other applications. However, viewing the production record indicates a marked difference in the two products. *

The Loewy firm which designed the revolutionary Studebaker car contradicted the ruling philosophy among merchandisers and designers who maintain that progress in design must evolve slowly and not all at once. One school of thought, pointing to a similar automobile adventure in the early thirties which failed dismally and was withdrawn from the market because it was years ahead of its time, believes that the new Studebaker might not have been accepted.

* 5, p. 19
<table>
<thead>
<tr>
<th></th>
<th>Model 75</th>
<th>Model 300</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production time</td>
<td>83 hours</td>
<td>27 hours</td>
</tr>
<tr>
<td>Percentage ratio</td>
<td>100 percent</td>
<td>32.5 percent</td>
</tr>
<tr>
<td>Cost of materials</td>
<td>Not disclosed</td>
<td>Not disclosed</td>
</tr>
<tr>
<td>Percentage ratio</td>
<td>100</td>
<td>21.9 percent</td>
</tr>
<tr>
<td>Dimensions</td>
<td>19&quot; x 20&quot; x 53 1/2&quot;</td>
<td>8&quot; x 13&quot; x 11&quot;</td>
</tr>
<tr>
<td>Volume of cu. in.</td>
<td>20,330</td>
<td>1,144</td>
</tr>
<tr>
<td>Weight</td>
<td>512 pounds</td>
<td>49 pounds</td>
</tr>
<tr>
<td>Units Produced</td>
<td>From 1913–1945, less than 800</td>
<td>From November 1946 to July 1947, more than 1,200</td>
</tr>
<tr>
<td>Actuation</td>
<td>Foot-pedal tripping device</td>
<td>Automatic insert trip</td>
</tr>
<tr>
<td>Motor</td>
<td>1/4 h.p., 1,140 r.p.m. continuous</td>
<td>3/8 h.p., 11,000 r.p.m., series stop and start</td>
</tr>
<tr>
<td>Drive</td>
<td>Belt driven, continuously running gear, runs only flywheel when machine is in use actuated</td>
<td>Worm and helical gear, runs only when machine is actuated</td>
</tr>
<tr>
<td>Matrix Rings</td>
<td>Set by removable, and often lost, pins. With locking pins missing, rings could turn freely, damaging cutting parts or selecting illegible punch combinations</td>
<td>Set and locked by key and spring device which is not removable. The machine will not operate unless all matrix rings are set to select punches forming a complete character</td>
</tr>
<tr>
<td>Punch Waste</td>
<td>Model 75</td>
<td>Model 300</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Protruding funnel and catch bucket. If not emptied, the waste chute filled with waste and serious damage resulted</td>
<td>Flush, self-contained drawer. If waste drawer is not emptied, the drawer is forced out of its guides</td>
</tr>
<tr>
<td>Finish</td>
<td>Smooth baked black warm, gray, wrinkle Japan. The casting finish. Only slight amount of brushing involved in preparing casting. Does not scratch or reflect. Trim is brushed chrome.</td>
<td></td>
</tr>
<tr>
<td>Operating Qualities</td>
<td>Vibration and noise</td>
<td>Sand casting used for weight and sound-deadening qualities. Noiseless and vibration free</td>
</tr>
</tbody>
</table>
if there had not been a car shortage. Nevertheless it must be admitted that the Studebaker design resulted in many design changes in other makes of cars; thus indicating the rare insight possessed by Mr. Loewy and his associates.

Today's designing profession has come a long way from the dreaming stage of a decade ago. They have learned to know and anticipate what the public desires. Dave Chapman claims that this anticipation results from some sort of uncanny ability to gaze into a crystal ball. However, a tour of his and other workshops would disclose that there is a great deal of science attached to it.

Competitor items are brought into the designer's workshops, compared, analyzed, and evaluated for mechanical advantages and defects in relation to the client's product. Draftsmen proceed to work and draw up as many as 100 sets of new ideas and improvements. When a fraction of these ideas has been selected with the client and his staff, mock-ups and working models are produced to determine their engineering possibilities and production economy.

Barnes & Reinecke, Inc., a Chicago firm that has acquired a large clientele in its 13 years in business, has designed plastic toothpicks for Lactona Inc., railroad cars.
for the Soviet government, and tractors for Allis-Chalmers. Forty-five B & R designers, working with Pullman-
Standard engineers, spent a year fashioning an entire
train. Loewy, who designed the famed bullet-nosed Penn-
sylvania Locomotive, points out that travel is being pro-
moted through these efforts to make the vehicles more
glamorous and attractive to the public.

D. Examples of Sales Increases Due to Design

Prior to the war, Barnes & Reinecke had the task
of adding sales appeal to the Minnesota Mining & Manu-
facturing Company’s Scotch-tape spool. B & R evolved the
scotch plaid holder readily and easily identifiable on
every drug and dime store counter. In the first 2 months
of 1938, sales leaped 73 per cent on the large spool and
the smaller spool gained 300 per cent in the entire year.

Another B & R client, the Dazey Corporation of
St. Louis, Missouri, producers of Kitchen Helps, was en-
abled through redesign, and use of plastic instead of
metal, to reduce costs and increase production slightly
although retail selling price was raised a dollar. Accord-
ing to figures given by the Committee for Economic Devel-
opment, McGraw Electric Company of Elgin, Illinois, in-
creased output 40 per cent in 1940 and 1941 on its Toastmas-
ter. Experimenting with public acceptance on a rear vision

* 5, p. 39
mirror for Erie Manufacturing Company Inc., B & R discovered that sales could be boosted 25 per cent by making the clamp attachable to the right side of the car as well as the left side.

Sears Roebuck, like many another company, retains about six designing firms to specialize on various products. To quote a Sears' spokesman; "With engineers, cost analysts, metallurgists, chemists, and many other specialists all coordinating the designing job, they are equipped to tackle a job more comprehensively than most companies could alone."

E. Design Revives a Stagnant Industry

Perhaps there is no better example of an industry-wide revival through design than the 1935 experience of the piano manufacturers. In the twenties this industry had seen its best meal ticket, the player piano, eclipsed by the phonograph. In the early thirties the industry, still clinging to its cumbersome grands and bulk uprights, was also suffering from the radio.

Then came the spinet, not from the drawing board of any industrial designer, but from the inspired editorial writing of a business paper editor, Roy Waite, who goaded the piano people into producing an instrument that would

* 5,p.39
** 5,p.40
take into account the smaller living-room space of homes and apartments. The sales results tell the story. In 1933, a total of 150 piano-makers were selling only 30,000 instruments a year. Today there are only 25 manufacturers left, but they are producing about 200,000 units a year.

Progressive design thinking in the piano industry has not stopped with the spinet. In 1947 Krakauer Bros. introduced a grand piano that can be folded and placed flush against the wall when not in use. Ansley Radio Corporation produced an instrument flanked on the sides by a record-changer and a radio. Pratt, Read and Co. brought out a 64-note Model K, which can be folded up like a suitcase and carried on a train.

The sales figures for these instruments are not available, but one thing is certain - the piano industry, after 100 years of doing little to improve the old piano, is now abreast of its competitors and looking ahead.

F. Good Design Aids Sales

Whether it's consumer or industrial products, every manufacturer can use a dash of sales appeal. Now, with prices and labor costs going up, it's essential to take advantage of ideas to capture buyers' interest and keep products out in front. Manufacturers should strive
to attract attention by proper design; give something extra; give something new; make the product easier to use. These are time-tested rules for selling any product in any market.

Competition is always present. In days of shortages competition may be with the butcher, the baker, the banker, and the bond salesmen, instead of directly between producers. However, it is still competition. So, it is important, to take advantage of every design feature that can bring in customers and build a lasting acceptance for your product.

Even a standard product such as a baby's high chair can be redesigned for greater sales appeal and lower cost. Robert Fondiller, design consultant, 50 Rockefeller Plaza, New York, 20, N.Y., redesigned a simple high chair for a child, and cut finishing and assembly cost to the vanishing point. Originally made of wood, the chair legs had to be sanded, varnished, glued; and arms had to be upholstered.

Now, two U-shaped aluminum tubing sections form the arms and legs, and a third acts as reinforcement.

A great variety of ideas may increase product sales. For example, a maker of sanding machines increased

* 12,p.116
sales appeal by adding a vacuum dust collector bag to his product. A maker of consumer items thusly gets a new product by adapting the vacuum principle to produce a new kind of hair brush.

The principle of disposability has invaded the heavy farm plow industry to add sales appeal to farm plows. The New Dearborn Motor Corporation has produced what it titles the "Economy" plow that has disposable "Razor Blade" shares that are cheaper to buy and cheaper to use. Another important trend demonstrated by the Dearborn plow is universality - one part doing the job of many. This plow has a "universal" bottom that may be used on many different types of land. Formerly, many farmers needed several different shapes.

The feature of portability can also aid sales appeal to standard products. The Freshn'd Aire Division of the Cory Corporation developed the "Fanette" traveling electric fan which is light enough to be packed in a suitcase. The plastic housing which helps reduce its weight also makes the use of color an easy matter.

One might ask where ideas like these come from. One of the best ways to get them is by adapting features from other products to your own particular product, as witnessed above in the case of the sanding machine which

* 13, p.44
adapted the principle of the vacuum cleaner to increase sales appeal. Salesmen's reports and employee suggestions are other excellent sources of such ideas.

The president of B & L Manufacturing Company, Chicago, got the idea for its newest product, the "Mar-kit", by visiting the Packaging Show. The "Mar-kit" is a throw-away marking unit for shipping rooms, sign shops and mail rooms. He noticed that marking devices were relatively high priced and realized the need for a disposable unit.

A firm must keep track of major design trends. The National Bureau of Standards and armed forces, for instance, are emphasizing "miniaturization" and "rugged-ization".

Products, like the new, tiny Otarion "Whisperwate" hearing aid use such ideas from military research to pack a lot of performance in a little space.

The Marion Electrical Instrument Co., Manchester, N.H., developed a line of "ruggedized" meters to meet military needs and offered new values to industry. Marion Electrical's new meter has a double core lock to prevent deflection of the core structure. New fastening methods, using stainless-steel screws for high strength, pointers of laminated aluminum-alloy tubing and better

* 13,p.44
hair springs and bearings, all increase this product's ability to take a great deal of punishment.

The manager looking for new products, or new ways to improve old products, will want to check such points as:

1- Has sense of touch as well as eye appeal, been considered? Smooth surfaces, "warm" plastics might help the situation.

2- Is there a way to tie in with current fads or interests? The "Schmoo" and Hopalong Cassidy have sold thousands of items - but tie-ins like these are for fast moving products. The manufacturer who can not change from one to the next with rocket speed would do well to cater to more-lasting trends.

3- Is the product really easy to maintain? Do units disassemble easily? Are fast-opening fasteners used? Is it easy to clean?

4- Has the full promotion value of such "new" materials as magnesium and nylon been realized?

5- Can extra sales be achieved by designing the product so it fits fast-growing sales outlets?

Attention to such points as power, safety, portability and low maintenance can spark sales. To hit the top of the sales curve today a product must offer more
than quality, in other words, a product must now be design engineered for sales.
Chapter X

Summary and Conclusions

A review of this study will be effected by discussing a number of important topics pertaining to industrial or product design. These topics are the following:

The Elements of Product Design

The elements of product design consist of three distinct yet integrated types of design: functional, production, and form design. Functional design is concerned with the ability of the product to perform what is desired of it; production design seeks to design the product for ease of production; and form design attempts to give the product a fashionable external appearance.

Each element is of equal importance and an attempt should be made to balance the influence of these components in the final design. Today, form design is being greatly emphasized, however, the other elements are still very important and should not be neglected. The ideal product design contains a perfect balance of these three components.

The Growth of Product Design

The growth of product design today can be attributed to such factors as: the constant search for mechanical perfection on the part of engineers and scientists;
competition among manufacturing concerns; and the desire for beauty in products indicated by the ultimate consumer.

The scientist and engineer constantly strived to achieve perfection in the products with which they were concerned. This resulted in the refinement and perfection of many products which are in existence today. The washing machine, telephone, refrigerator, typewriter and many others owe their efficient functional operation to the perfection conscious engineer and scientist.

Competition and the desire for beauty indicated by consumers urged manufacturers to cut costs and devise means whereby their products could be produced at the lowest cost and also be pleasing to the consumer's taste for beauty. This competitive struggle is still present and shall remain as long as there is a free economy prevailing in this country.

Basic Considerations Preceding Actual Design

A firm must decide what basic area of business it will be concerned with and the extent of this area. The decision of whether to make or buy the product or some of its component parts must be made previous to the actually designing of products. The questions of how many and how well to produce the product must also be attended to. Answering these basic problems will prepare the firm for the design stage of consideration. Failure to attend to those problems can prove disastrous.
Department or Departments Responsible for Product Design

The engineering and research departments may be directly concerned with product design. Where the two exist in an organization one might be subordinate to the other or the two might work independently. No matter what the actual arrangement is, these two departments should be mutually cooperative and their efforts pointed toward one objective: a better product for the firm.

Relationship of the Design Department with the Other Departments Within the Company Organization

The product design department must work closely with the following departments: sales, production and top management. Work with the sales department will be concerned with the type of products to produce in the future and any alterations to be made in existing products. The sales department can keep its finger on the pulse of the market and so direct attention to changes or additions to company items in order to best serve this market.

Working with the production department will determine the production feasibility of a new design. The production department can suggest certain revisions in design so that the product can be more economically manufactured.

Top management can expect a great deal of information from the product design group to aid in formulating policies and making decisions.
What the Industrial Design Offers to a Company

An industrial design concern can improve the market appeal of products, reduce manufacturing costs, suggest the use of new materials and plant the seed of imagination within a company's organization.

Great care must be exercised when selecting a professional designer. Failure to do so could mean a wasteful expenditure of time, money and effort.

Utilizing a Consultant Design Organization

Having decided on your designer, you must then extend to him your complete confidence and cooperation. You must clearly state what you expect to accomplish and then let the designer proceed. Forming a committee composed of all interested departments within the company to work with the designer is recommended. This will provide the designer with a complete source of information concerning company policies and methods of operation. The committee will also be able to voice its opinions and suggestions to the designer for consideration.

If the above mentioned suggestions and rules for utilizing the designer are followed, a great deal of benefit can be obtained.

What Efficient Product Design Can Offer a Firm

Product Design can result in overall reductions in costs. Material, tooling and labor costs can be reduced by efficiently designing a product for production.
The use of cost tables referring to materials can greatly aid the designer in selecting materials for a product. Tooling costs and labor costs can be reduced if production designs are complete and call for the utilization of existing tools and equipment.

Sales can definitely be increased if the external appearance of a product is improved. Many bulky and awkward products could be redesigned from the point of view of market appeal. These new designs could very well mean the difference between profit or loss. An increase in sales would improve company prestige in its field; with all its attendant benefits.

The Future Role of Product Design

The margin of excellence between similar products is fast disappearing so that style design is currently the distinguishing feature between these products. Today, the quality of style design can mean the difference between an increase or decrease in sales. However, in the near future, and we are now entering this period, style design alone will not be the deciding factor with regard to sales. True, style will be important but not as important as the present. Consumers will want style Plus - plus universatity, compactability, durability and convenience in products. They will want more than just beauty, and it will be the responsibility of product design divisions throughout industry to provide them with what they desire.
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