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Thesis No. 563

NATIONAL COLLEGE OF ART & DESIGN

Plastics: The History and Development of the Plastics Industry

A Thesis submitted to:

THE FACULTY OF HISTORY OF ART AND DESIGN AND COMPLEMENTARY STUDIES

and

IN CANDIDACY FOR THE DEGREE: B.DES IN INDUSTRIAL DESIGN

by

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March 1988

Title: The History And The Development Of The Plastics Industry.

ACKNOWLEDGEMENTS:

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Introduction.

As a student of design I am interested in learning about the history of my chosen career. As all designers do whether graphic designers, fashion designers, architects or industrial designers,I wish to know what events contributed to the development of the profession. Aspects, such as the luminaries who practiced the art, the styles and the philosophies subscribed to and also, the tools which they employed in the rendering of the work, is of great interest to me. One such aspect of the work is the research of the products through history which have become symbolic of what industrial design embodies. While researching the historical development of products, one notices the changing styles and philosophies and also the development of the materials utilised by the designers. The single most noteworthy development in the history of design is the use of plastics from the earliest examples such as combs made from bone, to the use of composites in aeronotical design.

Plastic began with the use of natural materials being used in a new way and by new treatments. The knowledge has increased through the years, devloping a new sophistication which has resulted in the development of fully synthetic material for which mankind may take full responsibility.

At times it could be argued that mankind has abused the material which has helped him develop through inovation, by disgarding used items which will not decay like all other materials. This has caused the material to loose face and become victim of association with dirt and rubbish. This association has caused a bad image which was rampant for decades because mankind had never experienced anything which would not return to the earth, therefore, he did not know how to treat it when its useful life was over.

In this dissertation I wish to discuss plastic and its development through the years and to catalogue the main innovations associated with the material. I will discuss also the nature of the material, what it is made up of and how it may be processed into new products. Examples of its use, concentrating on the modern utilisation are discussed in a further chapter. It is also important to realise, that far from being a material we cannot get rid of, plastic may be recycled to form further products after its previous life has been exhausted.

The subject of this dissertation is an enormous one. I do not pretend to write an all-embracing thesis on plastics but wish to write an account of the material which will be understandable to the general public. It will give him an understanding of the material, its inherent values, how it may be used and finally, to show that it need not be the source of filth, if only, we as a people decide to re-cycle all that has become used and obsolete.

A Back Ground To Plastic, The Material.

1 "Plastics are organic materials made from large molecules that are constructed by chainlike attachment of certain building-block molecules". The chemical make-up of the plastic determines the properties of the material, ie. the size of the molecule and the arrangement of the atoms in the molecule".

Polyethylene is made from the ethylene molecule chain which is initially a gas. The gas goes through a process called polymerisation thus forming a chain of ethylene by valence-bonding the carbon atoms within the ethylene molecule. The resulting product, which has a high molecular weight, is called a polymer. The designation polyethylene,is used to distinguish the polymer from its gaseous origin, ethylene which is the monomer which becomes polymerised. The prefix "Poly" refers to the"many" ethylene molecules which join to form the polyethylene plastic material. The word "Resin" is often used in place of the word "Polymer" to describe the chain-like make-up of a particular plastic material. It is also used to describe a synthetic syrupy liquid of both natural and synthetic origin.

The plastics we use today are not always used in the form comprised exclusively of polymers. Other ingredients, which will give the material a desired look, texture,or physical attributes are added. These are refered to as fillers and include pigments, stablisers and processing aids. These additives are not taken into account when the primary designation of the material is assigned, ie. polyethylene, etc.

Thermosetting Plastic, and Thermoplastic Materials.

There are two categories into which most of the plastic materials fall, Thermoplastics and Thermosets. These are the fundamental categories and each describes the nature of the plastics make-up.

Thermosetting plastics:
Thermosetting plastics polymers are useless in their raw states. When acted upon by heat a chemical reaction takes place which causes the molecules to bond together in a chain network called cross-linking. The thermoset material is rendered stable by curing, a process which may be vulcanisation or polymerisation. After curing, the polymer may not be brought back to its original state. Thus, we can see that the term "thermoset" identifies those plastics which, when added to fillers and reinforcing agents and acted on by heat, form a material which has high usability for a great number of purposes.

Thermosets are the hardest and stiffest of all plastics and are chemically insoluble after curing. They are much less affected by varying temperatures than their heat-sensitive counterparts, the "thermoplastics".

The thermoset plastics can be compared to ceramics in their physical characteristics.

Some examples of thermoset plastics are as follows: phenolics; melamine; urea; alkyds and epoxies.

To obtain optimum properties from these polymers, additional fillers and reinforcing agents must be added to the mix.

Thermoplastics:
Like most metals, thermoplastic materials are heat-sensitive polymers which are solid at room temperature. Heating of the thermoplastic materials causes them to melt and form a liquid. Upon cooling below their freezing point, the material again becomes solid. This process may be repeated several times, as can also be done with metals.

The fact that thermoplastics melt allows for their usability in forming finished parts when cooled. They can be used in a variety of ways to form these finished parts. Examples of thermoplastic fabrication techniques are as follows: injection moulding; extrusion; rotational casting and calandering. Below the melting point of the material other fabrication methods may be used. They are: thermoforming (vacuum or pressure); blow moulding and forging. Thermoplastics may also be fabricated from sheets using a variety of welding processes to join them.

Examples of thermoplastic polymers are: polyethylene; polystyrene; polyvynal chloride (P.V.C.) and nylon (polyamide); acrylonitrile butadine styrene (A.B.S.); polycarbonates; polyesters.

Processing Polymers Into Plastic Products.

All products or items which are made from the raw material commonly referred to as "plastic" share one common factor. They are moulded into shape, using a particular method and cannot be produced by any other means. I use the term "moulded" as an all-embracing one which describes several production methods but which is not strictly correct when referring to a production method known as "extrusion". This process exploits the same characteristic as is used when moulding, that of plasticity. Plasticity is the inherent quality which sets polymers apart from all others. It is the most obvious inherent value the material possesses and its exploitation is the basis for all plastic product production.

Several methods exist for the rendering of natural and synthetic polymers into rigid form due to the setting and subsequent curing of the material. Fundamentally, the material which is in a pellet form is heated to a melting point, a point at which it becomes plastic and is liable to flow. It is guided, pushed or driven under pressure through channels in a "mould" through which it enters a chamber, which, when occupied by the plastic, forms a solid which has a pre-determined shape. The shape is that of the desired item which has been tooled by the tool-maker, from a variety of materials depending on several factors, e.g. size; heat requirement, pressure, method of moulding, etc. After a period of time, usually a number of seconds, to allow cooling, the mould opens and an item in plastic is ejected. In the following minutes the item becomes harder until it reaches its required mechanical properties. These mechanical properties may be predicted by selecting the most suitable material for the desired result. The process outlined describes in a very brief way how injection moulding is accomplished. The process above

may be modified by the use of varying pressures, temperature and mould design to achieve differing results.
The earliest form of moulding undertaking was that of compression moulding, where, after heating and placing in the mould, the plastic is pressed under high compressive loading to squeeze the plastic into the detailed corners and crevices which make up the desired end result. This form of moulding was modified with the exploitation of new discoveries to become injection moulding as described above.

Further to injection moulding and compression moulding came "blow-moulding" which permitted the production of vessels such as bottles and barrels and commodities such as toys, e.g. wheels and bodies for toy tractors for children. Blow-moulding begins by producing a piece of plastic of desired volume and shape by injection moulding and placing it in amould where it is held in one or two positions ie. top and / or bottom.

Known as the"parison", it is heated to a desired temperature and inflated until the surface of the parison is in contact with the walls of the mould. Upon cooling the item is ejected from the open mould, the unwanted pieces, ie. the parts which were held in the mould in order to inflate it, are trimmed and a plastic hollow product is left.

"Rotational Moulding" is again a reference to a physical property which is common only to this type of moulding. The products are normally large vessels eg. oil tanks for domestic usage, which exploit centrifugal force by rotating the mould in two axes simultaneously.

"Extrusion" is a method which produces lengths of plastic material which often have elabourate cross-sectional configurations. Usually the purpose of the extrusion is to allow the cropping of the piece into specific lengths for fabrication of such as window frames or ducting.

"Vacuum-Forming" is the process where by a sheet form of a plastic material is placed in a framework in which is housed a vacuum. The vacuum is used to draw the air from around the mould, when the plastic is heated, to draw the sheet over the mould, thus forming the desired shape. When left to cool, the new form is extracted from the mould or the mould from it, depending on whether the mould is a"male" or"female" form.

"Foamed" plastic moulding is a process which is similar to injection moulding in that the form is ultimately dictated by the shape of the tool. However the mould is filled by foaming the material in the mould,by either a physical or chemical means. The surface of the material which touches the mould is denser than the inner foam and infact, has a finish which is phically like that of injection moulding.

It is not without reason that the plastics manufacturing industry has progressed from its simple beginings in the 18th century, to being one of the leading industries in the world today. Together with the fact that the material may be moulded into any desired shape, the cost factor is perhaps more important. If it was not possible to produce individual items at such a low price, the development of the indi ry may have been neglected and forgotton.

What then determines the price per unit of the items produced?
The whole question may be answered by the phrase, "mass-production." Each tool while costly to produce initially, may be used to produce as many as 100,000 units of the desired shape. This may be an astronomical price to commission initially depending on certain factors:
* The detail needed on the reproduction for the product
* Moving parts in the mould, ie.to accommodate undercuts;
*The treatments to the mould material to achieve certain textures and finishes;
* The volume of the cavity in the mould, etc.

A complicated mould may cost several hundred thousand pounds to commission initially, however, when the sum is divided by the number of items it will produce, the cost per unit may be reduced to a number of pence rather than pounds. In this way, the initial outlay of capital may be offset against the longterm gain when each unit is sold. As can be seen, even an expensive item to produce may be sold cheaply when the mass market for it exists.

From the last paragraph, it may be deduced that the production of mass-production items lowers the retail cost of the items. In comparison, the equivalent item in the last century, which was crafted with the skill and care of a master, contained a more immediately recognisable intrinsic value.
The plastic item is only a symbol of the skill of the tool-maker "master-craftsman", one of many.
As such, its intrinsic value is less and the regard with which we see his produce, is diminished, hence the throw-away society of the 20th century.

Plastics are now used for such mundane purposes to-day that we have little regard for it. It has suffered an image crisis due to its own inherent revolutionary attributes.

The Early Years Of Plastics. (Natural Plastics)

When we think of plastics, we think of synthetic materials in bright colours, which have been moulded into products which are cleverly designed and in use in all aspects of modern life. They usually are referred to by their generic name "plastic" rather than their scientific or trade names which are usually frighteningly long and polysyllabic.

In fact, the definition of "plastic" describes the material in the context of its capability:
Plastic: Synthetic resinous substance that can be given any permanent shape, pliant, supple, giving form to clay or wax.
By examining this definition, we can see that the use of plastic material has been known for centuries. Natural plastic materials which can be softened by heating and moulded or pressed into shape, such as amber, horn, tortoise-shell, shellac and paper mache, dated the early pioneering materials such as celluloid, etc.

Horn is capable of being laminated and pressed into a mould or being pulverised and the dust mixed with a binder, e.g. blood. The resultant dough may then be compression-moulded to form solid buttons brooches and walking-stick handles. These were often decorated with precious or semi-precious materials such as silver, at a later stage.

Bone was used extensively for combs and even as a substitute for glass windows. In the days when such commodities were regarded as heirlooms, real glass windows were even passed down through families, such was their value. When heated and pressed very thin, bone becomes transparent and turns a pale yellow. These sheets were common in the 18th century as a substitute for glass windows.

Amber, a hard natural thermoplastic resin fossilised from trees of the species "Purites Succinifers" from 40 - 60m. years ago, was used by the Greeks as a protective coating and lacquer. They also made ornaments and beads from it. The beauty of most of the natural plastics is, that they could be re-cycled or were bio-degradable.

Ambroid is a material which is the result of heating up of amber under pressure. The liquid is then usable for moulding. An example of a product using Ambroid is an injection-moulded amber cigarette-holder which dates from 1904. We know its date of origin because Gaylord patented a machine for this purpose.

Lacquer has been used the Chinese first used it around the year 1000B.C. When resin from the Rhus-Verniciflua is tapped and on contact with the air polymerisation occurs. Upon further curing, the laquer hardens like synthetic plastics. It was used for a hard tough coating on armour and up until the 1950's, it was being used as coating on domestic table ware.

Shellac was patented by Samual Peek in 1854 as a mouldable material. Shellac is made from a secretion of an insect called the "Coccus Lacca" which inhabits tropical Acacia trees. It is thermoplastic so it may be re-cycled. Broken gramaphone discs and dental plates etc. may be ground up and re-moulded. Its most famous applications were the glossy black frames and carrying cases known as"union cases" for wet plate photographs called "ambrotypes" and for "daguerrotypes". Also because of its ability to reproduce fine detail, the record industry exploited it as a medium for recording and reproduction.

Papier Mache was patented in Birmingham in 1772, by Henry Clay.It was made from layers of paper and glue, placed in a metal mould and dried in an oven. The end product is a hard,strong and heatproof thermosetting material. The product may then be sanded and polished but is most often found laquered and inlaid. It was often used for teatrays, pen-trays, writing-boxes and snuff-boxes.

Discovered in 1822,Gutta Percha is a completly natural plastic, stripped in solid pieces from the Malayan Palaquim trees' bark, widely used, from garden-hoses to acid bottles, jewellery, picture frames and matchboxes. The material does not endure well, and so not many pieces endure today.

Bois Durci, patented in France in 1850, is a mixture of woodflour and albumen from eggs or blood. The mixture is thermosetting so cannot be re-cycled after moulding. The most common uses of Bois Durci are, moulded plaques to adorn furniture and knife handles.

The Middle Ages Of Plastic. (The Semi-Synthetics).

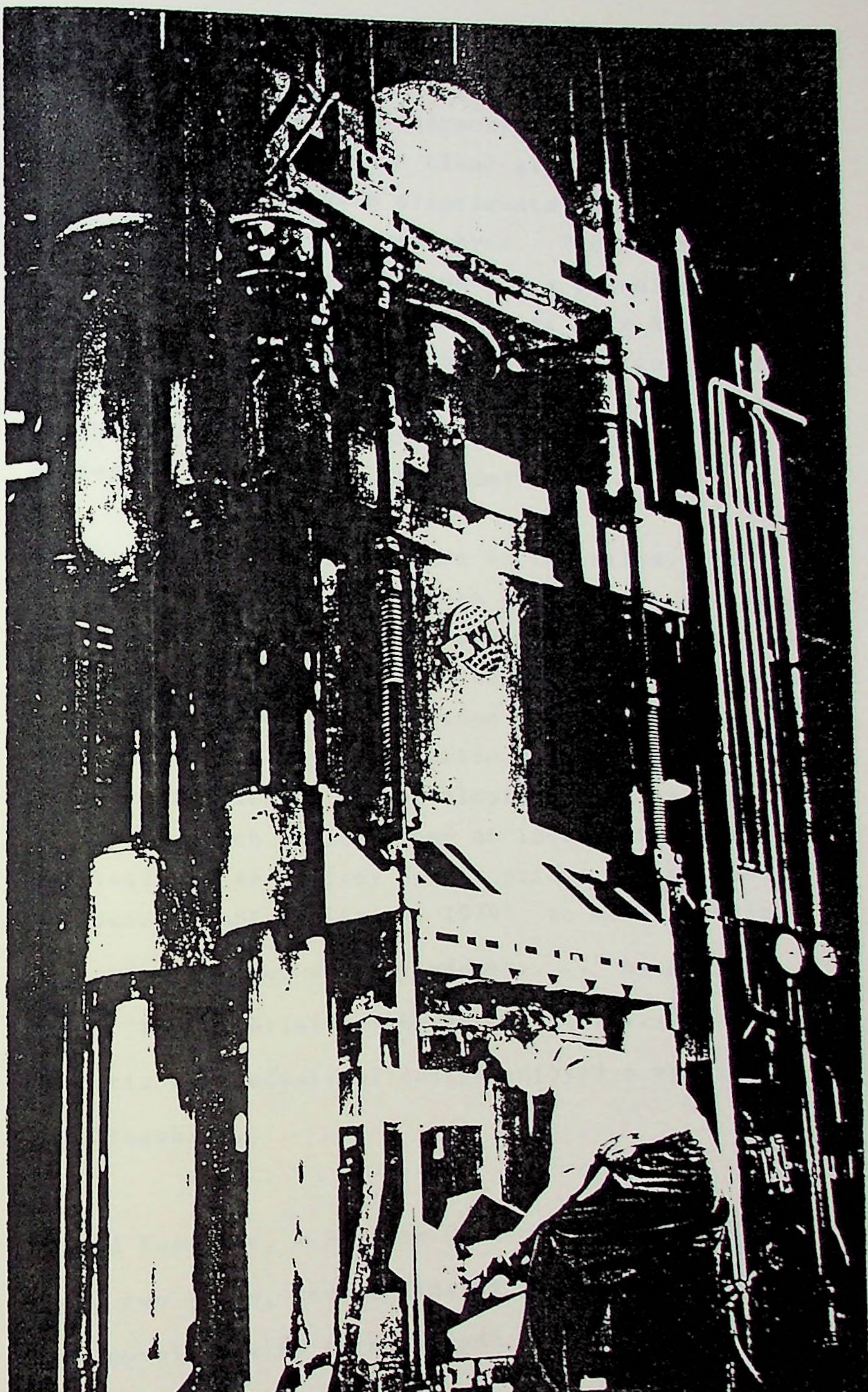
In 1839, Charles Goodyear discovered that he could make rubber highly resilient by adding varying amounts of sulphur and latex. The resultant material he named"Ebonite" or "Vulcanite". The greater the amount of sulphur, the harder and shinier the material became. It was used to mould such objects as fountain-pens, vesta matchboxes,pipe-stems, etc.

Alexander Parkes, in the 1840's, discovered parkesine, by dissolving woodflour and cotton fibre in nitric acid and sulphuric acid.By further mixing oils he formed a dough which dried to form a substance like ivory or horn. The chemical name for Parkasine is"cellulose nitrate" or "Pyrozylin" which is explosive on impact.

The Hyatt Brothers patented Celluloid in 1869 following work in response to a competition which was held in America to find a less brittle, mouldable, substitute for ivory. The Hyatt Brothers discovered that by adding camphor as an admixture to Mr. Parkes' Parkasine, a less brittle result was achieved. It was called Celluloid. Celluloid has become one of the plastics which we tend to be blase about. Due to its association with the screen, its name has become synonymous with unreality. Celluloid's properties lent themselves to great feats of mimicry. It was used to imitate tortoise-shell and pearls. In the 1920's, women still wore their hair long and it was estimated that the women wore an average of about a quarter of a pound, of cellulose in the form of decorative combs in it. Cellulose is a thermoplastic so it could be melted down and re-used. Other plastics based on celluloid are Cellophane, Cellulose Acetate and Viscose Rayon.

Patented as a moulding compound by Spitteler in Bavaria, in the 1890's, Casein is formed by curdling skimmed milk with rennet. It is cured by long immersion in formaldehyde to form a plastic which is a good thermosetting material which he first described as a good substitute for horn or 'artificial horn'. It was first registered under the name Galalith (Milk Stone). Casein absorbs water easily and starts cracking. Even so, it is still used to-day as a competitor of Polyester and Nylon in the manufacture of buttons. There is an interesting relationship between Casein and Ireland. In England, the material was called Erinoid because of the assocation of milk with Ireland. In fact, milk was supplied for the making of Erinoid by the Creamery in Co. Cork.

Plastics Develop. (The First Synthetic Polymers).



Bakelite was developed by a Belgian-born Chemist, Leo Bakeland, in 1907, after a search which started several years before. Distracted from his original goal, which was to find a clear glasslike plastic, he became involved with experiments using Phenol (Carbolic Acid) and Formaldehyde. The first truly synthetic plastic was the result, a phenolic resin which became known as Bakelite. It is a hard and brittle reinforcement of fibres or woodflour which gives the plastic its mottled effect. The colours of the mouldings are restricted to black and dark shades of brown, green, blue and red.

Its biggest applications were in imitation, where it was used to simulate wooden dashboards, mouldings for radio cabinets, knobs, ashtrays, etc. Also, it was used for hair-dryers and other electrical goods where its insulating properties were exploited. This led to new experimentation with shape and form. A new consciousness was developing which was opening up a path which would become an industrial design revolution. As Jeffrey Meikle points out in his
2 "Twentieth Century Limited 1979" to move plastic "beyond a limited novelty market....." by publicising "the material's inherent beauty....." "Plastic and industrial design enjoyed a symbiotic relationship".

Edmund Rossiter, a British Chemist, in 1924, combined two gases, carbon dioxide and ammonia, which, when combined with formaldehyde, produces a water-white, transparent moulding powder. It was the first of its type and was referred to as Bandalasta or Linga-Longa. Its scientific name is Urea thiourea formaldehyde. Depending on the mixture's nature the thiourea could achieve a simulation of marble, alabaster and stone.

An improved material, urea formaldehyde, in 1932, pushed the thiourea into the background. The Bandalasta or Linga Longa, was replaced in the home with plastic cutlery, light fittings, cream makers and picnic sets made from thiourea in bright clear colours. At last, bright-coloured plastic kitchen appliances, which could cope with kitchen treatment, had been developed.

In the 1930's there was an increase in the use of plastics, not only because of the use of injection-machines became more practical. This was due to developments in the process. Now, a fully automatic plant could run off hugh numbers of end products thus satisfying a great demand which existed for products of the new modern age. Life styles were changing with the times. People were letting go their domestic staff and socialising more. A new pride in people's domestic equipment blossomed. The cigarette companies were also becoming more sophisticated in their associated product design, producing ashtrays, cigarette holders, boxes from plastic using very elaborate designs. There was a frenzy in the use of plastic. People were using it for every purpose they could. It was the wonder material of the day. Its exploitation in the production of cheaper products than their predecessors led to a reduction in the quality of the plastic. Low grade moulding powders, skimpy design and faulty moulding techniques led to the lowering of the image of the material. Plastics were being associated with the image of cheapness and bad quality. Manufacturers tried to rally behind the material. The British Plastics Federation tried to get up a hallmarking scheme but the social development of the time was the timely rescuer. The war broke out and made the plastic's industry into a vital resource using mass production to produce the vital goods with which to run the campaign.

World War II opened up a new design awareness with
women working outside the home for the first time
in large numbers. The machinery of war was soph-
isticated and ergonomically designed giving women,
en mass, an appreciation for quality. During the
war years many plastics were developed many being
petroleum-based. Acrylic was the main discovery
having household utensils made from it. The New
York Museum of Modern Art held an exhibition in
1940 of utensils made from acrylic which were replac-
ing the mundane kitchen utensils. This was billed
3 as the "Useful objects under 10 dollars" which was
almost prophetic in its summation of the percieved
value which, even to-day, the plastic industry must
live with even though enormous strides are being
made in latter years to revolutionise the use and
development of plastic.

In 1938 Du Pont Laboritories in America discovered Nylon, the first totally man-made fibre.

Other plastics to emerge during the war were P.V.C. (Vinyl), Melamine, Polyethylene and Polystyrene.
Discovered by Mr. Wallace Carothers, Nylon was swiftly made into bristles and brushes under the trade name of "Exton" and soon became very import-

ant to the fashion industry, where stockings, to replace the natural sheer silk ones, were being made of nylon. "Nylons" became an essential accessory for any fashion-conscious woman, a trend which has lasted through the years and, until to-day, nylon was even used as hair lacquer.

Throughout the 1940's in America, Formica, Roanide and Micarta were proliferating as the work surface in kitchens, trains, air-liners, hotel bars and cinemas. These tough, heat-resistant, melamine faced laminates were to characterise the 1950's era and even into the 60's and 70's. Indeed, the person of the 50's was truely of the plastic generation. They wore "terylene shirts, moulded (pleated) polyester skirts, beehive hairdo's, sealed in position with vinyl acetate laquer, and legs
4 encased in "sheerer era"stockings suspended from synthetic rubber lycra roll-ons".

Polythene, a war surplus material was the material from which the 60m. Hoola-Hoops, were made. The Hoola-Hoop was the first enormouse cult object, which was only possible because of the proliferation and low price of the material, due to its mass-production capability.

During the 1950's moulded melamine tableware accounted for approximately 50% of the market, previously the domain of ceramics. The reason for this was the range of colours which were available,which could not previously be achieved. Also, even though melamine was more expensive than the traditional material, it was much stronger and longer lasting. Two noteable names associated with melamine were, Russel Wright (America) and Ron Brookes (England) whose

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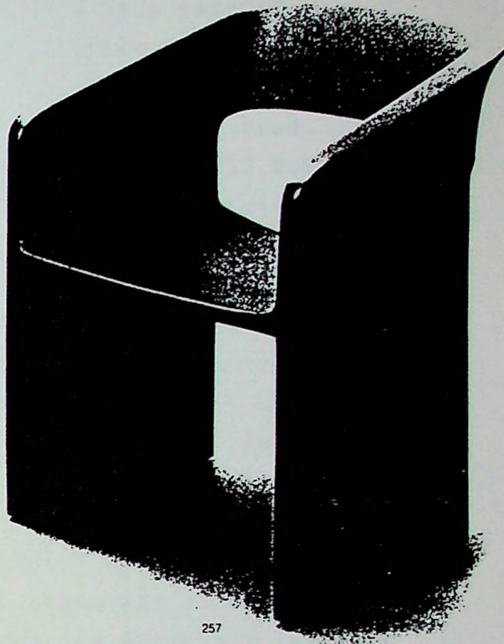

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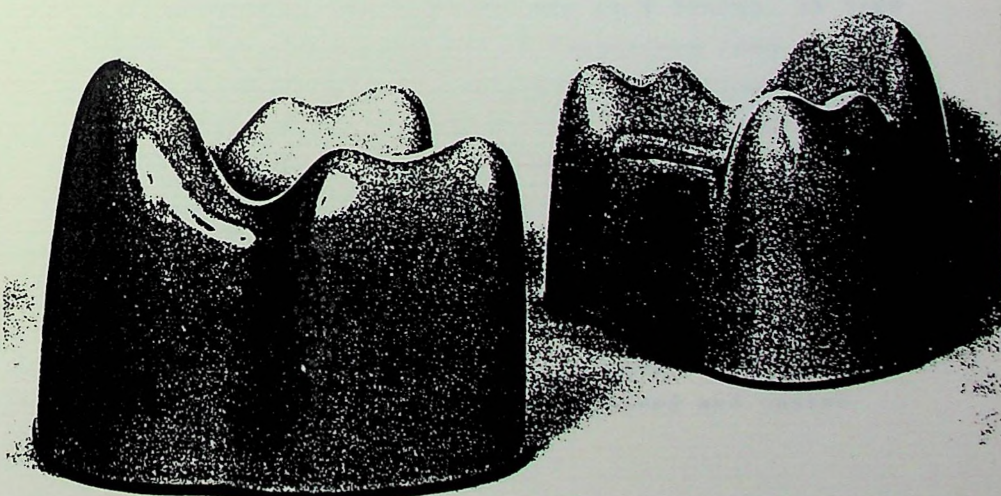


designs were most effective.

A material of the present day, polyethylene, began its development back in the 30's as a part of a chain of discoveries, which is often characteristic of the nature of discovery, in plastic technology. Often accidently, new materials are discovered. Such is the case with polyethylene. In 1953 DuPont derived the new polymer from oil, polymerising at low temperature and high pressure originally, when used during the war. DuPont used a newer safer process, which exploited lower and safer pressures. DuPonts tradename, High-density Polyethylene, became better known as Polythene and the material though not generally known by its real name, is probably the most widely used plastic,since the 1950's.

Buckets for hot water, dustbins, baby-baths and containers for all kinds of chemicals were made from polyethylene, exploiting the materials inherant properties, strength, hardness and a higher melting point. The "Tupperware Parties" of the 50's,60'S and the 70's made the material even more popular. From a social aspect, plastic was being appreciated for its cheapness and also for its good design. As time moved on, the perception of Tupperware food containers became despised as a greater sophistication among the people of the 60' and the 70'looked down on the temporary nature of the material. Again plastic was becoming despised for its proliferation rather than being appreciated for its inherant value.

Also, in the 50's came PVC. Originally unstable in its finished form, it was improved and ousted

shellac and phenolic resin, as material for LP's and single records, perhaps the most famous application of plastic ever. It is today the material which carries the enormous task of changing and updating fashion, politics and society through the recorded medium of the record industry.

If a survey were to be carried out among the people of the western world, as to what was the plastic age? I'm sure that the majority would reply, the 60's. As mentioned previously, clothes,shoes,laquer,table-tops etc. were exploiting the the properties of plastic in several forms. In the "swinging sixties" furniture, made from, or covered by plastic became very popular. Sculptural forms were covered and padded with foam and plastic, to initiate a new aestethic in furniture design. Blow-up chairs, transparent and brightly coloured, were the new vogue. Names like, Gufram,Jørn Utzon, Johannes Larsen, were synominous with the up-to-date image of plastic furniture.

"By the late 1960's plastics had made technically possible the destruction of our familiar domestic world. The important and aptly titled exhibition, 'Italy: The New Domestic Landscape', staged in New York in 1972, proved to be the visual and polemic summary of the crisis in design. The catologue encapsulated, in a tracing paper cover, cut-outs of plastic products which shifted loosely around inside.

5 On the subject of plastics, Giulio Carlo Argan,professor of history of art, describes the products of the Italian company Kartell as 'exemplary'. Their pieces 'are constantly changing.... The shapes are not governed by any fixed or precise aesthetic

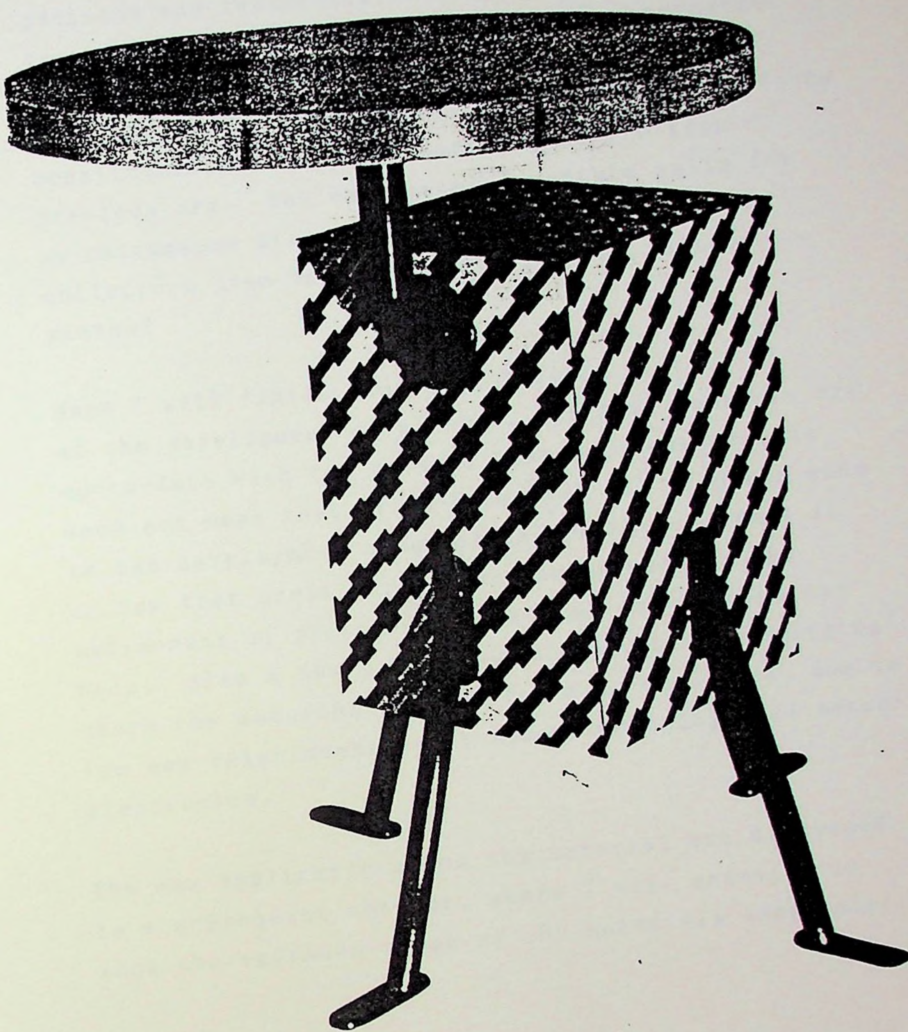
notions but serve as typical signs. The "thing", besides not being of any intrinsic worth and therefore not reqiring preservation indefinately [except now by collectors and museums (author) is also resiliant and almost transparent. It has no existance of its own but merely a transitory presence in the course of ones life".

In the 1970's, for a variety of reasons, there was a dramatic fall away in the use of plastic. The energy crisis of 1973 caused a depression in the petrochemical market, which directly hit the plastics industry. Also, as is the nature of the human race, who tend to have pendulum swings, in action and reaction, from one era to the next, plastic became unpopular and the opposite the fashion. In the 70's we reverted to traditional crafts, and materials to the detriment of plastics.

Less was being done to discover new materials. The new developments were in the economy of materials usage and sophistication of processes. Miniaturisation became the key-word in the microchip world. Hi-technology became the catch-phrase and the fashion.

As a reaction to the state of flux in society (western society) and the inertia throughout the world, a new radical movement began to grow. Punk culture in England spread to Europe and America.

Punks singled out plastics as the epitomy of tastelessness and cheapness. They were agressive in their philosophy, which was becoming anarchistic. Perhaps because punks medium for expression was in plastic, it was consiously rescues by the Italian movement, Memphis. In the early 80's,Studio Alchyma,in Italy



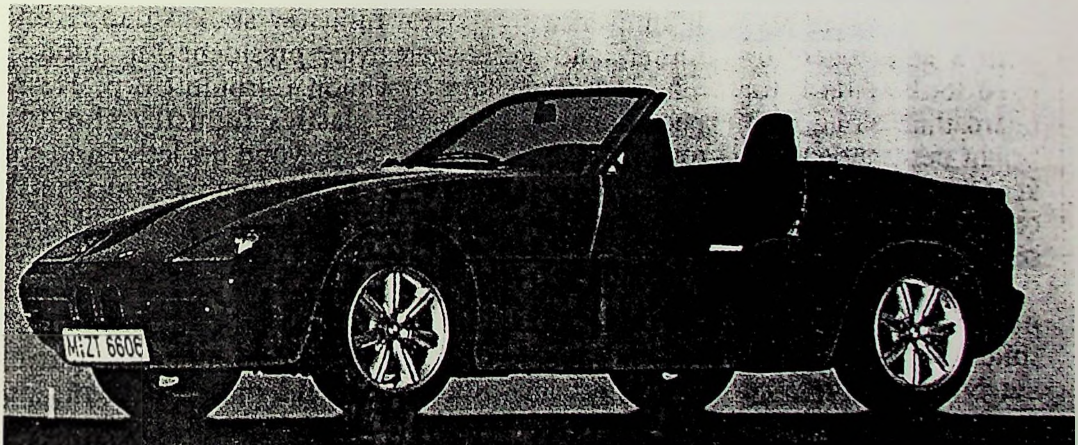
again exploited laminates but this time in a new way. The image of Memphis is one of multicoloured patterns and textures,with form borrowed from previous movements,and mixed to form a new aesthetic.

6 The furniture was uncomfortable to use. "Seats were flat,book-cases sloped, quasi-geometrical forms constituted seating with borrowed motifs from a previous era. The outrageous furniture sells for an outrageous price. Often the furniture is a collectors item because of its limited edition status".

Here I will finish the chronological history of of the development of plastic. At this point we are up-to-date with the general history, however this does not mean that it is here that all progress ends in the development of plastics. On the contrary it is now that great strides are being made in the refinement of processes due to the use of electronics. Also a new perception of plastics is emerging where the material is adopting a hi-tech aura, due to its new relationship with space technology and microelectronics.

The new applications for the material are discussed in a subsequant chapter, where I will endevour to show the enormous range of the materials uses today.

The Current Work Being Carried Out On Plastics Today.



BMW Z 1 *features body panels of injection-molded engineering thermoplastics.*

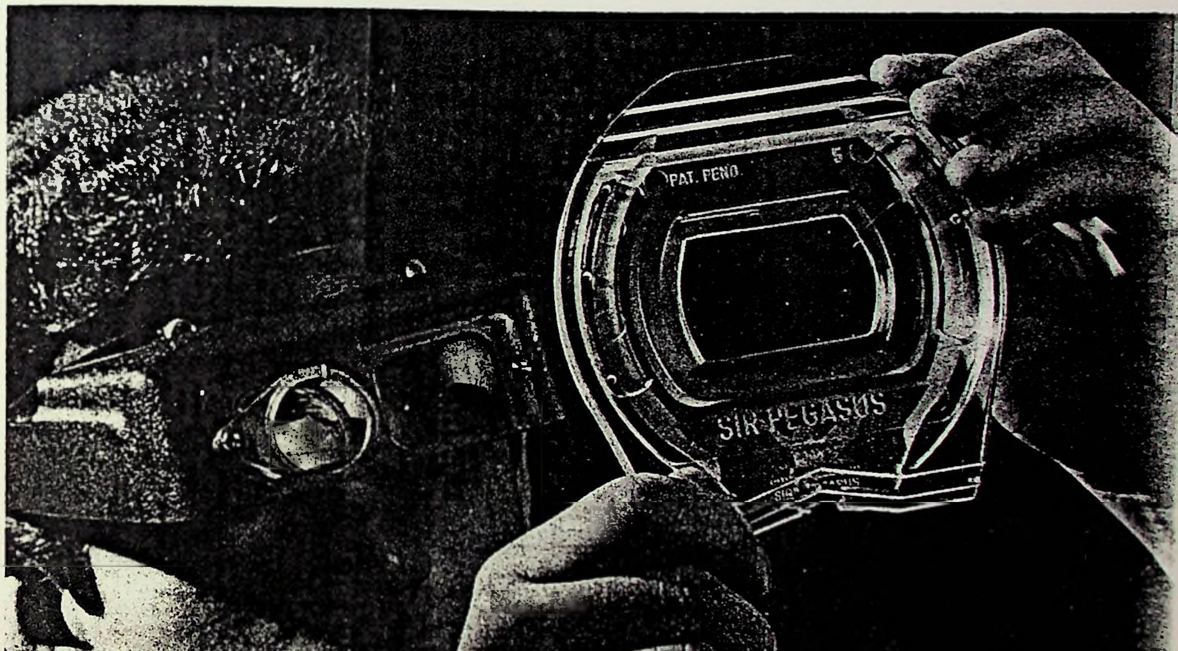
Today plastics are being used in a large variety of applications. Each day the boundries of usage are being pushed back to reveal new applications. The limiting factors in the discovery of new applications depends on several considerations,but the most important one is the flair of the human mind. Because of the emmence capacity of the brain to create new concepts and ideas,it is reasonable to assume that the limit to the development of plastic and its applications, depends directly on the stimulation of the human brain.Therefore I propose that there is no limiting factor, except perhaps the possible difficiencies which may be inherent in the material itself.

In this chapter I wish to discuss a number of products which are being manufactured from plastic and also, some proposals, which as yet, are at the development stage. There are a myriad of plastic products. I have selected only a few for discussion, which will provide an incling as to the versitality of the medium.

7 "BMW's Z1 roadster will feature components no other car can claim - body panels injection moulded of engineering thermoplastic.

Front fenders, doors, rear quarter panels and rocker panels are moulded of Xenoy polymer alloy resin, while front and rear facias are moulded of Lomod thermoplastic elastomer. The GE. (General Electric) plastics resins provide low-temperature impact performance, easy mouldability and class A finish right out of the mould.

In addition, side door supports and rocker panel enforcements, consi[illegible] of Azmet Techpolymer structures from Azdel, Inc., a joint venture company of GE. and PPG. industries. The material has extreme stiffness


PAT. PEND.
SIR PEGASUS

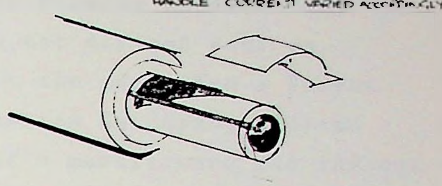
low coefficient of thermal expansion and high impact at temperature extremes.

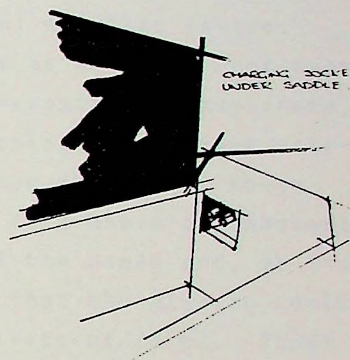
About 120lbs of plastic material helps form the two-seater. The result: adurable, yet aerodynamic exterior".

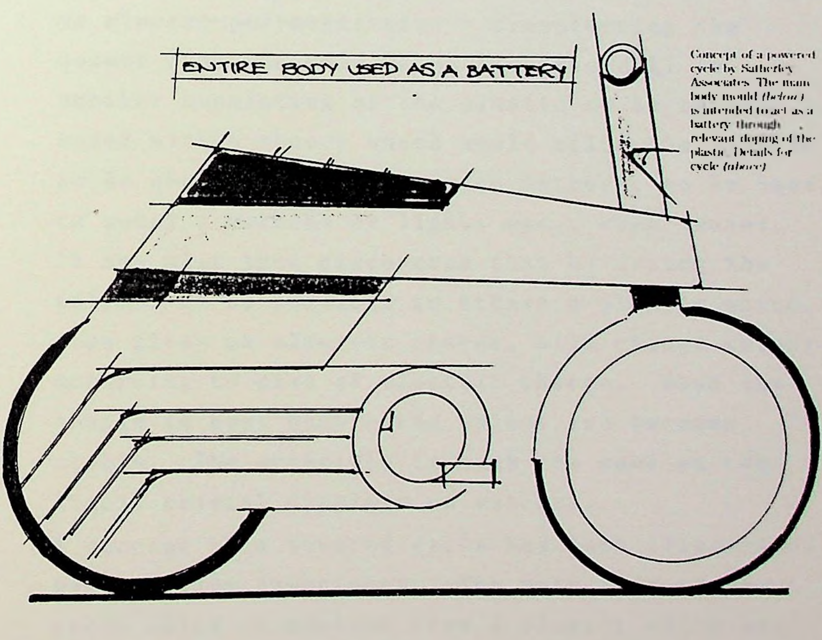
The artical goes on to describe how the performance and feul economy is improved directly due to the new manufacturing methods with plastic..BMW. also claim to have saved 60% time and cost by moulding using zinc alloy instead of steel in the moulding tools.

8 "It aint the 'eavy 'auling that 'urts the 'orses 'ooves; Its the 'ammer, 'ammer, 'ammer on the 'ard 'ighways" (British bard).

Horses develop pain through the clip-clop of their walk by shock and vibration through the steel horse-shoe. In San Jose, California, Mr. David McKibben, President, Sir Pegasus Company, has developed a new tough thermoplastic horse-shoe which, he claims, becomes an extension of the horse's hoof. The new shoe allows the horse to use his foot in a more natural way, a way which is not possible with steel shoes. When walking, the horse's hoof expands and goes through a number of shape and movement adjustments. Because the new shoe is flexible and specifically designed to accommodate this movement, the horse is, as a result, more comfortable. The Sir Pegasus shoe is injection moulded from two Pellethane polyurethane elastomers.
McKibben adds "my horse-shoes are the equivalent of a specialised athletic shoe".





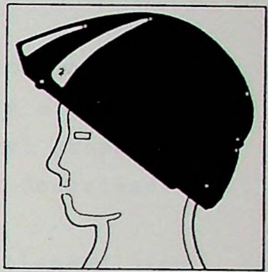


Concept of a powered cycle by Satherley Associates. The main body mould *(below)* is intended to act as a battery through relevant doping of the plastic. Details for cycle *(above)*

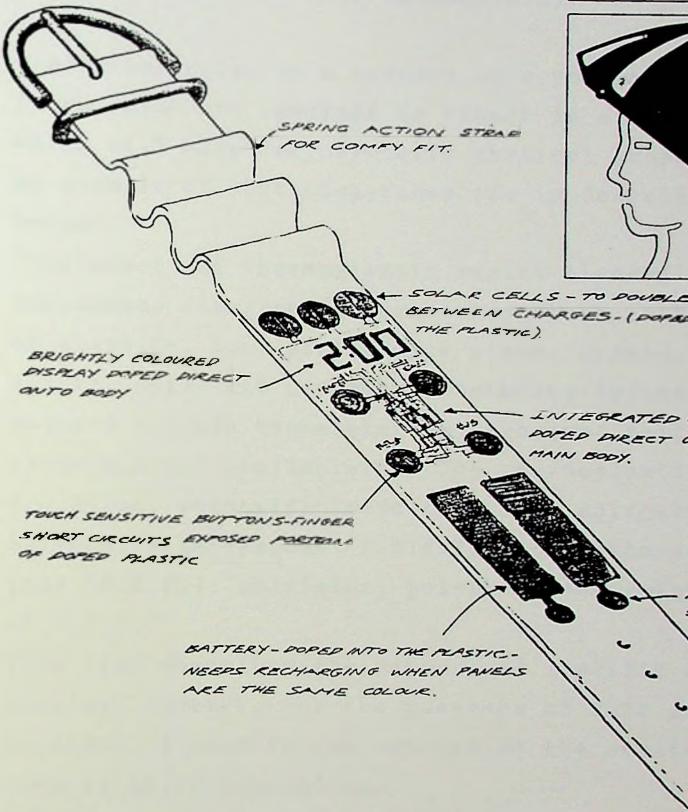
Just as many scientific discoveries have been made through chance and accident, e.g. Nobel applied collodion to a cut finger to come up with the idea for a safe, powerful explosive; Newton saw the apple fall and Alexander Fleming wondered why the milk that he fed to his cat did not sour on standing. So too was it the case when a Korean student, working on plastics in Japan, misread the details of a polymer's manufacture and instead stumbled across a product which possessed some odd properties and an unusual metallic lustre. Under further development by an American Professor, Alan MacDiarmid, of the University of Pensylvania, it was discovered that by doping the polymer poly-acetylene with traces of other chemicals, these properties could be changed to achieve an insulating capability at one extreme of the scale and, at the other extreme, it was found that the plastic could have the electrical conductivity of metal. Study gained impetus and work on plastic doping, known as electro-polymerisation - transferring the dopant from one pole of an electric cell to another consisting of the plastic to be treated - ended with a theory which would allow the plastic to be changed, like a storage battery, to be used to power a machine or light, etc., when needed. It has also been discovered that by doping the polymer it is possible to attain a plastic which, when given an electric charge, will change colour according to size of electric charge. When the charge is kept stable the colour too becomes stable. The principle is much the same as the liquid crystal displays on watches.

A concept of a powered cycle has been illustrated by Satherley Associates. The main body to the cycle which is moulded from a plastic which has

Conceptual design for a safety helmet for the mining industry *(right)* by Heights Design. The new plastics preclude the need for battery packs and their associated cables and sockets



One piece watch by Satherley Associates *(below)*. All the components are integrated into the strap. The plastic changes colour according to the strength of the charge



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Science & Engineering Research Council, Molecular Electronics Advisory Group,
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0793 26222

been suitably doped, will act as the battery for the powering of the vehicle.

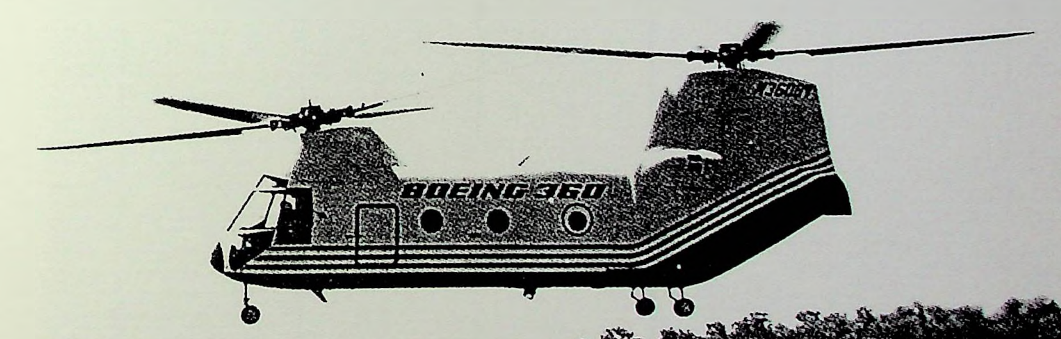
9 "From a record pole vault to a successful space flight and scores of other uses, composites have played a vital role. Even more exotic applications are on the way". (From "Design Feature" by F.W. Tortolano and Gary Chamberlain).

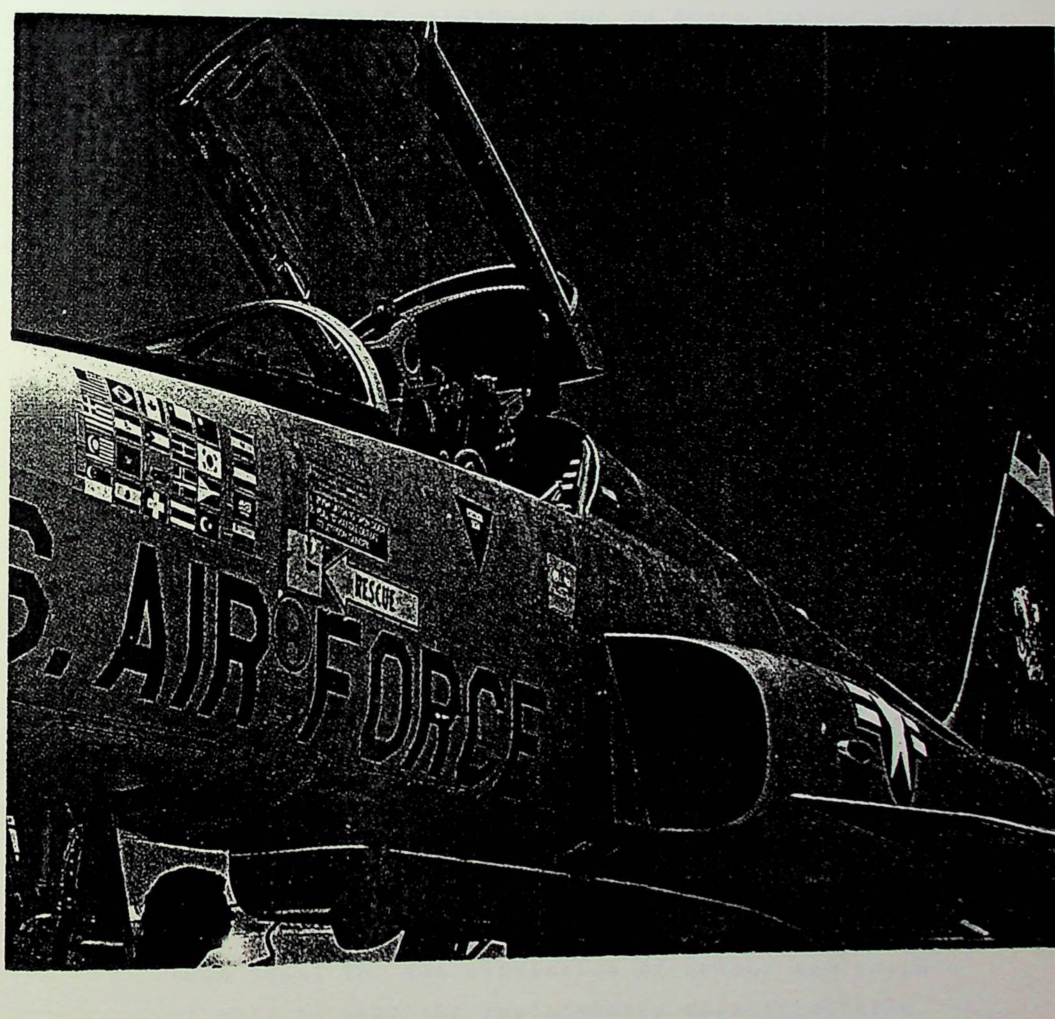
Composites refer to a mixture of a polymer and a fibre which are combined to result in a composite which will have very specific physical properties. An example of what composites are is described below:

10 "Thermoset and thermoplastic resins blended with continuous fibre reinforcements such as carbon or graphite, high performance glass, aramid, boron, quartz, metal and ceramic. Thermoset resins covered include bismaleimides, epoxies, polyesters, phenolics and vinylesters. The thermoplastics are nylon, polyamide-imide (P.A.I.), polycarbonate, polyetherether-ketone (P.E.E.K.), polyethersultone (P.E.S.), polyimide, polyphenylene sulphide (P.P.S.)."

This list describes the make-up of specific composites, however, for the purposes of this dissertation, I wish to concentrate on the apolications of these composites.

Composites are being utulised to a high degree by the aeronautical engineers and space programmes because of the weight/strength ratio which is very favourable. Also, as an example of how the moulding and fabrication capabilities of plastic may reduce complexity to a product, we can examine the carbon version of the Airbus rudder which has 96 component parts as against 1,100 components in the aluminium version.

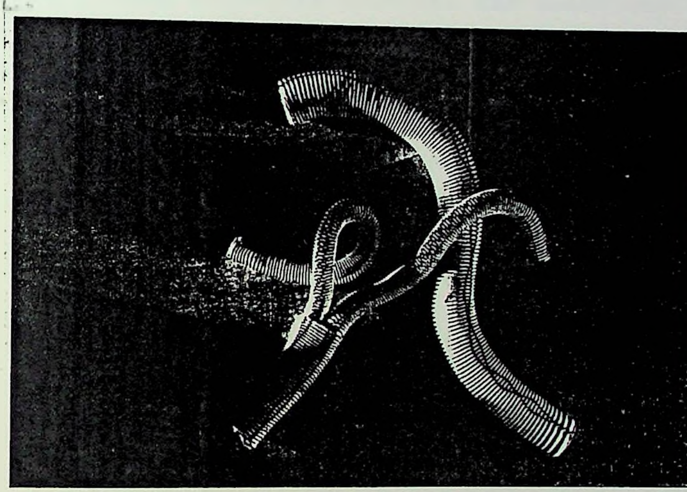

BOEING 360


AIR FORCE
RESCUE

In the future, an even greater role for composites
is forecast. The American Advanced Tactical Fighter
will have half its weight in composites. Also,
according to George Husman, B.A.S.F. structural
11 materials vice-president "the next generation of
military helicopters will be as much as 80% to 90%
composites".

The advanced technology helicopter by Boeing, the
model 360, when built, became the largest all-
composite helicopter to fly. At 51 feet long and
12 weighing 30,500 lbs. "the entire fuselage struct-
ure consists of graphite and Du Ponts Kevlar aramid
fibre and Nomex honeycomb all non-metallic mater-
ials. Combinations of fibre-glass and graphite
are the basic materials of the eight rotor blades,
two rotor hubs, numerous controls and shafts and
major components in the retractable tricycle landing
gear".
The article continues on to describe how the
assembly fixture" was completed in one go as
against six with conventional metal aircraft build-
up. Tooling costs have been reduced by 90% in
cost. The resulting Boeing 360 has proved to be
reliable in maintenance performance availability
and cost.

We have accepted plastic as being necessary to modern living. It is proven that the image of the material is fighting back to gain an esteem which it did not possess before. How much do we trust the material though? The ultimate test as to our confidence and acceptance of plastic surely comes in our use of artificial limbs and replacement organs. For years now we have been using artificial limbs where our own have failed or have been lost. Plastic has been ideal for the simulation of colour and texture of skin to make the replacements more acceptable.



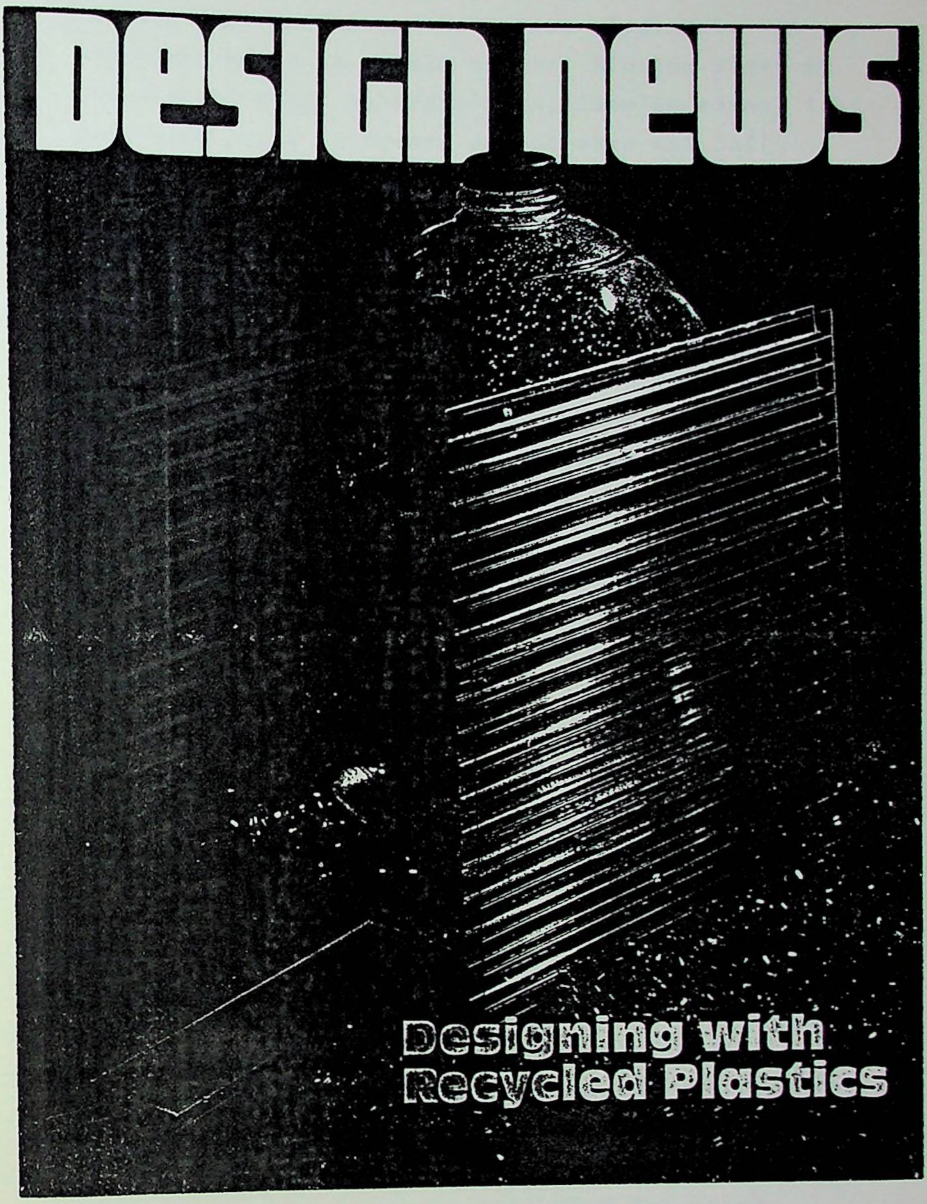
Vascuteck, Newmains Avenue, Inchinnan, Renfrewshire PA4 9RR; 041 812 5555

The true test was, however, in allowing a foreign material to enter the sacred confines of our mortal bodies. Now we accept as a matter of course, the instalation of not just false limbs, but also replacement arteries and hearts for those which have been damaged.

13 "Replacement arteries.
Vascutek now produce an artificial artery that is claimed to be a signifant advance on its imported rivals. Called"Triaxial", the prosthesis is produced from knitted Dacron using computerised knitting techniques. As well as greater strength and long stability Triaxial has controled low porosity which reduces blood loss"

A unique torque tension indicator allows the grafts to be made at the correct tension. The crimping process used in the operation also prevents kinking and compression.

Recycling Waste Plastic Material.


DESIGN NEWS
Designing with
Recycled Plastics

Perhaps what irritates most about plastic is its presence, where it should not be. Blowing about on the street, stuck in hedge'rows, flowing along, like open parachutes in rivers and streams and half burried in gardens, fields and building sites. Plasic which has been discarded will not organically breakdown with time, or be rotten by the elements. It is true to say that plastics know no time scale. We become annoyed with its dirty and untidy presence and the image of the material is further tarnished. Perhaps the "rubbish" factor is the material's worst enemy and stems from its own most valuable trait, that of longevity.

Plastic recycling opens a new dimension to the use of the material. In the U.S. in 1984 the "throw-away" society discarded 30 billion pounds of plastic, Japan discarded 8.5 billion pounds and an estimate from the European Common Market countries accounts for 12.8 billion pounds. These 1984 figures alone are frightening in the context of plastics' non-biodegradeability. In total, the developed world discarded 51.3 billion pounds of potential raw material which, in essence, was thrown away without thought for where it would go. The truth is that it will go nowhere, that is unless it is recycled. In America, Europe and Japan recycling is now recognised as being a lucrative proposition. Research foundations have been set up throughout universities in the U.S. A typical process for recycling carries out the following functions:

* Grinding the containers to chips or particles of an optimum size for processing;

* Air classifying the ground chips to remove light or fine materials i.e. paper, labels , dirt and dust;

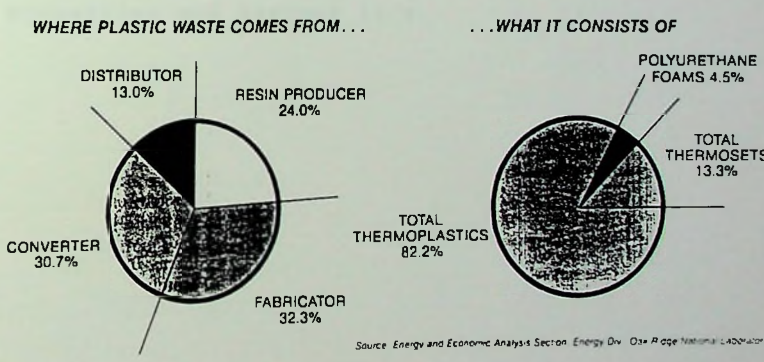
* Washing the chips in a hot caustic solution to sanitise, loosen and digest the attached papers and remove glues and residual syrups;

* Flotation separation of the light polymer (polyethylene) from heavier components (polyester and aluminium);

* Drying the polyethylene and polyester.

The reclaimation methods are not very sophisticated and, with little adaption, can cope with the reclamation of high-density polyethylene and polyvinyl/chloride.
After the reclamation of the polymers from their previous state, the raw material is once again ready to be used to form new products utilising the normal plastic moulding and extrusion processes.

In America, Tom Norton of Turtle Plastics, Cleveland, has set up a manufacturing industry producing "Waffle Tiles" by extrusion. Because of his recycling investment, he can cut the price of his product by 40% below current market rates. This is a typical statistic for recycling and points to a new future in the plastic industry.



Source: Energy and Economic Analysis Section, Energy Div., Oak Ridge National Laboratory

Recycling is not, however, just carried out among small business men. Coca Cola Company in America have begun to re-use base caps for their bottles.

The uses to which recycled plastics have been put are diverse and also surprising in their application. In West Germany where "Recycloplast" organise collection from designated bins, in the local neighbourhoods, produce 24 tons of end products in a 24 hour cycle of reclamation. The electrical out-put for the recycling plant runs at about 400 kw.per hour.
From the collection bins the rubbish is moved to the plant where it is treated by separation, grinding, digestion and drying, from where the end product is used for a variety of purposes. Desired colours are mixed in the process to produce fillers for wood products like chipboard and wall board, synthetic aggregate for pavements. Some German autobahns have been constructed from a mixture of concrete in plastic waste that improve insulating properties and highway life.

Recycling of polyethylene terephthalate from carbonated beverage bottle tops typifies a secondary recycling process. As mentioned above, the recycling of high-density polyethylene from bottle bases represents secondary and primary recycling. Tertiary recycling processors purchase old x-ray film to recover the silver. Some also recover the remaining polyethylene terephathalate. Although less valuable than P.E.T. reclaimed from bottles, it will produce a chemical intermediate Polyol which can be used to make polyurethanes and unsaturated polyesters.

Thermoplastics are recyclable because they only undergo structural physical change. Therefore, they can go from bottle to car bumper to bottle again without suffering any physical degradation. In fact, the polymer's physical characteristics can be enhanced through recycling.

General Electric estimates that the market for recycled plastics will capture 60% to 70% of the total market by the year 2000, not only because of the viability of the process but also because of the changing attitude to the environment and its preservation.

14 "So the future scenario for plastics might go like this: an all-plastic car is built. A collision sends it to an auto salvage yard. Plastic waste collectors sort out the plastics and transport them to a recycling facility. The bumpers, body panels and plastic packaging might be transformed into tough, strong building panels. An all-plastic building is erected from the panels. Several years later the building is torn down to make way for a new highway. Recyclers gather the building debris and turn it into a concrete base for the

highway. And the cycle goes on, and on, and on..."

Conclusion.

We now fully trust and accept the use of plastic and depend on it for life itself. It is the revolutionary material we claim it to be, because no other material in the history of the world can offer the same adaptability to the tasks we find for it. Perhaps we should do a service for the material which has helped us so much. To clean up the environment from the abuse of plastic, would go a long way towards clearing the reputation of the material it does not deserve. Possibly then, the material would be appreciated for its true value, and not be despised through our own lack of respect for our environment.

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