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FOURTH YEAR INDUSTRIAL DESIGN

NATURAL BEAUTY AND SENSUALITY

by

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ACKNOLDGEMENTS

Paul Caffrey

The World of Nature

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INTRODUCTION

Through evolution nature produces an immense variety of forms, patterns and principles that spur our imagination and thought, the application of which can be for the benefit of mankind both physically and emotionally. This is the principle point of discussion within this thesis.

Chapter I 'Bionics' explores citing examples of designs within the man-made world that have evolved using the principles relevant to the designs in question found in nature. As with nature that evolves, the evolution of the designs are discussed with reference to an understanding of the principles involved.

Chapter II 'Sensuality' discuses how organic designs have a positive psychological affect upon the human senses. The importance of human senses which make our world clear is discussed with relation to perception and design.

Chapter III 'forms' discusses the application and misapplication of organic forms upon design and its consequences. The search for harmony between form, applied form and function id discussed. A comparison of modernist views and organic concepts of design is

explored in relation to form, applied form and how people interact with such opposing ideas.

Chapter IV 'Structure' similar to Bionics discusses the relevance of structural principles within nature being employed in architecture and forms which require strength of structure. The fact that using such natural principles in structure provides expression without the need for extra superfluous decoration is explained.

CHAPTER 1 Bionics

I waited ,waited
and calmly awaited,
with thoughts
unimpetuously grasping
images...

of the Surging Chaos,
The unexplained.

Images they came
and I knew,
but I questioned
and understood.

Bionics is a process of design where by designers, engineers or architects use principles from the world of nature, through an understanding of nature and its systems.

Within nature we can see economy of means, simplicity an elegance; in the way the leaves of a plant grow towards the light and bend to maintain right angles to the sun thereby gaining the most benefit from the sunlight. This is a logical solution for survival, although there is order, pattern and beauty there is a lack of conscious intention. Although the streamlining of a trouts body is aesthetically pleasing it is formed as a by-product of swimming efficiency. Nature produces forms and systems of immense functional efficiency, many of which are aesthetically pleasing while giving intuitive insight into the reasoning behind the forms.

Biology bionics and related fields offer great creative insight to the designer. Bionics can be described as the use of biological prototypes for the design of man made systems. Through the study of nature and understanding it principles and processes designers can emerge with applications to the needs of mankind, born consciously and unconsciously.

Design is essentially a problem solving activity, a process of finding the ideal solution to problems in design, the object of which like nature is to achieve fitness for purpose in an economical manner.

Plate 1.1 - Angle Poise Lamp

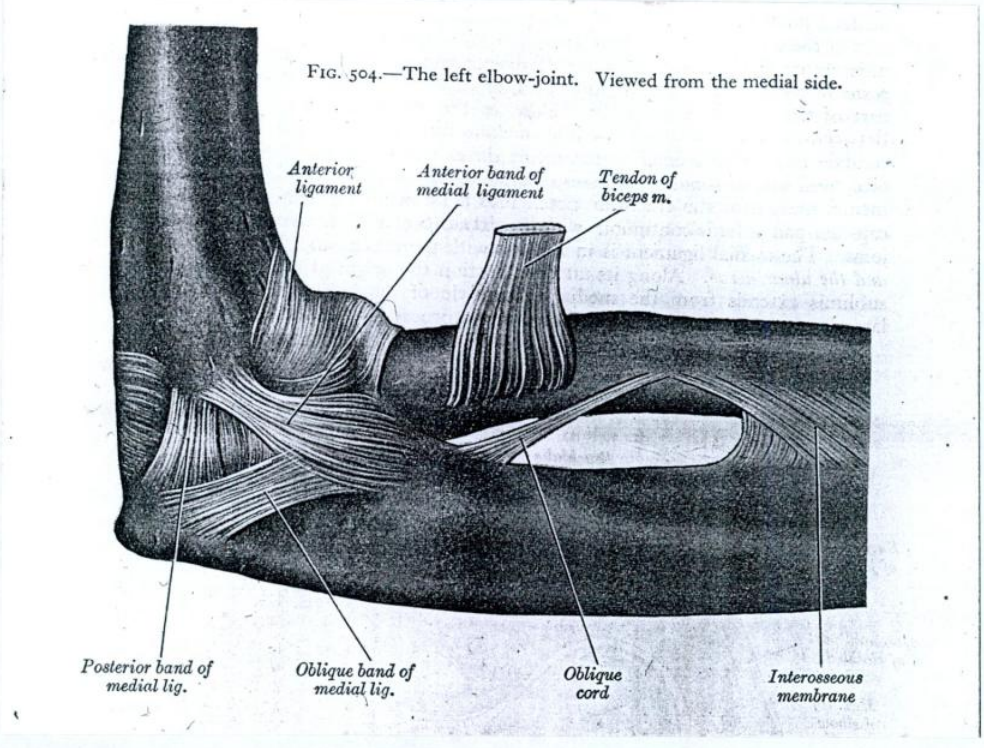


FIG. 504.—The left elbow-joint. Viewed from the medial side.

Plate 1.2 - Elbow Joint

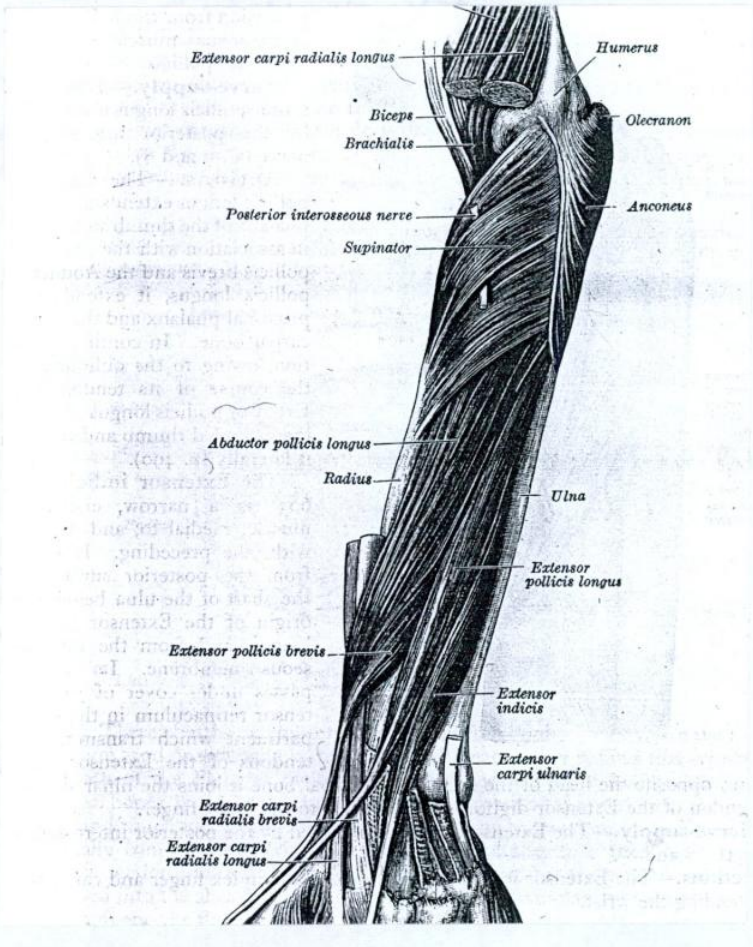


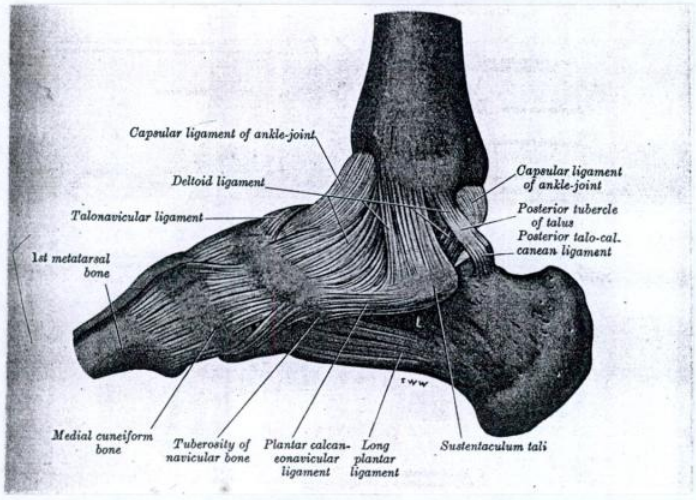
Plate 1.3 - Muscles of the forearm

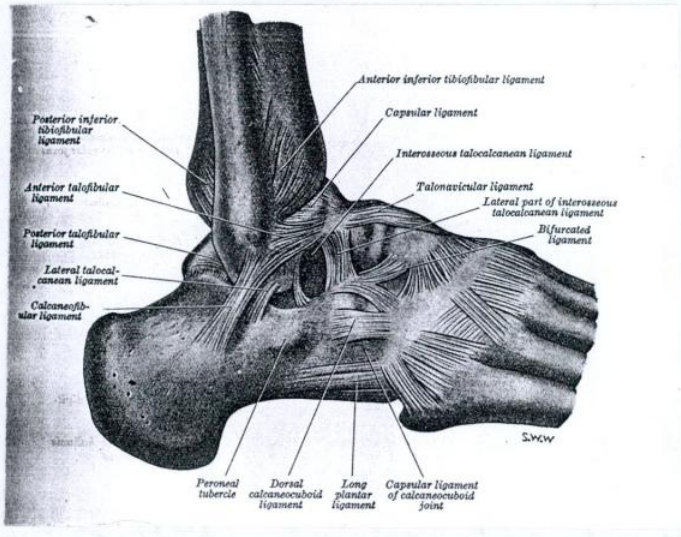
Within the realms of the human anatomy there is an immense variety of principles and systems that can be used for design purposes.

The everyday *Anglepoise Lamp* is an example of this (Plate 1.1) Interestingly this was designed by a doctor namely George Carwardine. Carwardine sought a convenient adjustable lamp for the purpose of examining his patients. As a model for his design he turned to the human arm. The arm rotating about a ball and socket joint in the shoulder and pivoting at the elbow has a wide variety of positions and flexibility. (Plate 1.2, 1.3) The arm move back and forward by means of muscles called 'Biceps' and 'Triceps' which push the bone by acting in opposing tension to each other.

Using this principle Carwardine designed a jointed lamp using springs to act as muscles working in opposing tension to each other. Providing an infinite range of positions over a wide arc. The angle poise clearly shows fitness for purpose with economy of means, while providing a character of its own. The lamp has progressed with many changes in shape and style. Its simplicity and efficiency may have been equalled but never bettered with the original character remaining intact.

The muscles and sinews that join the bones express a streamlined flow of line similar to the line of the 'trabeculae' in bones, muscles are aligned as bundles of fibres similar to the alignment of continuous carbon fibres. The study of the lines of flow of the muscles in joints (Plates 1.4, 1.5) is useful in the





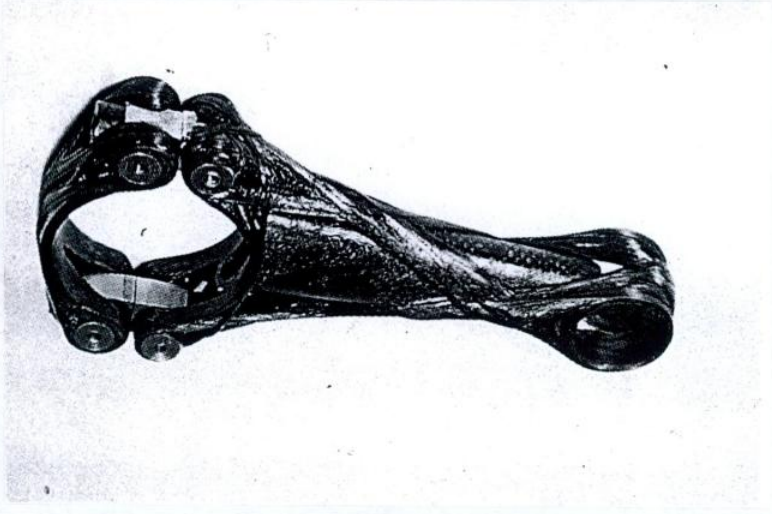


Plate 1.4 - Connection of Bones by Ligaments

Plate 1.5 - Connection of bones by Ligaments

Plate 1.6 - Connection rod of cligned fibres.

carbon fibre industry as it increases in development. This can be seen in the connecting rod of composite materials with aligned fibres (Plate 1.6)

Successful designs both in the man made world and the natural world express economy as an enduring factor. An economical design is one that achieves fitness for purpose with the least energy or material used. The designs of Christopher Dresser show economy of means. The dolphin and porpoise have undergone very little change since they swam in the sea while dinosaurs roamed the earth.

One such long lasting design in the man made world is the sewing needle, being perhaps the oldest and most unchanged tool used by man. Although there were changes in material from fishbone and wood to stainless steel, the only design change in the sewing needle came in recent times. The addition of the diagonal slit to the side or on top of the eye enabled the thread to be snapped into place, eliminating the difficulties of pushing it through the eye.

Nature produces the most amazing variety of shape, pattern and rhythm. What we see with our eyes can be augmented by the use of the cameras, telescope and the microscope. Products in themselves based upon a natural prototype - the eye. The newest eyes are those in that have been invented, such as the electric eye based upon principles of the motion detection of a frogs eye also the mirror telescope based on the contrast judging design of the horse-shoe crabs eye and the synchronous lenses for use in microsurgery, optical scanning

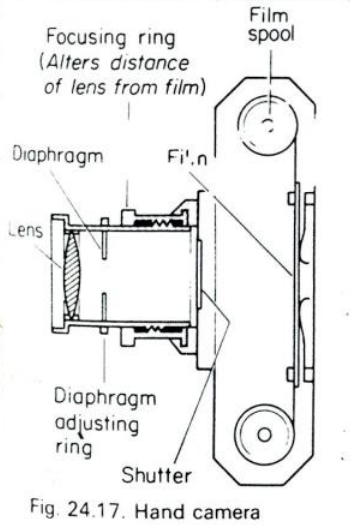


Fig. 24.17. Hand camera

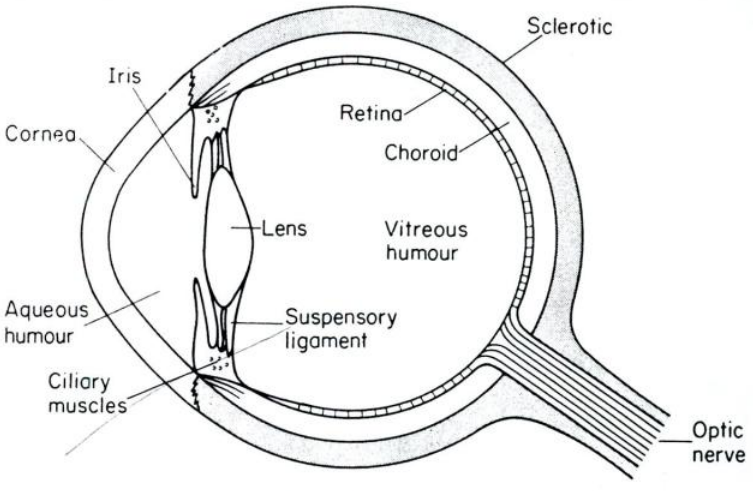


Fig. 24.18. Main features of the eye

Plate 1.7 - Diagram of the Eye and Camera

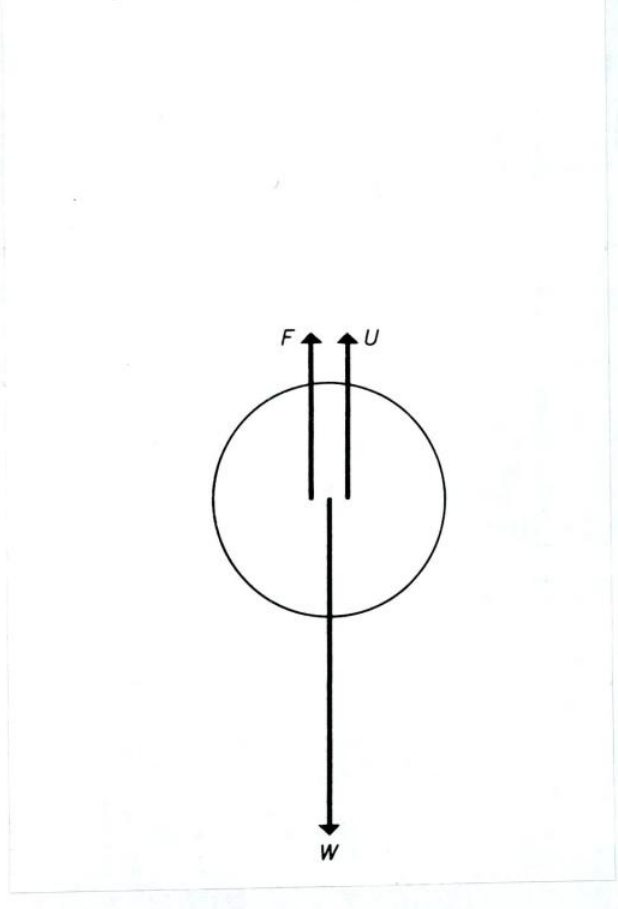


Plate 1.8 - Forces acting on a falling object.

and improving vision problems. The design of the Synchronous lens is based upon finding in the double lens of the Copilia, a myopic crustation that lives in the mediterranean.

In its simplest form a camera consists of a lens and a light sensitive film within a light-tight box. Focusing of an image onto the film is achieved by adjusting the distance between the lens and the film. There is also a shutter of variable speed and a diaphragm of variable aperture to regulate the amount of light allowed to pass through the lens. (Plate 1.7) In the eye light passes through the 'Cornea' which is the transparent part of the 'Sclerotic Coat'. Before the light passes through the lens it passes through the 'Iris' or coloured part of the eye which automatically adjusts the size of the pupil accordingly to the amount of light falling on it. the lens passes the light on the retina containing rods and cones which send electrical impulses to the brain where the image is registered. The sharpness of the image formed on the retina is controlled by 'ciliary muscles' which alter the focal lengths of the eye by varying the thickness and curvature of the lens. In this way the camera differs from the eye since in the camera focusing is obtained by varying the distance of the lens from the film.

> Future camera design clearly centres around the way in which the image is captured and the medium on which, or in which, it is stored. As the camera is now a mass market product the fashion of the day will play their pat too. The aim at present is a unit with a *Flexible Lens - like a human eye* - which responds to instructions from the brain, rather than crude fumblings of the fingers.
>
> (Dilkie Dec. 1991, P. 31)

During the past hundred years man has been looking even deeper into the biological sciences searching models and solutions that can be transferred to solve design problems.

Streamlining is a perfect example of the synthesis of aesthetics and technology through research in the natural world. The origins of streamlining can be traced back to the end of the nineteenth century when designers began to and appreciate the efficiency of organic forms such as birds and fish.

In the field of physics Sir George Stokes an eminent Physicist and mathematician of the nineteenth century investigated the effects of viscous drag on small spheres falling through liquids, finding that bodies moving through fluids (i.e. Liquid or gases) experienced a retarding force known as fluid friction or viscous drag (F). There are two other forces acting on the falling sphere (Plate 1.8) namely gravity (W) acting downwards and the upthrust (U) of the liquid as given by the principle of Archimedes which acts upwards. These two forces have resultant downward direction (W-U). If a sphere falls through a liquid it at first accelerates, as it does so its velocity increases subsequently viscous drag increases. Eventually (F) becomes equal to (W-U) and the resulting force on the sphere is zero in accordance with Newtons first law of motion the sphere then falls with uniform or terminal velocity. The intention of streamlining is to achieve just this. By reducing the retarding viscous drag to a minimum where more efficiency and economy can be attained.

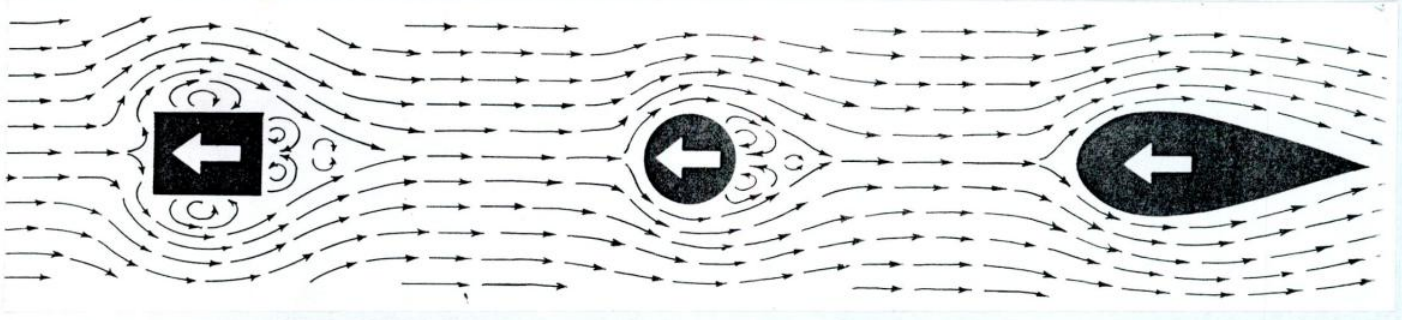


Plate 1.9 - Diagram illustrating the principles of streamlining

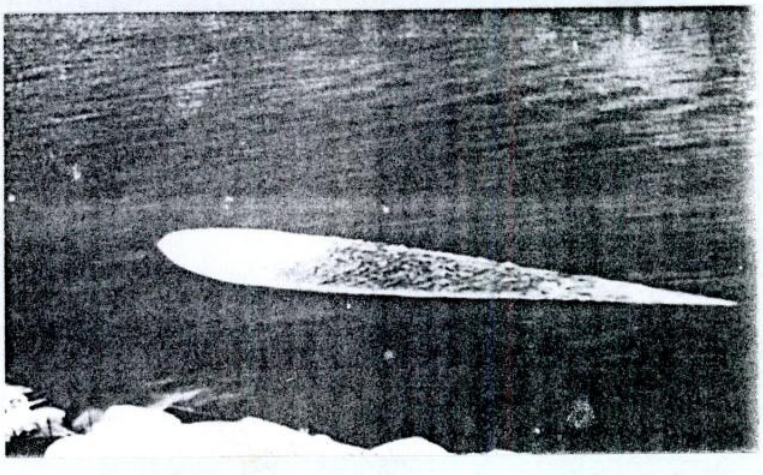


Plate 1.10 - Sheet of ice in a stream demonstrating Natures streamlining

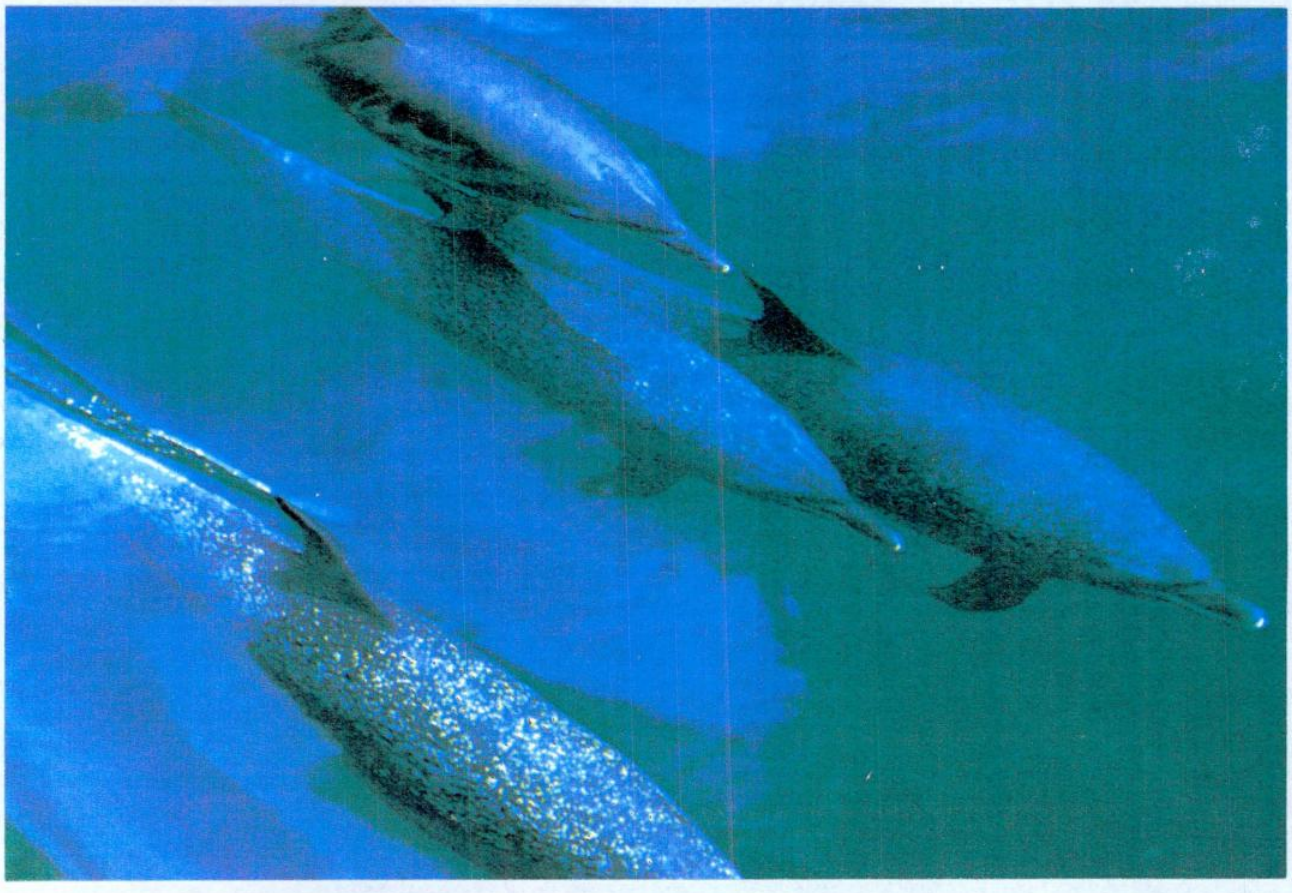


Plate 1.11 - Speed of Dolphins

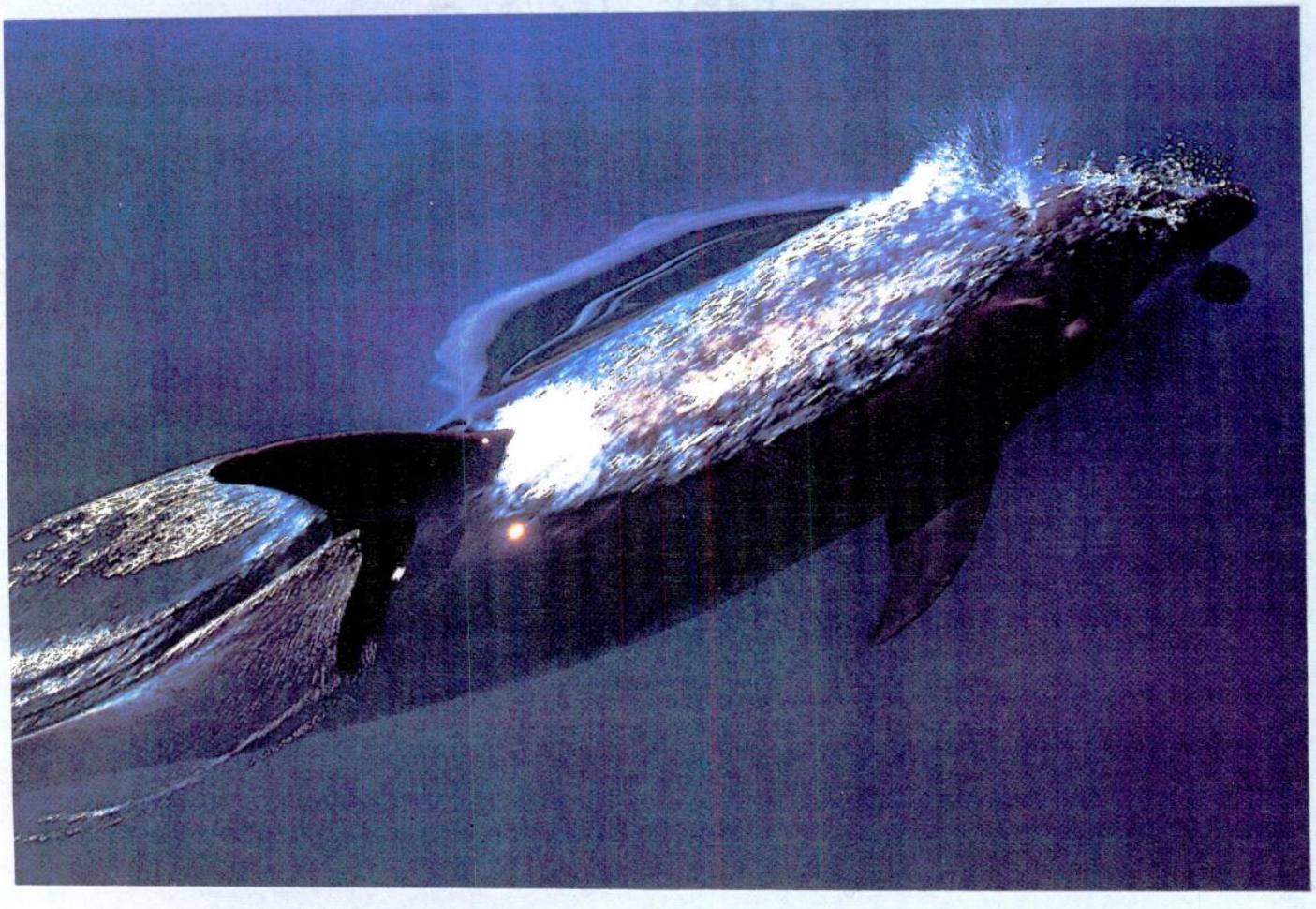


Plate 1.12 - Laminar flow of water over a dolphin's body to reduce drag.

The motion of fluid takes place under two forms, laminar and turbulent flow, laminar flow can be described as the fluid moving as parallel lines with direction and velocity without disturbance in this motion. Turbulent flow is what creates viscous drag created by the eddy currents or vortices caused by an alien form in the Laminar flow. The vortical turbulence creates a vacuum behind the alien form creating drag which retards forward motion a streamlined form is one that reduces this drag to a minimum.

> When a body immersed in a flow does not induce turbulence it may be said to be streamlined. (Bush, 1975, P.5)

The streamlined form reduces drag by creating as little disturbance in Laminar flow as possible. (Plate 1.9). In nature forms are altered by the forces acting upon them or more gradually by adaptation. A sheet of ice in a flowing stream is altered by the flow of water which changes its form to allow its easy passage (Plate 1.10)

The dolphins having evolved from mammals to which water is an alien environment strongly reflect their watery environment through its external forms. Streamlining of the body was necessary to minimise drag. The body of the dolphin became smooth and streamlined eliminating unnecessary protrusions that offer resistance to movement in the water. The form of the Dolphins is a dramatic expression of speed by the fact that they can achieve speeds up to 40KLM. (Plate 1.11) The streamlined form of the Dolphins shows perfect adaptation to its environment and swimming efficiency. The

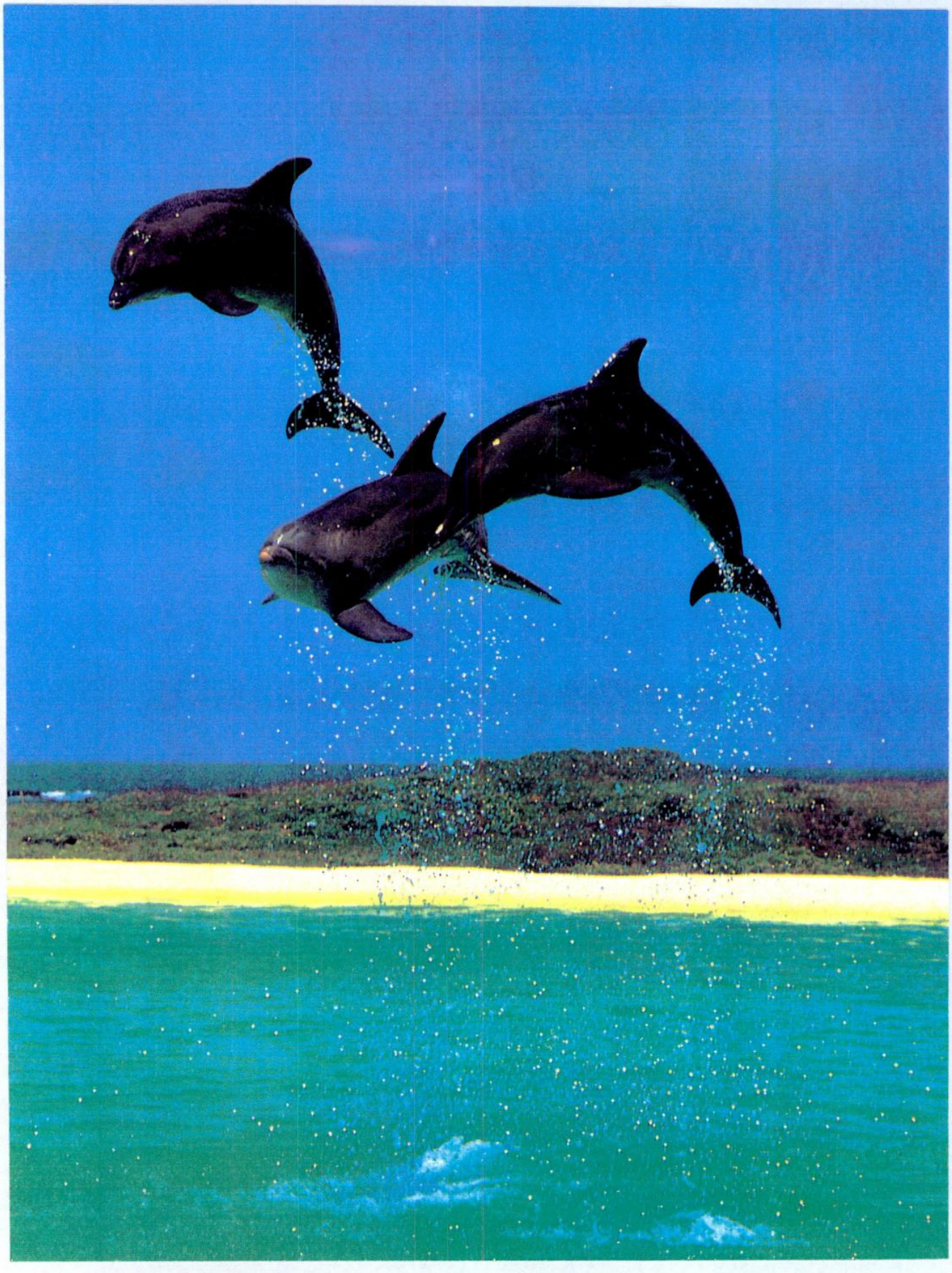


Plate 1.13 - Performing Dolphins

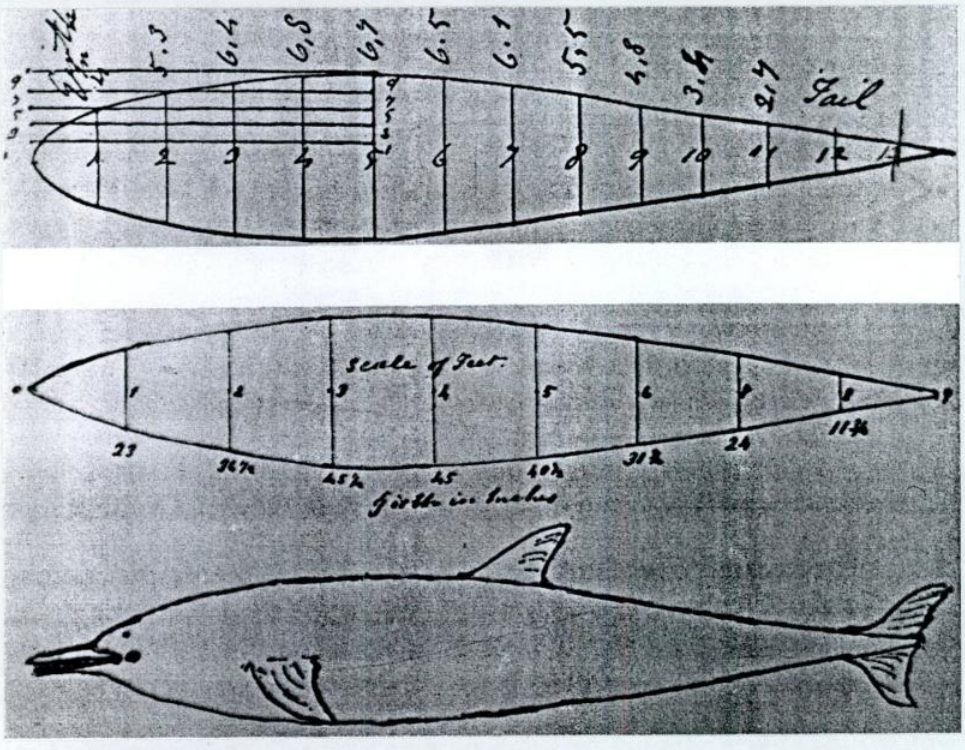


Plate 1.14 - True form of least resistance
Sir George Cayley.

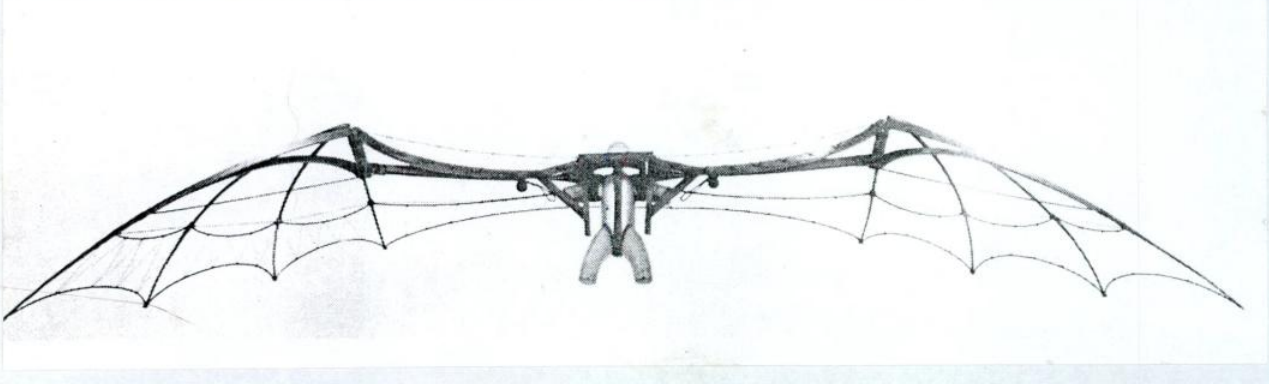


Plate 1.15 - Model of Leonardo da Vincis ornithopter
Sixteenth Century

speed and efficiency is further enhanced by the creation of Laminar flow of water over the Dolphin's body to further reduce drag (Plate 1.12). The speed of the Dolphins and its adaptations to perform this provides a perfect model for the study of hydro and aerodynamics. The speed and Leaping gymnastics of the Dolphins provides a dramatic spur for this study (Plate 1.13)

Sir George Cayley saw the use of such streamlining evolved from swimming efficiency. He measured the girth of a trout at regular intervals along the length converting the figures to mean diameters (Plate 1.14). Stating in his 'essay upon the mechanical principles of aerial navigation 1804.'

> We should then be deriving our boat from a better architect than man, and should probably have the real solid of least resistance.
>
> (Gibbs-Smith, 1962,P.41)

Which he proposed to be

> A form approaching to that of a very oblong spheroid, but varied according to what may be found the true solid of least resistance in air.
>
> (Gibbs-Smith 1962 P. 41)

Sir D'arcy Wentworth Thompson also felt that through nature man could discover the basic principles that could be used for their benefit.

> The naval architect, learns a great part of his lesson from the streamlining of a fish; the yachtsman learns that his sails are nothing more than a great birds wing, causing the slender hull to fly along; and the mathematical study of the streamline of a bird, and of the principles underlying the areas and curvatures of its wings and tail, has helped to lay the very foundations of the modern science of aeronautics.
>
> (Thompson 1963. Vol 11. P. 941)

Plate 1.16 - Douglas DC2

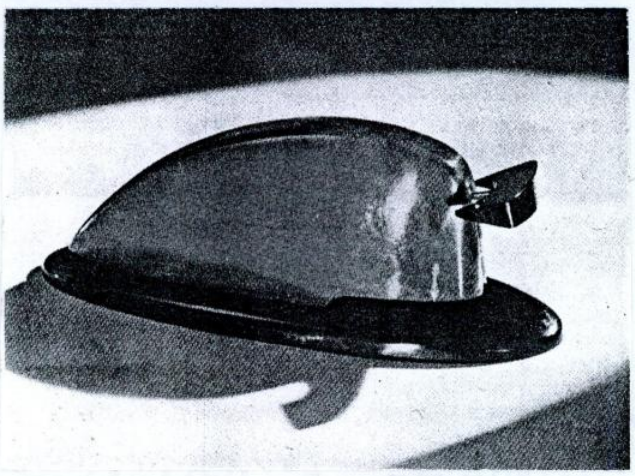


Plate 1.17 - Hotchkiss Stapler - Orla Heller

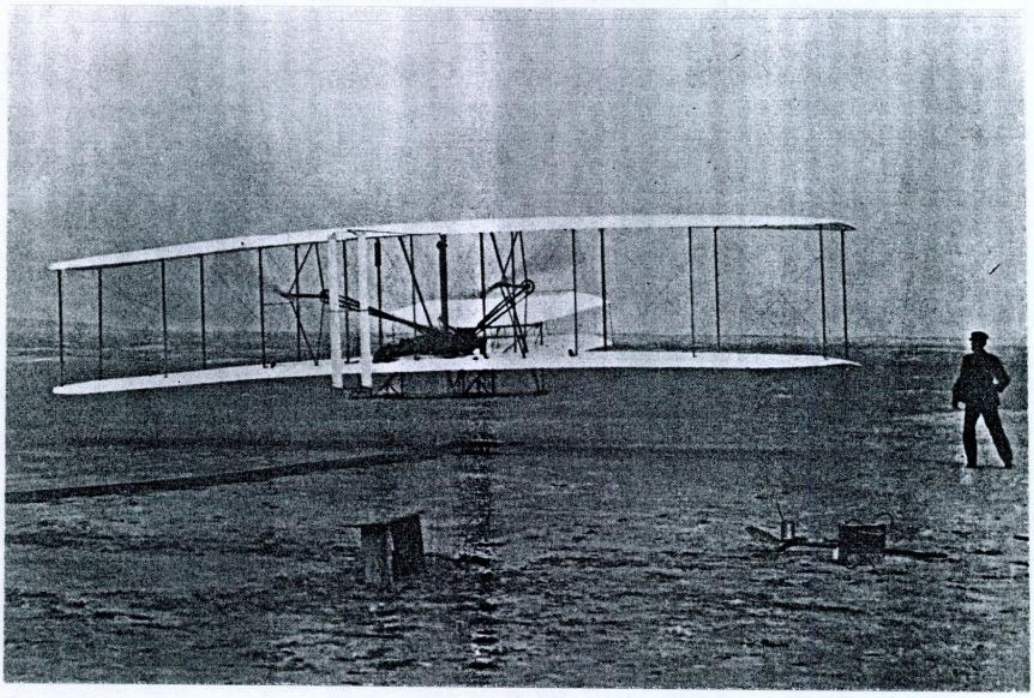


Plate 1.18 - Wright Brothers Kittyhawk 1903

The teardrop became accepted as the form of least resistance, pointed at the front to improve penetration and tapered at the rear to reduce turbulence and drag. The ideas of streamlining were applied with great success in the evolution of the submarine and the airplane. Streamlining also had an effect on other products ranging from the household appliance to the train.

In the invention of the airplane the first ideas were literal copies of wings flapping like birds. Leonardo da Vinci's ornithopter of the sixteenth century is a visual transportation of a process in nature to the man made world. (Plate 1.15)

> a bird is an instrument working according to mathematical laws, with instrument it is within the capacity of man to reproduce with all its movement
>
> Leonardo da Vinci, 1511
> (Papánek 1980 p.185)

The first commercial airline company to adopt the relevance of streamline was Boeing in the design of the Boeing 247 of 1933. In 1934 Boeing and Douglas entered their latest designs into the London Melbourne air race. Finishing third and second respectively behind the British DH88 Comet built especially for the race. The difference between the Douglas DC2 (Plate 1.16) which came second and Leonardo's ornithopter is staggering, obviously nature has brought us a long way.

Cyrill Kay a pilot in the race recalled that..

> One glance at their aerodynamically clean lines and handsome, stressed skin finish was enough to emphasise their advance over all contemporary design.
>
> (Hesket, 1980, P.122)

A later model of the Douglas DC-2 the DC-3 proved one of the most stable and useful aircraft in both the transport of personnel and cargo.

The streamlined form of these planes with their polished stainless steel exteriors provided a machine aesthetic that inspired America during its depression. As Le Corbusier Says in his book 'Aircraft' (1935) in describing the airplane as...

> A symbol of the new age... [an] advance guard of the converging armies of the new age, the airplane arouses our energies and our faith.
>
> (Corbusier, 1987, P.10)

Streamlining although stemmed from scientific research rather than aesthetic theories became a symbol of technological advancement creating an aesthetic style popularised by designers of vision such as Norman Bell Geddes and Raymond Lewy. The streamlined form with its rounded contours and unified form was applied to many objects of which such a style was unnecessary to their function. As a style streamlining provided objects with decoration without the need for superfluous ornaments. Streamlining, a machine aesthetic drawn from nature had its own expression - that of movement. An example

of such styling can be seen in the 'Hotchkiss stapler' designed by Orlo Heller in 1936 'claimed to be the most beautiful stapler in the world" (Hesket 1980 P. 120) (Plate 1.16) Although being a style of movement applied to an inanimate object unnecessary in its function. The style gave the machine an aesthetic quality of its own. This will be spoken of in greater depth in Chapter 2.

To achieve success in functional and mechanical designs the concept must be abstracted to suit the need, as can be seen in the evolution of the airplane from Leonardo's 'Ornithopter', through the Wrights brothers 'Kityhawk' proving that a flying machine ought not be a direct imitation of a bird (Plate 1.17)

The use of natural principles in design is not a matter of copying. Imagination and understanding of the principles being manipulated is required, often the principles need abstraction to gain success as can be seen in the evolution of the plane. Contrary to popular belief abstraction is not a process of getting away from nature but a process of getting closer through understanding. To abstract is to consider nature.

CHAPTER 11 Sense and Sensuality

Images they came
rushing and creeping,
I touched and
was touched.

Bubbles of emotion
burst inside.

When I arose
and turned away
I remembered
I was here once,
and this Says
I was here.

"That we find a crystal or a poppy beautiful means that we are less alone."

(Ackerman 1992, P. 272)

Nature broadens our sense of community, reminding us that we are living and of this earth. This is achieved through the forms nature takes, providing metaphors for our perceptions. Our Senses are our most valuable tool in understanding the world around us.

> The evolving universe around and within ourselves can be encountered only through the Sensory instrument that we inhabit. Therefore our brains and bodies necessarily shape all our perceptions, and have themselves been shaped by the same seen and unseen energies that have shaped every perceivable thing. Body, Mind and Universe must be in a parallel, formative identity.
> *"Man know thyself"*
>
> (Lawlor, 1982 P.92)

Many of the metaphors within nature are of a sensual kind, of which there are numerous examples. Many foods have been prized for their aphrodisiac qualities, many of which are due purely to the physical forms providing metaphors of male and female genitalia. Cucumbers, pickles, leeks or bananas have been prized for their phallic shape from ancient times. Oysters are still perceived as having aphrodisiac qualities, reminding us of female genitalia. The rhinoceros's horn has been prized and almost slaughtered into extinction for their horns, the peach and other similar fruits such as plums or tomatoes provide metaphors of smooth buttocks especially the

Plate 2.1 - Coca-Cola Bottle.

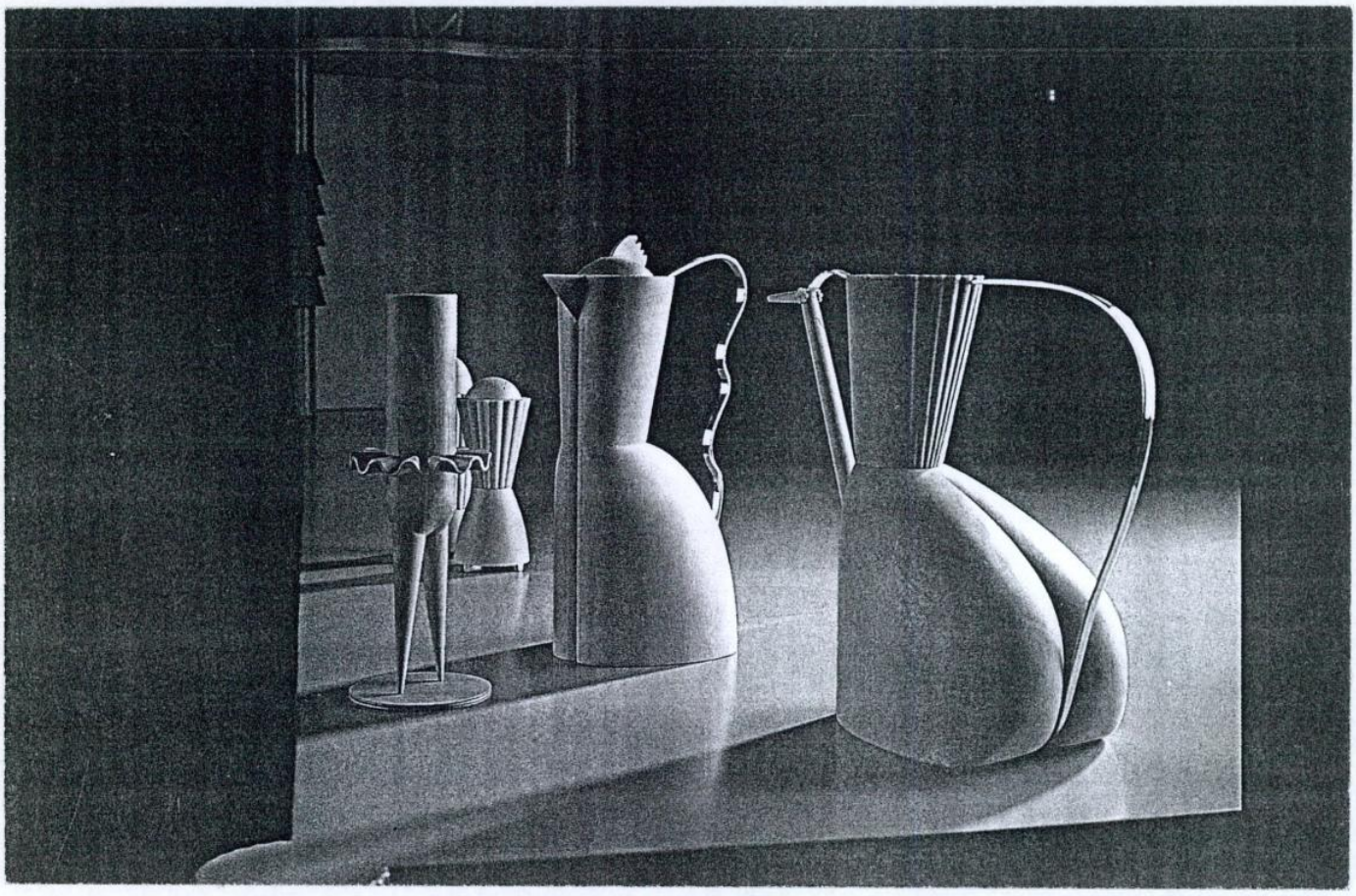


Plate 2.2 - Tea and Coffee Service.

peach being smooth and softly furry. Interestingly when such fruit is eaten what is being eaten is the placenta of the seed within. If the metaphor of sensuality is not perceived consciously it can be perceived subconsciously since the same organs and sense receptors are used in eating or kissing, those being the Krause's end bulb providing the same reactions to stimulation.

The *coca-cola bottle* is a perfect example of similar perception in the work of man made designs (Plate 2.1). Although originally based on the coca bean the buxom curves of the coca-cola bottle are obvious. There is no mistaking the coca-cola bottle. Although the Mae West buxom curves of the 1920's were deemed too buxom for modern times resulting in Raymond Loewy being slenderising them in 1955, but the essence of the sensual metaphor remains intact. Making Coke not just a drink but a symbol of America and life.

Ugo la Pletra with is view of imbuing design with culture and the synthesis of art designed his prototype *tea and coffee service* 1988. The set is anatomical with references of a sensual nature. This is shown in the buttock shapes of the tea and coffee pots and the elegant ballerina image contained within the candelabra. (Plate 2.2)

In speaking of sensuality and its appeal the poem '96 by cc Cummings seems fitting.

'96

i like my body when it with your

body. it is quite a new thing.

muscles better and nerve more,

i like your body. i like what it does.

i like its hows. i like to feel the spine

of your body and its bones, and the trembling

firm smoothness and which i will

again and again and again

kiss, i like kissing this and that of you.

i like slowly stroking the shocking fuzz

of your electric fur, and what is it comes

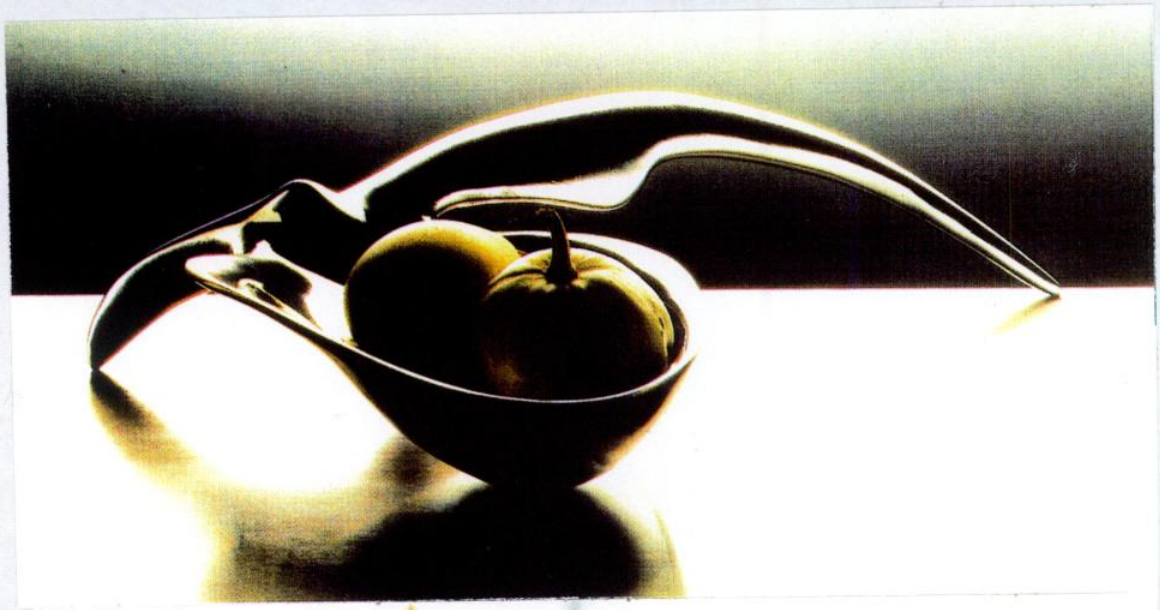
over panting flesh ... and eyes big love crumbs

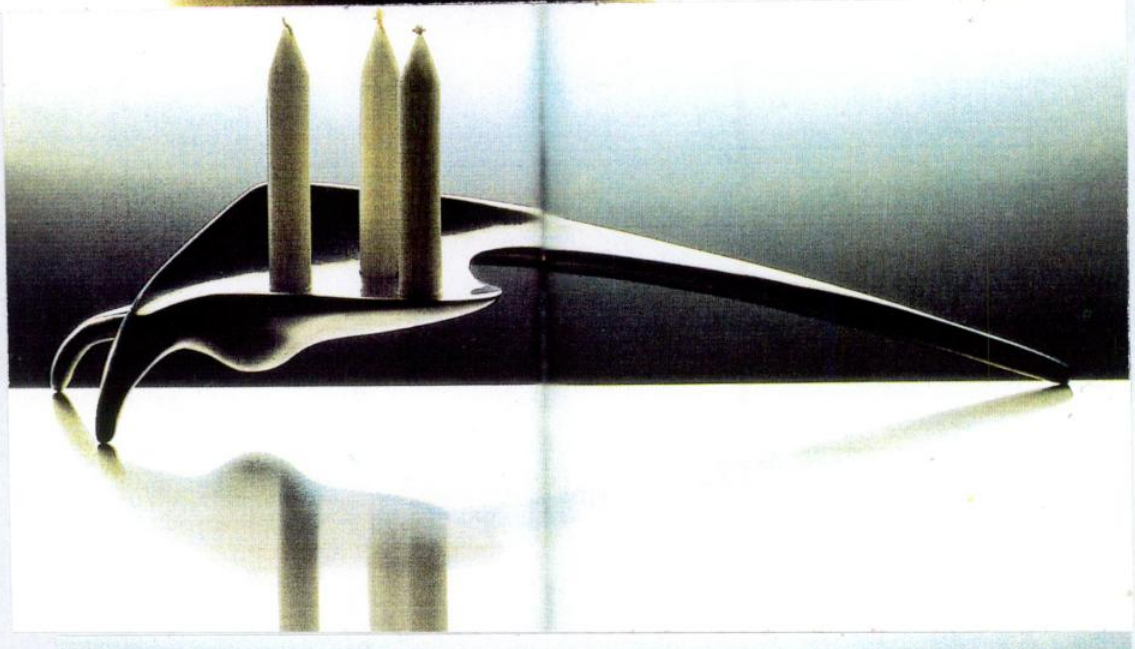
and possibly I like the thrill

of under me you so quite new

(Ackerman 1992, P.306)

We like Cummings glory in the novelty and excitement of nature, being atavists at heart the pantomime of sex within nature reminds us of our own sensuality.





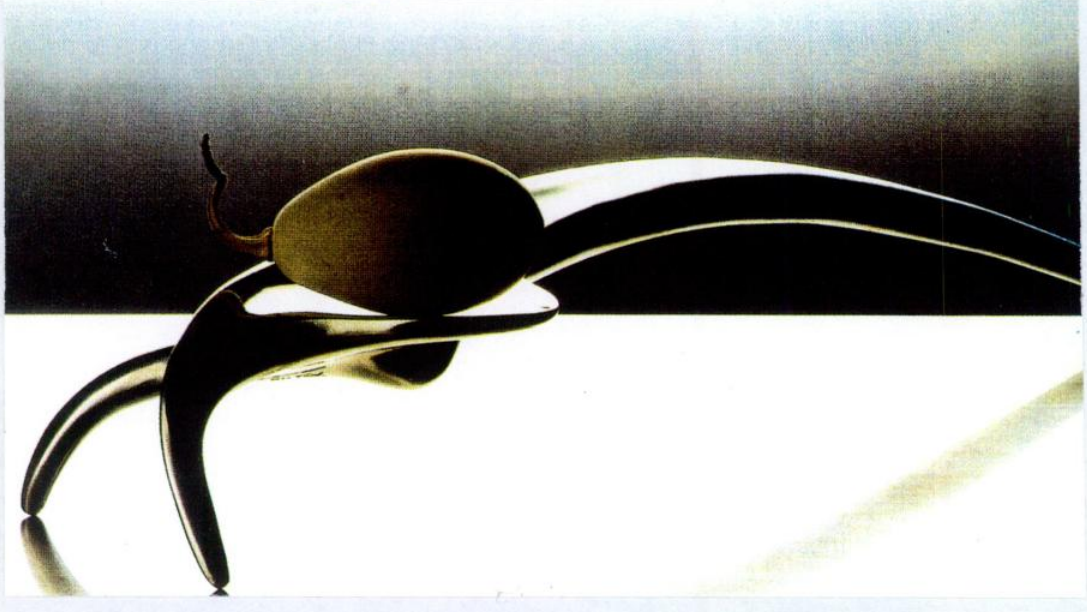
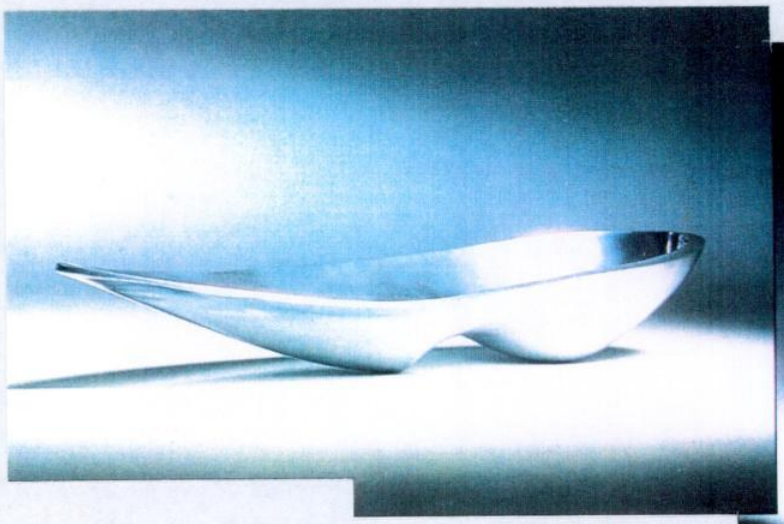


Plate 2.3 - Bowl - Di-ordna.

Plate 2.4 - Swan Candleholder

Plate 2.5 - Bowl - To-bor.



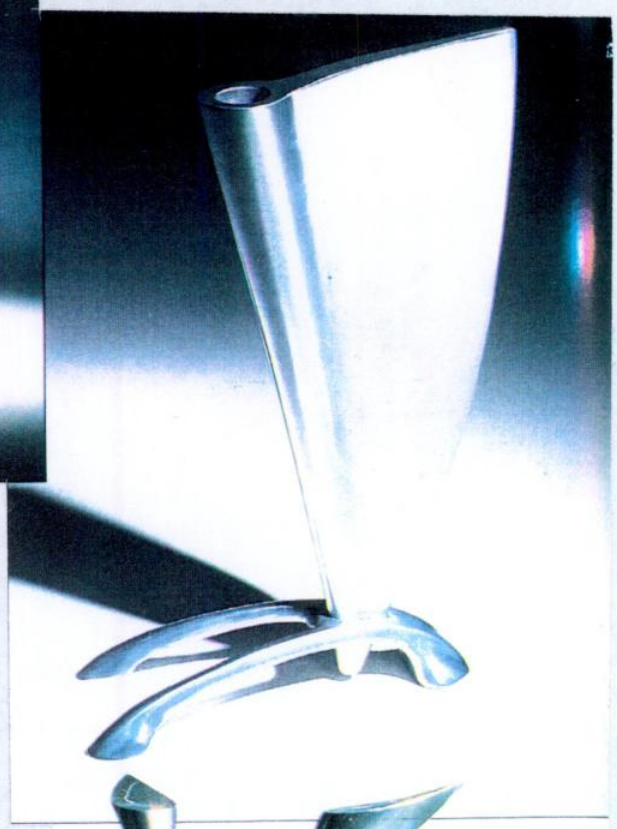


Plate 2.6 - Bowl

Plate 2.7 - Candleholder

Plate 2.8 - Crane Candlestick

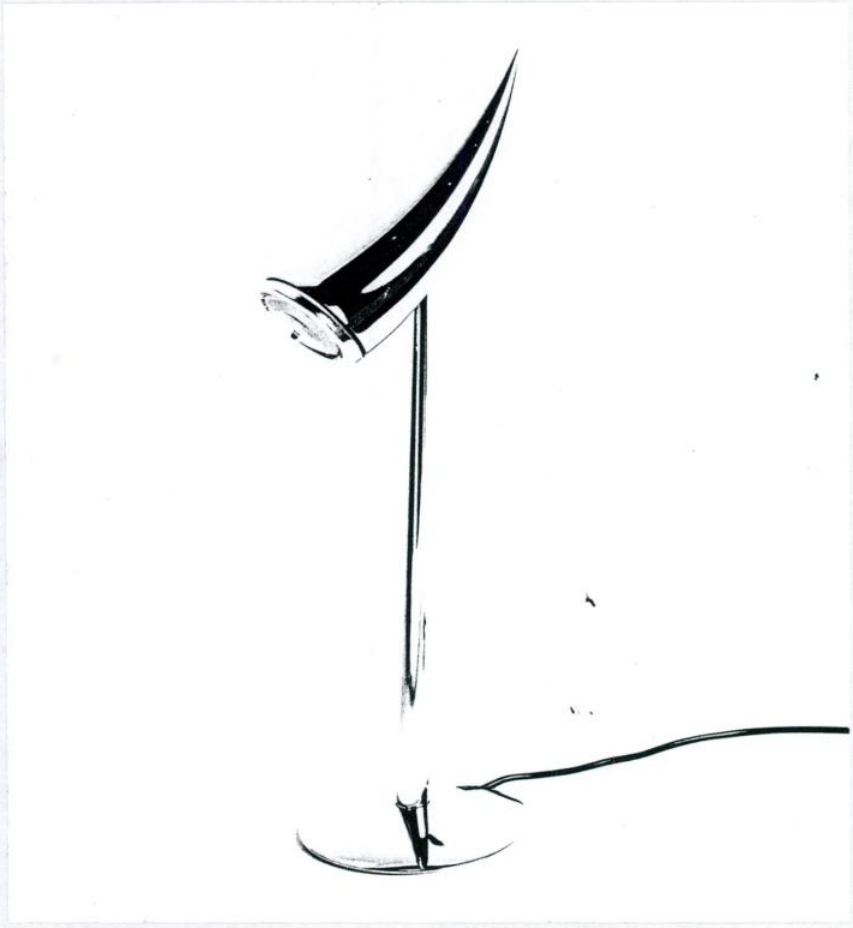


Plate 2.9 - Ara Lamp

Plate 2.10 - Juicy Salif spiral evolution

Plate 2.11 - Juicy Salif

Many designs of a zoomorphic nature, with a biomarphic sculptural appeal often have an intrinsically sensual appeal. Having an expression of vitality and virility that only a living organism can have. The *Swan Candleholder*, *Di-ordna* bowl and *the bowl To-bar* (Plates 2.3,2.4,2.5) seem poised on pointed elongated legs ready to leap if touched. Animation is inherent in the forms of Hilton's designs. Smooth reflective surfaces heighten this tension appearing molten but smoothly hard and sensual to touch. The leg of the *Di-ordna* bowl tapers curlingly away from the bowl containing a receptor of shadow, almost embryogenic. The bowl to-bar appears caught in freeze frame. While the horn shaped candlestick (plate 2.7) held upright between a pair of open legs appears almost caught in the midst of copulation. Be this conscious or unconscious perception.

As with Hilton's designs many streamlined forms have a sensual appeal both in form and its expression of movement. The designs of Phillippe Starck express this movement in a similar fashion as can be seen in his *ara lamp* (Plate 9) and the *juicy Salif* (Plate 2.10,2.11) which evolved from a spiral pattern. Both Matthew Hilton and Philippe Starck, show an affinity with Christopher Dresser, showing a restrained but expressive use of material, use of nature with a sparse simplicity of geometry. As with *Bionic* design spoken of in Chapter 1 *Zoo morphic*, organic or anthropomorphic designs are not copies of nature but are conventionalised as Dresser might put it.

The simplicity of geometry shows a link with modernism that is both comparable and contrasting. Comparable in simplicity, contrasting in the -superior lyrical expression of an organic form over a platonic modern form.

> Streamlining Cleansed the Surfaces of two dimensional ornamental patterns and directed attentions to the plastic qualities of three-dimensional farm. As useful objects streamlined designs were necessarily abstract forms. Their organic quality evoked an association with natural forms and with modern biomorphic sculpture. This produced the emotional experience, lacking in geometric machine art...
> (Bush, 1975, P. 186)

This dynamism and perception of movement in tension expressed by organic or zoomorphic designs is inherent in our nature. The nature of which we must take into account in design for people. An understanding of human nature, culture and peoples perceptions is important in design.

> In Jean Cocteau's extraordinary film version of the classic fairy tale 'Beauty and the Beast', a sensitive beast lives in a magical castle, the walls and furnishing of which are all psychosensitive
> (Ackerman, 1992, P.171)

In the same sense we are psychosensitive, being affected by everything around us. Designers must remember that what they are designing is going to be used in some way or another by people.

Mondrian, Rietveld and Theo Van Doesburg worked for the future convinced that the values of plasticity supported by the theory of gestaltism should give solutions to the moral and social problems of society. Mondrian's idea of the 'urban dream' saw de Stijk plasticity as the path to salvation. Saying that ...

> The truly evolved human being will no longer attempt to cultivate, protect or beautify streets and parks with flowers and trees, but will construct healthy and beautiful cities by means of a well balanced contrast between buildings and empty spaces. The exterior will give him just as much satisfaction as the interior.
> (Thomas, Baron, 1987, P.25)

Plate 2.12 - Pruitt-Igoe Building

Although the views proposed by de Stijil and later Bauhaus and the modernist movement were economical to build being simple in construction, they appear to have left human nature out of their structural equation to a large extent. Despite the intention of designing a sort of platonic garden of Eden man doesn't seem to have much involvement.

> and man being nothing in himself, he will be merely a part of the whole, and then having lost the vanity of his small and trivial individuality, he will be happy in this eden which he has created
> Mondrian (Thomas-Baron 1987, P.26)

But man being individual in nature will change any environment to suit himself. Human nature is too strong and important to have such rigid and authoritarian plans imposed upon.

> As a result of economic pressures, or the lack of biological awareness of architects. Endless rows of uniformly repeated, identical houses have been erected in cities and towns all over the world. In the case of blocks of flats the situation is even more acute. The psychological damage done to territorialism of the families forced by architects, planners and builders to live under these conditions is incalculable.
> (Morris, 1968, P.160)

This idea of authoritarian utopia was also held by Le Corbusier in his early work where he reconsidered the house by analogy 'A machine for living in' (Dormer. 1991, P.144) where rooms of the living area were grouped according to function.

In 1955 the *Pruitt-Igoe* housing project was built along Corbusian lines by Minoru Gamasaki, winning awards from the American Institute of Architects. The building was comprised of highrise hives of steel, glass and concrete separated by open spaces of green area. (Plate 2.12). The blocks were linked by covered walkways keeping

with Corbusiers idea of 'streets in the air'.

The *Prutt-Igo* project proved to be a disaster as a result people soon began to leave refusing to live there.

> Since there was no other place in the project in which to sin in public, whatever might ordinarily have taken place in bars, brothels, social clubs....
> ... now took place in the 'street in the air.'
>
> (Wolfe. 1981, P.82)

In 1971 a final taskforce asked the remaining residents their opinions to which they received the reply 'blow it up'! In July 1972 the city of St. Louis 'blew up!' the three central block of the Pruitt-Igoe with dynamite.

It appears such plans although well intentioned has not taken the psychology of human nature into well enough account. The notions of the modernists ranging from 'de Stijil', 'Bauhaus', and 'Constructivism' were too restrictive and authoritarian, speaking of platonic ideas.

> Their approach was conceptual, and their synthetic forms rationalised through mathematics, afford only cerebral pleasure. The sterility of these designs stemmed from a dominance of thinking and an exclusion of feeling.
>
> (Bush, 1975, P.181).

The dictum of Mies van de Rohe was 'less is more' (Dormer, 1991, P.165). This minimalist approach to architecture as advocated by Mies van de Rohe and Corbusier became a model for most modern architecture. Reducing decoration and expression to a platonic functional minimal has had on hindsight a detrimental effect on society

and our environment as Henry Skolimonski says..

> Intoxicated by the image of technology triumphant and with the slogans 'form follows function' we have made our rationality and our perceptions of the built environment a slave to industrial efficiency. In the process we have deluded ourselves in many ways for example we insisted that the modern movement was 'doing more with less' while when we carefully look at the actual record, we come to the surprising conclusion that wehave been doing less with more, with more technology, more know-how, more new materials we have created architecture which is less memorable than any created before. Having at our disposal the best means, we have created the worst architecture in history.
>
> (Sharp, 1978, P.164)

With the use of standardisation inducing a lack of creativity and individuality in design there has been a detrimental affect on our environment.

Designers such as Eero Sarriner show a new direction. Although showing simplicity of line and geometry and bare a restrained use of material in keeping with modernist views his designs can't be described as 'Modernist' or 'Post Modernist' in the pure sense. Being an organic evolution perhaps he can be described as 'Organic Post Modern' showing an individual and new approach imbued with personal expression unlike the 'de Stijil' or Modernists' who wanted to subordinate the individual.

The buildings of Sarriner are organic with a strong view of function that comes from the organic. They are buildings that people enjoy using and working within. In this way the organic forms and by Sarrinen fulfil their function. Sarrinen understood what makes a person enjoy a building. this makes his designs memorable.

At first glance his *TWA Terminal* is striking because of the use of organic forms, the

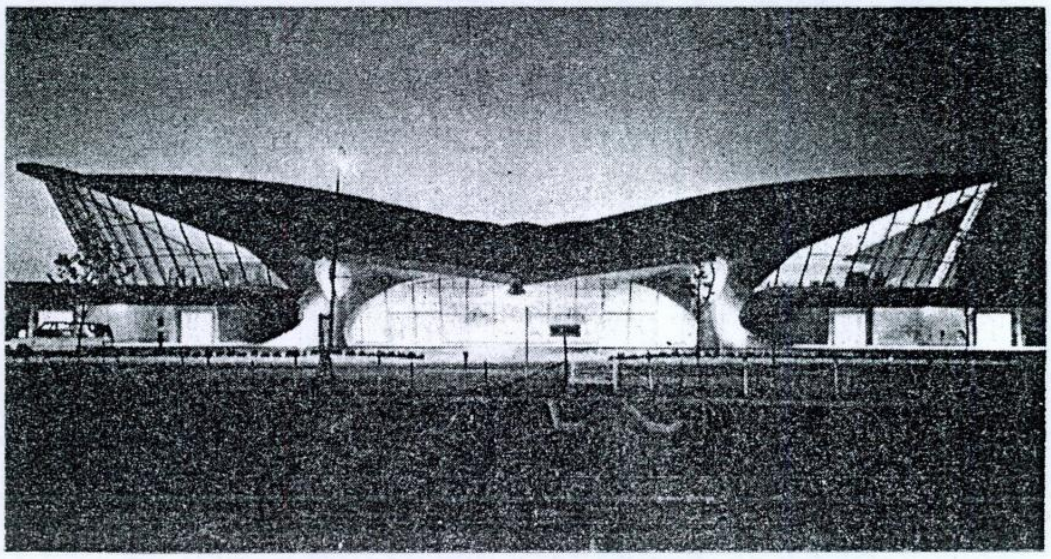


Plate 2.13 - TWA Terminal Exterior

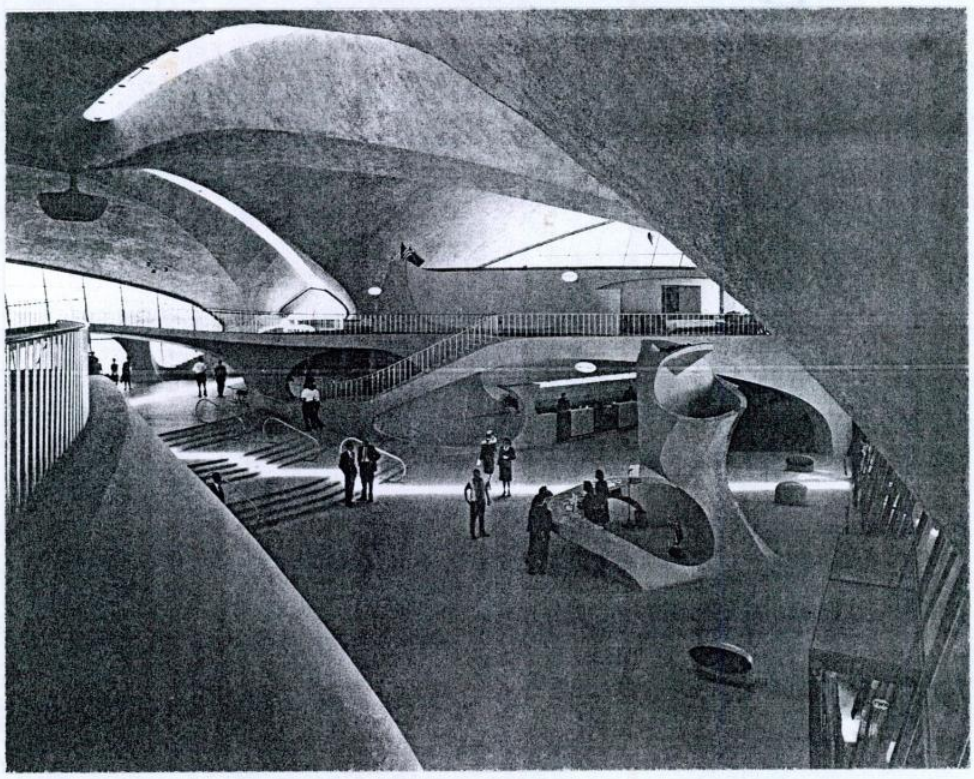


Plate 2.14 - TWA Terminal Interior Detail.

fast flowing curves gives a lasting metaphor of a bird about to leap into the air. It can be shown that these forms have a deeper functional purpose. (Plate 2.13,2.14).

The terminal building comprised of departure and arrival areas is essentially a building of movement. The interior employs wide sweeping walkways erasing the claustrophobic sensation of walking down a long straight corridor full of people. It is in human nature to prefer walking in a curve around an object as opposed to taking a sharp corner. The curve allows easy transition of movement that is not only visually appealing, fulfils the function of creating a pleasant environment (Plate 2.14)

> If architecture is to offer comfort and shelter in any complete sense, it must keep as one of its concise goals, the satisfaction of mans psychological needs
>
> (Green, 1976, P.200)

The exterior can be described as a shell like expression of flight. This has a psychological function, the nature of a shell is to harbour an organism from the environment while the metaphor of flight makes the building easier to relate to. It is important to note that when the terminal was built (1958) commercial flight was still new and many of the customers of the time would be flying for the first time. Being a building of transition from the ground to the air it was important for the user to relate to the outside especially the sky. This is provided by the large curving eye like windows giving a panoramic view. The metaphor of large eyes gives the impression of not only being inside but a part of a large flying creature.

The terminal being steeped in metaphors of movement and life of an organic nature creates a pleasant environment. Sarrinen is intensely aware of human scale in his

creation of environments that are psychologically satisfying for the user. Humanscale is important.

> In using it architects devise symbolsthat will enable us to reflect on and recover the valued experience that can be associated with symbols of the bodily life.
>
> (Greene, 1974, P. 144)

Organic forms appeal more to our senses in the creation of satisfying environments as opposed to the machine aesthetic of many modern architects. It can be seen that an organic progression of modernism has more positive aspects for the user, with the application of humanscale giving a building that human touch, an expression of life where people can be comfortable can be found. As Dieter Sieger says...

> Design must be sensual, all important designers are moving away from pure functionalism'... Dieter calls his own work 'Design with feeling'.
>
> (Frumme, Jan 91, P.37)

CHAPTER 111 FORM

Forms they arose
Gleaming...
from a chaotic
wilderness

But I formed
moulded and caressed
them.

fulfilling an emotion
of light and harmony.

CHAPTER 111. FORM

To decorate is inherent in mans nature. In prehistoric times man painted the roofs and walls of his cave dwellings. Today we hang paintings on a wall. Superfluous elements are very important, being a part of us and an expression of our feelings.

> its shape and general appearance must make it stand out as an easily identifiable entity, so that it can become the personalised property...
>
> (Morris. 1968. P. 160)

In the production of man made objects nature has been a source of information and pattern, although not always being to the benefit of the object.

It is important to note that form is intrinsically related to the structure that gives on object its form, for the purpose of discussion they will theoretically divided, structure being discussed in detail in chapter 4.

In relation to form, function and styling there is no clear line of demarcation as there are close links between form, function and peoples reaction to an object. But there must be a measure to govern those elements and their appropriate relationships. Otherwise there would be meaningless application of decoration with a lack of intelligent proportions between form and function.

Having new processes and endless lists of new materials and methods of production at the disposal of the designer, absolute choice with few limitations is possible. In such a situation design can become a search for novelty with the designer becoming alienated from the user society and function. the designer must express care and understanding of the elements of design and the material being used.

The industrial revolution saw such a search for beauty and novelty in modern machines and the objects they produced. It is important to note that beauty is an indefinable quantity being idiosyncratic, it is different for different people and cultures. As Abraham Cowley noted in the seventeenth century.

> Beauty, Thou wild fantastic ape who dost in every country change thy shape
>
> (Ackerman. 1992. P.273)

The beauty of an object can be described as a relationship of the elements of design in a harmonious relationship forming a consistent whole; free from dissent.

Designers of the industrial revolution saw objects crying out for decoration. Such decoration was usually taken from classical antiquity and raids into the animal and plant kingdoms.

Designers ran riot with new methods of production and the plasticity of materials was exploited. Nature and art were used for purely decorative

Plate 3.1 - glass imitating cut glass.

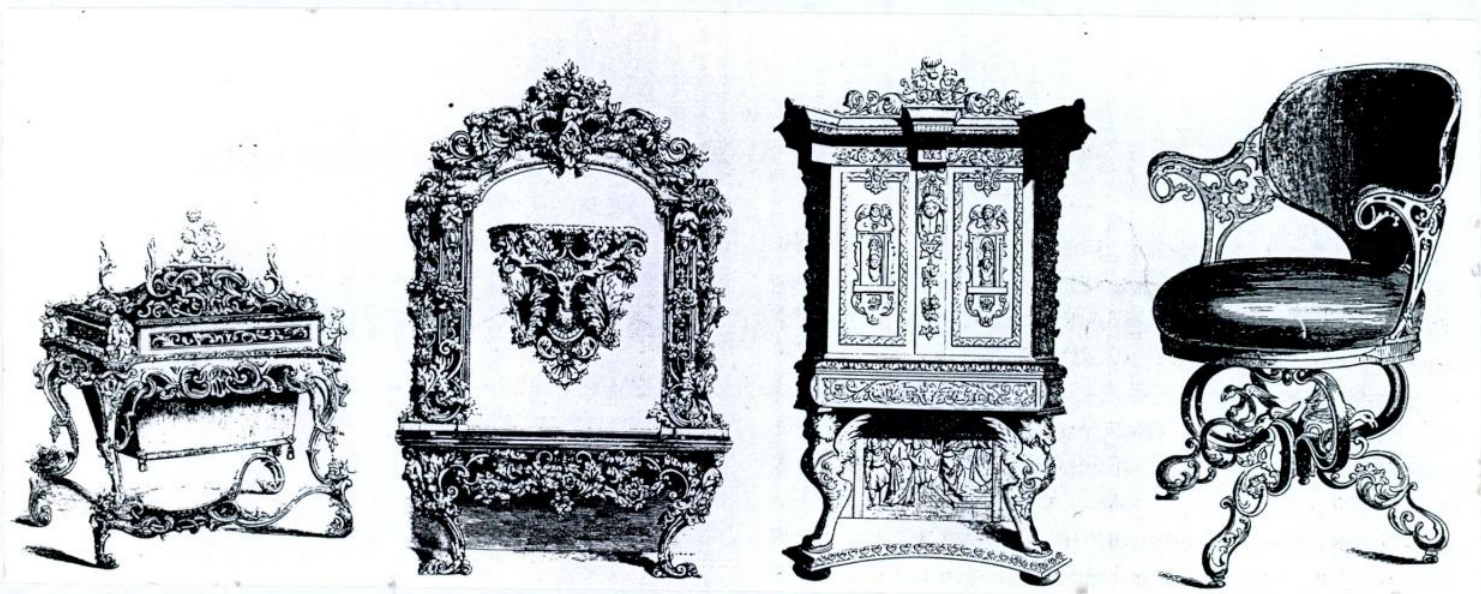


Plate 3.2 - Selection of furniture from the Great Exhibition Catalogue (1851).

reasons having no relationship with neither the form or the function of the object they adorned. Designers having a lack of understanding of new materials tried to bring them into line with what they already knew. As Pevsner says in his enquiry into industrial art in Britain 1937.

> A pressed glass bowl trying to look like crystal, a machine made coal skittle trying to look hand beaten,
> machine made mouldings on furniture, a tricky device to make an electric fire look like a flickering coke fire
> - a metal bed masquerading ..as wood - all this is immoral, so are sham materials and sham techniques.
>
> (Smith. 1983, P.43)
> (Plate 3.1)

Such prostitution of nature for the purpose of decoration (Plate 3.2) and a lack of truth to the materials used expresses a disharmony of relationships. Since the applied decoration has no relevant relationship to the form and the material not only being used to imitate another material, (often wood carved in a victorian baroque style) (plate 3.2) had no expression of its own. It takes time to overcome tradition, only through an understanding of style and materials used can a more refined relationship of form and function come about. As Aesop says in one of his fables.

> "imitators lose the substance by
>
> grasping at shadows!"

Manufacturers were somewhat responsible for the lowering of taste in this period. Eager for profits they made simple products appear ornate and complex for the purpose of looking expensive. Many designers of the

industrial revolution were either perpetrators of eclectic victorian baroque or members of the arts and crafts movement led by John Ruskin and William Morris, sharing Pugins admiration for the art and Society of Medieval Britain. Although in awe of its power they were dismayed by machine technology as John Ruskin dismissively says!

> This shrieking thing whatever the fine of it may be, can but pull, or push, and do oxens work, in an impetuous manner.
> (Hesket. 1980. P26)

The views of William Morris were essentially social; pointing out the imbalance of relationships between man and machine.

> It is not this or that tangible steel or brass machine which we want to get rid of, but the great intangible machine of commercial tyranny which oppresses the lives of us all.
> (Sparke. 1987. P67)

Being essentially negative and nostalgic rather than an effort to improve the situation, the arts and crafts movement had little affect on industry. But with the powerful voices of Ruskin and Morris it dominated design attitudes. Almost acting as custodians of the elements of form, function and styling pointing out to designers the social consequences of disharmony. Ruskin very strongly insists.

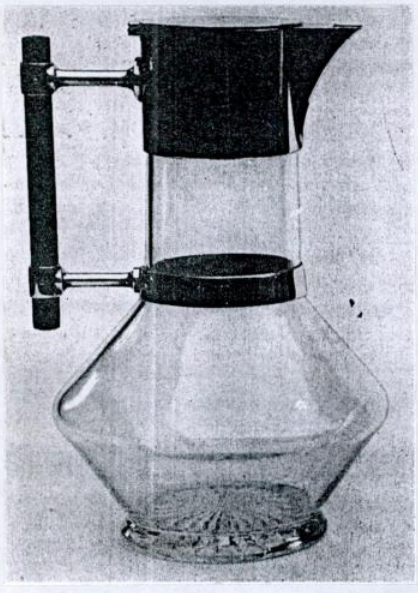
> Now I would insist especially on the fact,.... that art most lovely forms and thoughts are directly taken from natural objects; because I would fein be allowed to assume also the converse of this, namely that forms which are not taken from natural objects must be ugly.
> (Masini. 1990. P21)

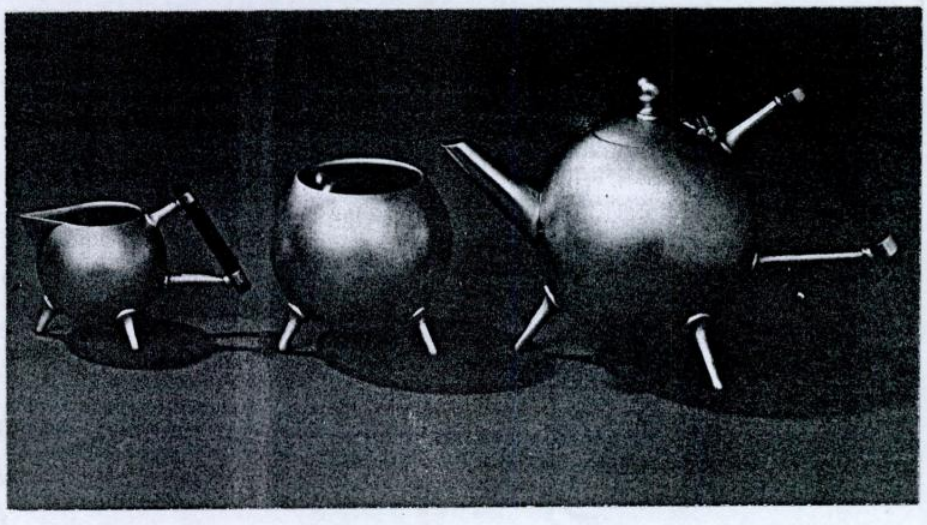
In opposition Christopher Dresser used nature allowing the machine to express its nature. Dresser to was dismayed by the misuse of technology and the plundering of nature, but instead of staring melancholily into the past, Dresser's vision was forward looking with an understanding of the past. Dresser initially a teacher of botany where he gained a knowledge of nature was influenced by Owen Jones who sought a formulation of rules to govern design based upon studies of natural forms and styles of the past, as he states in 'Proposition 13' of his 'Grammer of Ornament' 1856.

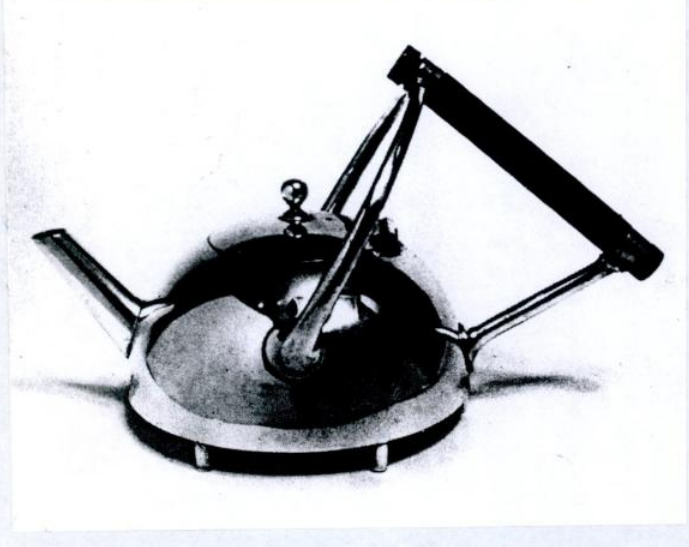
> Flowers or natural objects should not be used as ornaments, but conventionalised representations founded upon them sufficiently suggestive to convey the intended image to the mind, without destroying the unity of the object they were employed to decorate.
>
> (Sparke. 1987. P 61)

Dresser brought these views further rejecting re-representing the past and styling solutions. Dresser like Gaudi was an exception to his time from which we may learn a lot. As with Gaudi Dresser believed that getting the most from a material was to honour it unlike the prostitutions of many other designers of his time. As Gaudi says...."To use a material to its fullest extent is to honour it" (Dalisi 1978, p.64).

Dressers designs were based on the structure of plant forms emphasising their underlying principles, as with Owen Jones he believed the natural form had to be conventionalised not applied to be of value. Botany being not just a source of form and pattern expressed fitness for purpose.







3.3 - Glass Claret Jug - Christopher Dresser

3.4 - Silver Tea set - Christopher Dresser

3.5 - Electroplated Teapot - Christopher Dresser

The designs of Christopher Dresser emphasise simplicity of form and geometry with discretion in the use of materials (Plates, 3.3 - 3.5) compared to the victorian baroque mentioned earlier (Plate 3.2). Dresser has clearly found a harmonious relationship between form, function and the material being used. None of the elements are in dissent to the point of destroying the unity of the object. Dresser was one of the first to analyze the relationship between form and function. Providing diagrammatic laws governing the efficiency of tea pot pouring spouts, and handles in his 'Principles of Decorative Design' 1873. His own teapots show slanted handles related to pouring efficiency (Plate 3.4, 3.5). Dresser has combined expression and ergonomics in a common unison.

Dresser's designs characterised by simplicity of geometry were based on meticulous calculations and analysis of function, nature and ergonomics. He wrote:

> I have availed myself of these forms, to be seen in certain bones of birds which are associated with the origins of flight, and which gives us an impression of great strength, as well as those observable in the propelling fins of certain species of fish. (Smith, 1983. P.75)

This enabled him to produce forms using nature for a reason rather than a visual analogue purely for decorative purposes. Effectively Dressers designs became a marriage of 'form' and 'function' with an aesthetic quality derived from understanding nature and an enhancement of material fulfilling the dictum of Mies van de Rohe of 'less is more' (Dormer 1985. P.165). In this case Dresser's forms rid themselves of the useless forms of the baroque, producing an object bereft of superficial elements and complications,

producing an aesthetically harmonious union of nature and the machine aesthetic allowing both expression. Dresser's designs have been proclaimed by many design historians as a fore-runner of the twentieth century. In a sense there is a close affinity between Dresser and Sarriner in their use of geometrically simple form with organic metaphors, maintaining minimal but expressive use of material in the creation of a harmony between form, function and the reaction of the user. This can be shown in Sarrinen's TWA Terminal discussed in chapter 2.

The contrast between the voluptuous, victorian baroque and the geometrically pure design of Dresser can be seen clearly in relation to 'two verses on form and content' by Piet Hein. If we see the misuse of nature in victorian baroque imitations in the industrial revolutions early designers as the first verse and Dresser as the second.

I

"Most Design
is shear disaster!
hiding what one
doesn't master.

II

True Design
asks one thing of us;
to uncover
what it covers.

(Heisinger, 1983. P120)

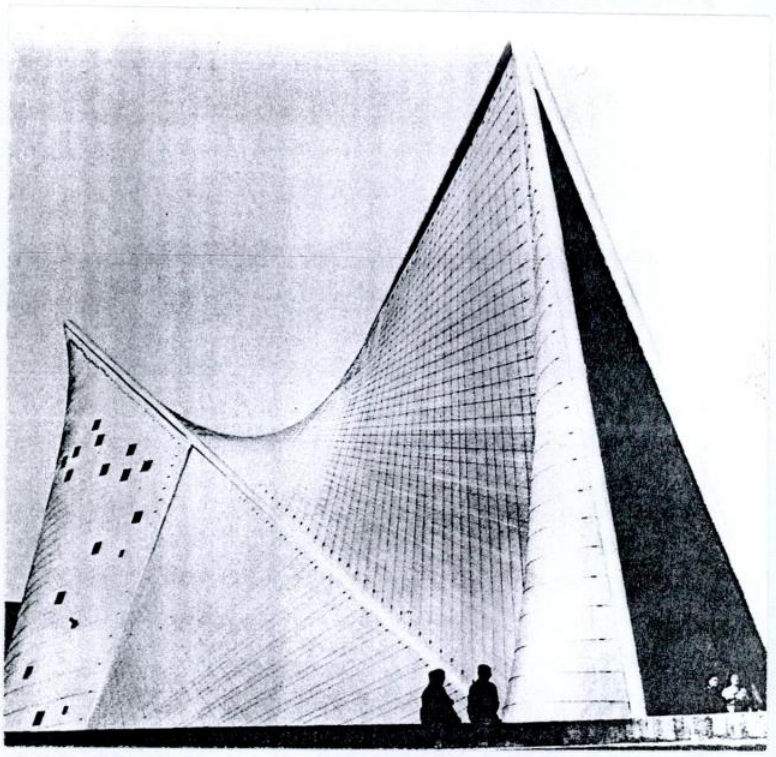


Plate 3.6 - Phillips Pavilion, Brussels World Fair 1958
Le Corbusier

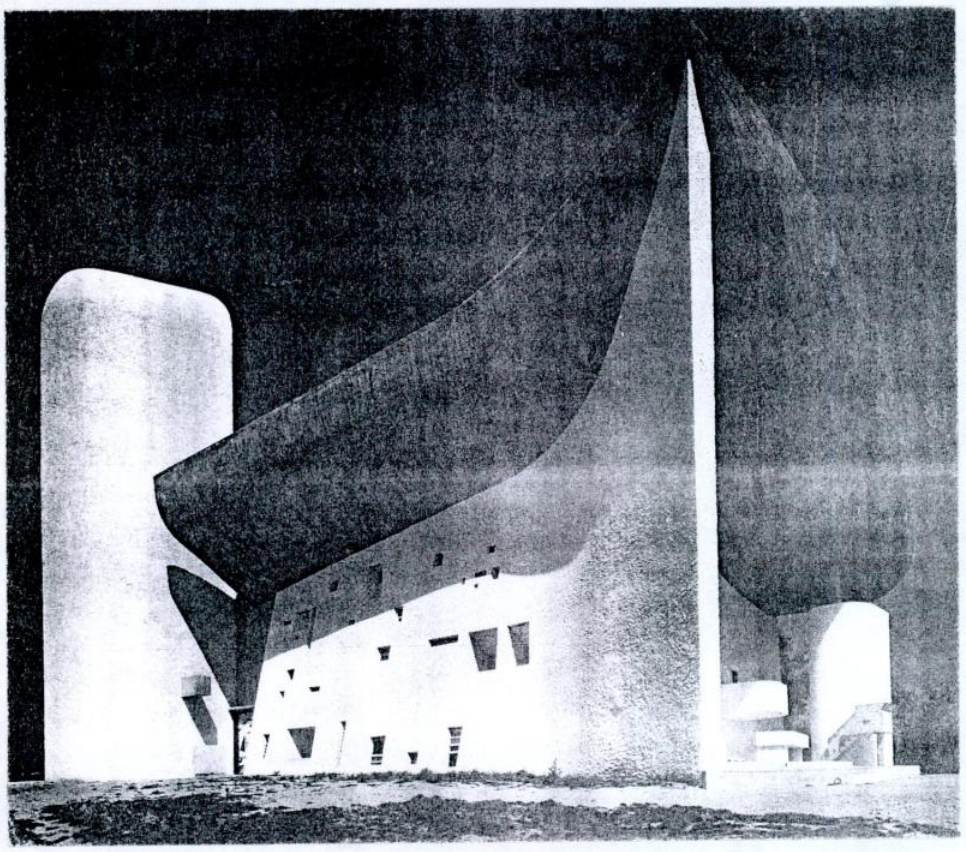


Plate 3.7 - Notra Dame du haut Ronchamp - exterior.
Le Corbusier.

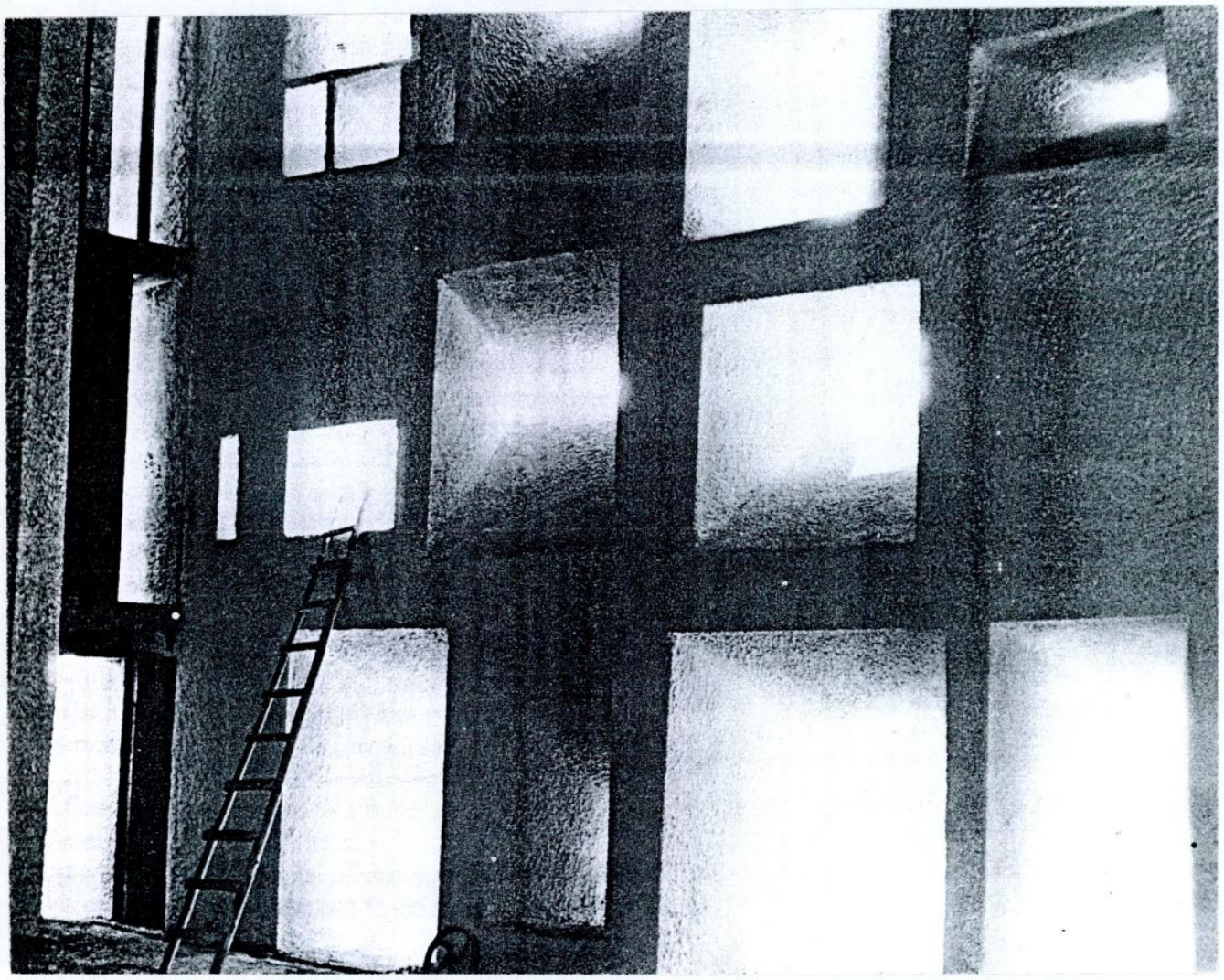


Plate 3.8 - Notra Dame du haut Ronchamp - Interior
Le Corbusier.

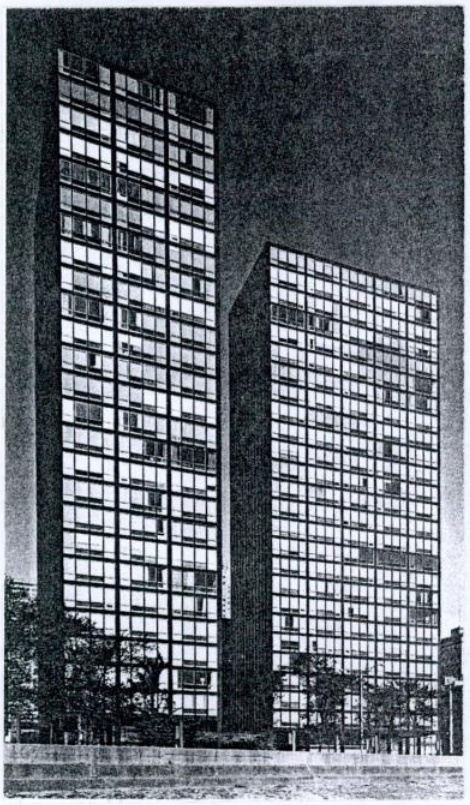


Plate 3.9 - Lake Shore Apartments - Chicago
Mias van de Rohe.

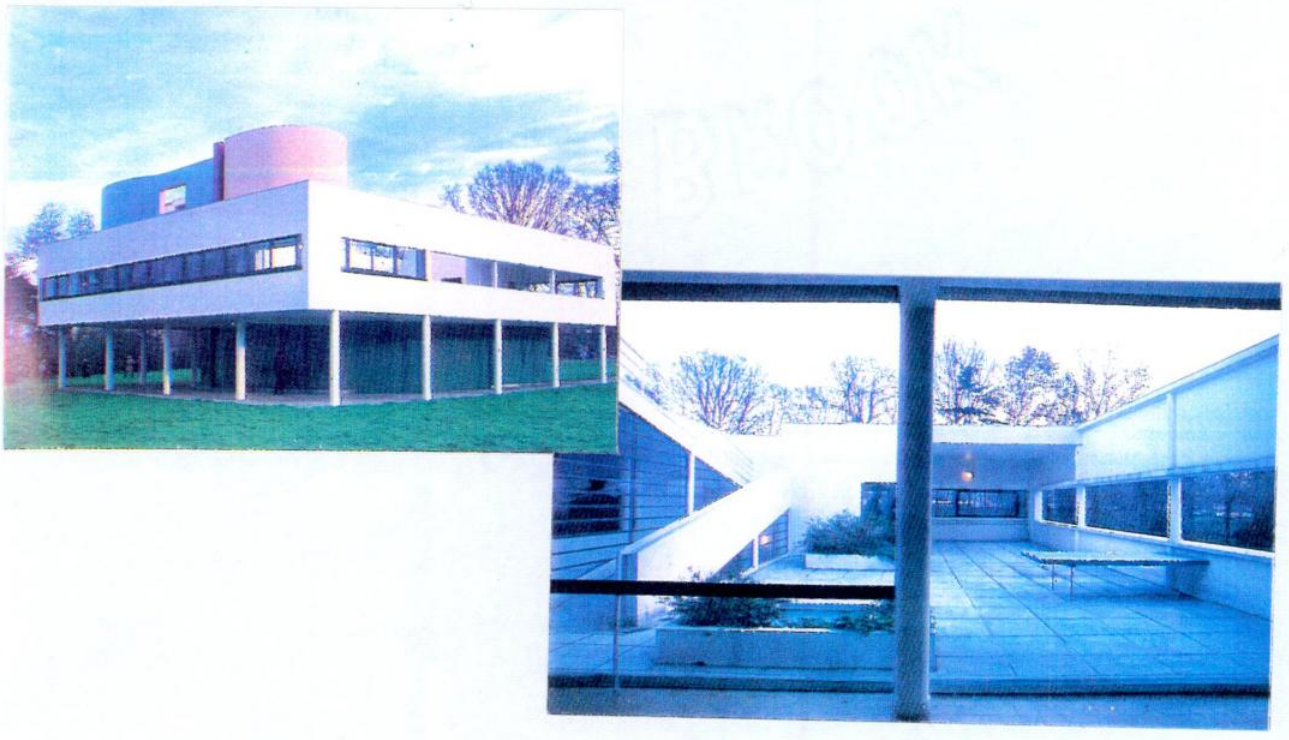


Plate 3.10 - Viola Savoye Poisoy sur Siene
Le Corbusier

The geometric simplicity of Dresser and the organic flowing lines of Sarrinen's T.W.A. Terminal entered the vocabulary of some advocates of modernism, including Le Corbusier. This new repertoire displays organic metaphors and a refinement of the streamlining ideas of the pre second world war decades. Streamlining although often used for its symbolic properties expresses a compact fluency of form such as Le Corbosier's Phillip's pavilion, Brassels world fare 1958 (Plate 3.6) and the Notra Dame do Haut Ronchamp (Plate 3.7, 3.8)

In a comparison of such organic streamlined buildings of Le Corbusier's, Phillips pavilion and the Notra Dame Du Haut Ronchamp with Mies van de Rohe's Lake Shore apartments Chicago 1951 (Plate 3.9) a Juxtaposition of opposites can be seen. Between the curvilinear and rectangular both express in a modernist use of materials and simplicity of line. The modernists were platonic idealists with strange notions of mechanisation and modernity. Composition was controlled by laws based on the golden section ration whose proportions related to each other by a modular system. But these theories were based upon notions of man being a human machine, with these notions the house was reconsidered by analogy as "a machine for lining in" as Le Corbusier says (Dormet 1985, P. 165) providing standardised dwelling such as Mies's Lake Shore apartments.

The difference between the later work of Corbusier and that of Mies's is expression and lyrical quality. While both show the simplicity of line and volume, Mies's lake shore apartments expresses less flair than the forms of an organic curvilinear nature, and fade in comparison with the expression stemming from a poetic sculptural tendency of the streamlined biomorphic object.

The later architecture of Le Corbusier is organic having a close relationship to the surrounding landscape as opposed to earlier purist work where buildings were independent of the ground, by use of Pilotis suspending the structure from the ground (Plate 3.1○) The organic structure appears moving upwards from the ground while the incline swoops down into the foundations to freely flow away. It can be said Corbusier's work through an understanding of the nature of the form being employed together with an influence from Antoni Gaudi, has created a new vocabulary of forms drawn from the human and natural world. As Corbusier says in 'Prats Gomis Gaudi', recognising Gaudi influence

> It will continue to be the task of the great artists to show us the road, and Gaudi was a great artist. Only they remain and will endure who touch the sensitive hearts of men.
> (Prats Gomis, Gaudi, 1958 P.11)

In Corbusier's use of an organic vocabulary he may have found a balance, a harmonious relationship between the formal, functional and expressionate values of architecture.

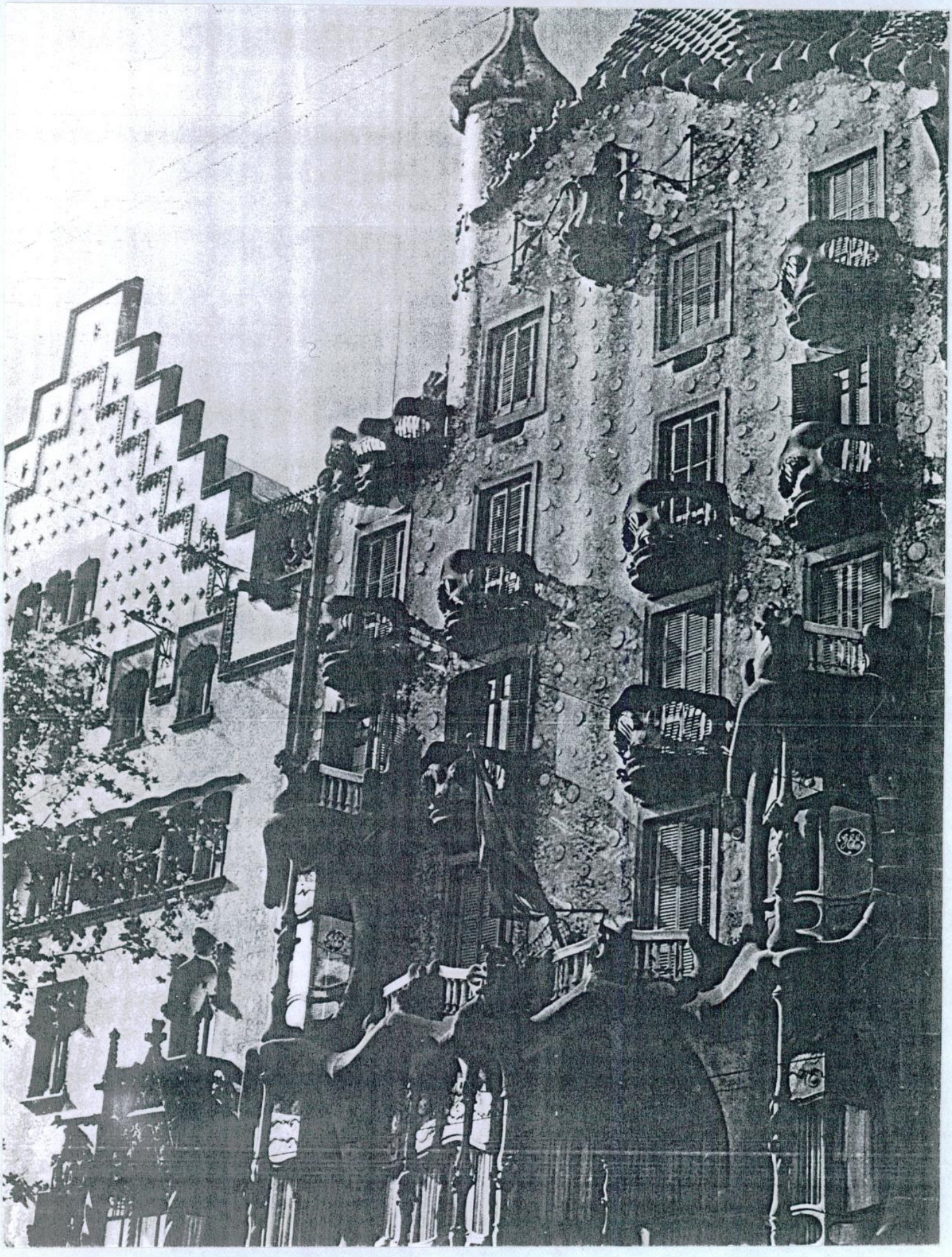


Plate 3.11 - Casa Battlo - Exterior
Antoni Gaudi

Mies said 'Less is More' (Dormer. 1985. P 165) but he may be criticised for what he left out mainly expression which is important to man and his enjoyment of a building or object. In the organically streamlined building the essence of its expression is of movement, created not only by the invocation of tension within a stretched curve, but by the play of light across a curved form. This is true of Corbusier's phillips pavilion, the Notra Dame du haut Ranchamp and of Sarrinen's TWA terminal.

Roberto Pane quotes a phrase attributed to Gaudi

> The corners and angles will disappear and the matter will show itself abundant in astral roundness; the sun will penetrate on all four sides and it will be the image of paradise. The contrasts will make my palace more luminous than light.
>
> (Masini. 1970. P.40)

In reference to the Casa Battlo (Plate 3.11) which sparkles as a jewelled majestical beast travelling from night to day and day to night. Architecture and indeed objects need the luminous range of 'light from night to day'. Light totally expresses their nature. (Plates 3.11, 3.12)

> Gaudi's architecture needs the luminous range from night to day; light, like other 'materials', must totally express nature. It is the sun that orientates his buildings in time and space. Later architecture would definitively divest itself of this sensitivity to daylight, acquiring the museographic indifference of boxed-in space.
>
> (Dalisi. 1979. P.117)

Gaudi's work and the later work of Corbusier in particular the Notra Dame Du Haute Ranchamp (Plate 3.8) express sensitivity to light. This gives luminous

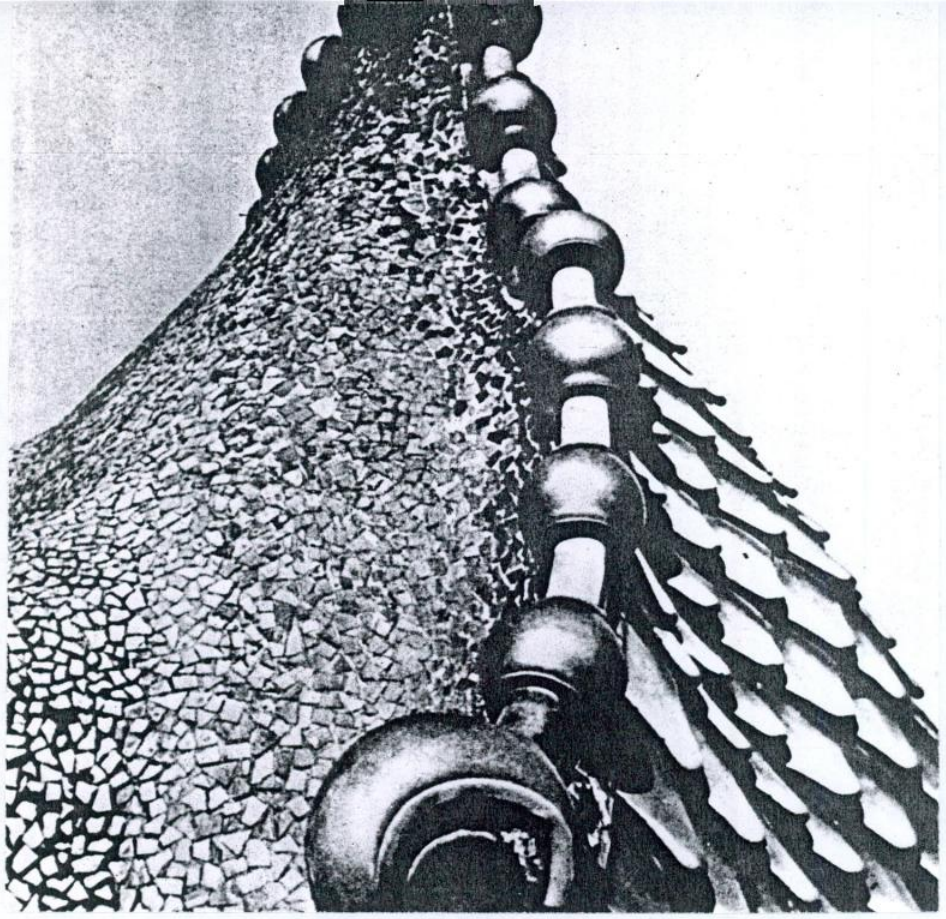


Plate 3.12 - Casa Battlo - Detail of the crest of the roof.

Plate 3.13 - Casa Battlo Colour detail

vitality going from the exterior to the interior. In comparison to Mies's Lake Shore Apartments Chicago (Plate 3.9) it is clear who is sensitive to light allowing it to add to the expressionate story of a building and who has divested himself of this sensitivity.

Colour too is essential to the vitality of a building in Gaudi's opinion.

> Architecture does not have to renounce colour but, on the contrary, should make use of it to bring forms and volume to life. Colour compliments form and is clearest manifestation of life.
>
> (Descharnes. 1971. P.143)

A manifestation of this view can be seen quite strongly in the Casa Battlo facade (Plate 3.13) and the towers of the Sagrada Familia to name two examples. Gaudi's architecture reveals an animal virulence in a dragon's back, shining scales, bony limbs and towering totemic forms. The lake shore apartments and many other works by Mies van de Rohe would pale into the distance in terms of expression and harmony with people and their surroundings, in comparison as Max Planck comments:

> Scientific works seem to be an incessant race towards a goal that will never be reached. The goal is in fact of a metaphysical nature and beyond any experience.
>
> Dalisi. 1979. P.42)

It is then the task of the artist to express this metaphysical nature in the medium at his control.

Gaudi, Corbusier and Sarrinen have found an expression of this through forms

evolved from, as Dresser might put it: a conventionalisation of nature.

> Gaudi's works are like a logical national mans dreams of unleashed fantasies.
>
> (Dalisi, 1979, P.22)

Decoration is an accessary to form, nevertheless it is an important accessory. Decoration such as painting or sculpture is often inserted into the living area of a building. This process can be reversed as Corbusier and Gaudi have done. Instead of decoration being applied as an accessory, the form of the structure can become this accessory; with expression, movement and a sensitivity to light as with a piece of sculpture.

The use of organic forms creates images in motion beneath an apparently elastic covering. To further understand the compositional laws of the object or building. It is then necessary to look deeper, into the structure of the objects organism.

CHAPTER IV STRUCTURE.

Empires rise and fall,
species survive and fail
what lives fulfills
a purpose...

Defined by
its limitations.

To stretch
the limits
we must understand
our limits.

CHAPTER IV STRUCTURE

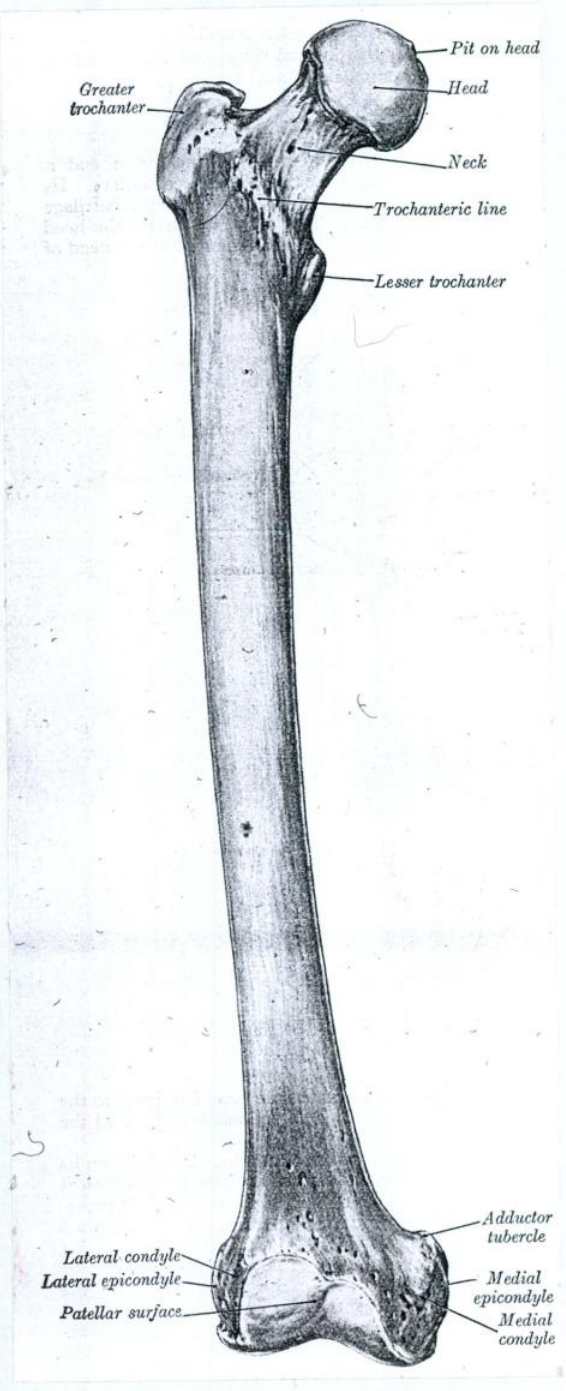
The mode of action by which a design fulfils its purpose is its function. The function of a structure is focused upon obtaining fitness for purpose in an economical manner. As opposed to making something strong by building mass and volume where it is not necessary. To achieve fitness for purpose within a structure the materials must be used in an appropriate manner to achieve maximum strength with economy of materials.

> Without economy of structure the bird could not fly, nor the airplane, for they would fall to earth from their own weakness or great weight. Without economy of materials the bridge could not hold its own weight nor could the tree, the very large and light, the very strong and fast demand the most from structure.
>
> (Williams, 1981, p.30)

It can be said that for every purpose there is a form. Biologists say that all morphology is adaptive;- meaning that over generations a species may alter its form to remain obedient to its function, which essentially is survival and the reproduction of offspring to carry on the species. This depends upon the demands of survival and the prevailing conditions. If a species survives it is clear that it has evolved such a fitness for purpose. This is shown in the case of the dolphins as spoken of in chapter I.

Within the human anatomy there is a variety of systems that with the whole show a fitness of purpose. One such example is the human bone. The function of the bone is to hold the body, withstanding forces that would rupture, tear asunder or crush the bone. To withstand bending in all directions

Plate 4.1 - Human Femur



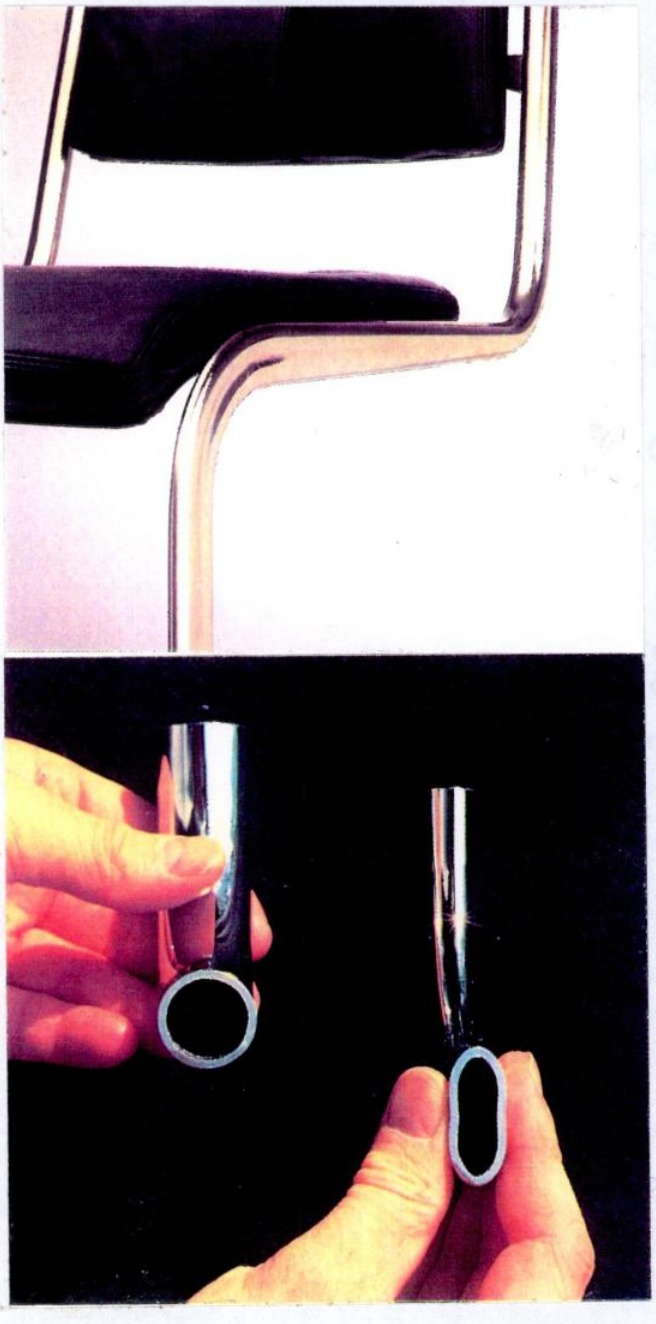


Plate 4.2 - Furniture for a student hall
Jean Prouve

tubular structure best fits the purpose. The human bone is essentially tubular as are the bones of an Albatross's wing which must withstand the powerful bending moment of carrying the birds body.

It is known that if a tubular structure was to bend under a bending movement it would bend in the middle. Obviously this is the place where structural support is of the upmost necessity. This can be done by making the walls of the tube thickest in the middle to withstand bending. If we look at the human femur this is precisely the case. The presence of a danger point is avoided by making the bone denser in the middle, Thinning off towards the ends (Plate 4.1). The bone becomes a diagram of the bending movements along its length.

Jean Prouve in his design of furniture for a student hall achieved a satisfactory degree of stability using the same principle, by flattening the tube in the points where bending moments were the greatest. This also made the chair stackable. (Plate 4.2)

When studied closer it can be seen that amidst the marrow and blood vessels that occupy the hollow of the bone there is a fine lattice work of 'Trabeculae', interlaced with each other forming the 'cancellous tissue'.

Professor Culman of Zurich an eminent engineer of the nineteenth century, and to whom we owe the modern methods of graphic statistics; recognised the

importance of the 'Trabeculae' when he happened to come into Hermann Meyer's dissecting room in 1886. He saw that the Trabeculae was a diagram of the lines of stress. They are laid down in such a way as to enable them to withstand stresses without unnecessary weight. The compactness and number of 'trabeculae' varies according to the strength and lightness required.

Using the method of graphic statistics an engineer begins by drawing the outline of the structure required, then calculates the stresses and bending moments necessitated by the loads and dimensions of the structure. Finally a new diagram is drawn representing such forces. The structure is built essentially along the lines of this statistical diagram. In doing this the designer is doing exactly what nature has done in the case of the bone. In this case the engineer is like the natural gardener in the view of Stephen Switzer who says in 'Ichonographia Rustica'

> The natural gardener ... has made his designs submit to nature, and not nature to his design.
>
> (Sweeny & Sert, 1960, p.132)

Antoni Gaudi utilized the logic that can be discovered in nature, through careful study of the structure of skeletons, plants and shells. Gaudi found fresh forms as his structural guides after meticulous calculations proved them suited for a particular purpose. Gaudi's interest in nature went beyond his art nouveau contempories; being interested in nature's inner forces as expressed on the surface, rather than mere surface expression as utilised by art nouveau

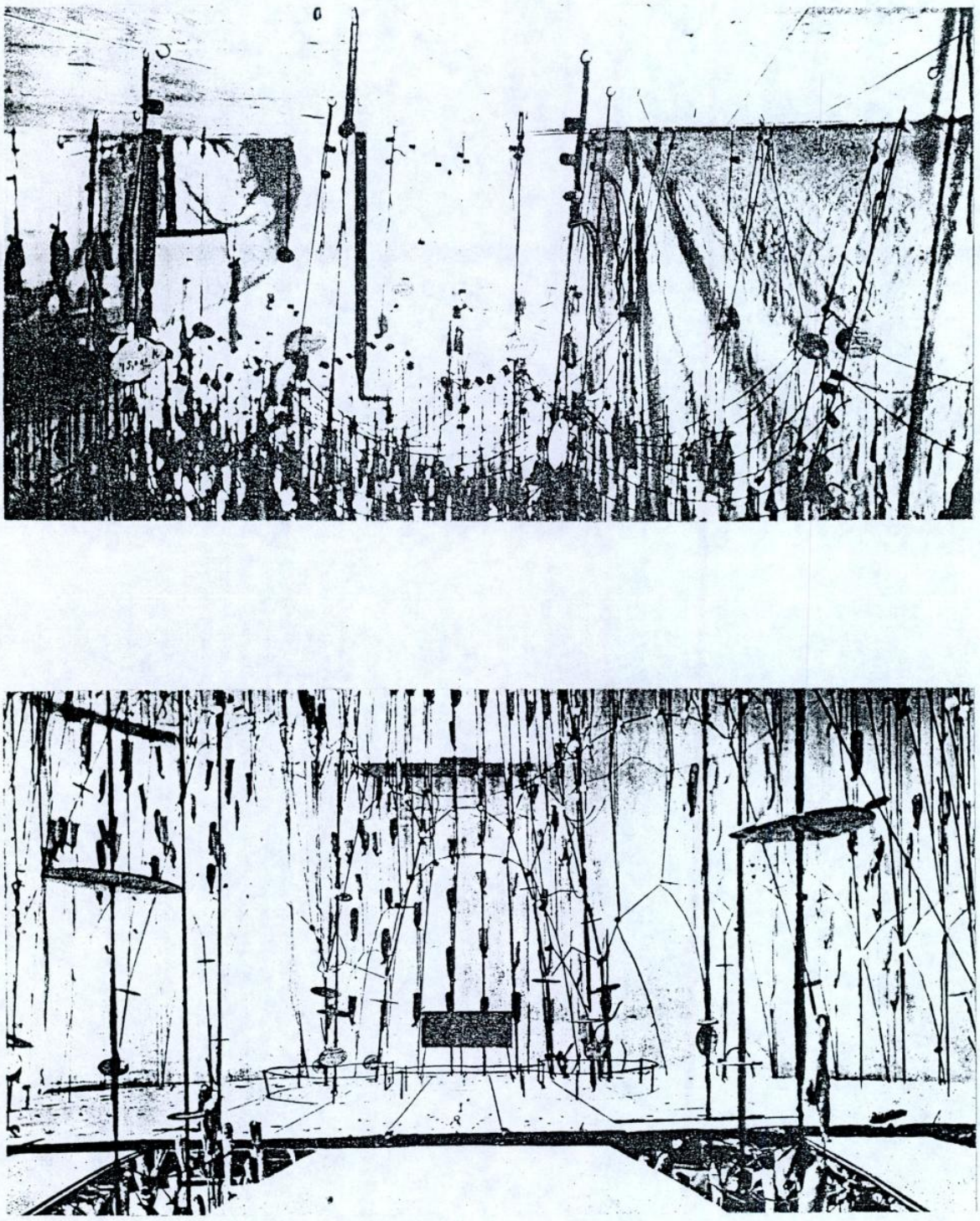


Plate 4.3 - Funacular models for churches
Gaudi

artists and designers. Gaudi questioned and understood nature.

> He finds in nature the rules and guidance that should define and govern the architectural elements. The roof like a mountain has ridges and slopes, the vaulting is like a natural cave of parabolic section.....he observes the profusion of enveloping warped surfaces and.... the smoothness of transitions from one natural ground or rock form to the next one, and would comment, 'look everything is parabolids' and 'when we turn our arms or torso helicoidal forms appear.
>
> (Sweeny & Sert. 1960, p.133)

Gaudi's mastering of structural laws and static equilibrium enabled him to achieve expression and organic vitality in his buildings through the structure. Every apparent liberty of expression is a result of precise calculations governed by rules of balance and counterbalancing, forces and loads.

> There is no architectural creation, however full of fantasy that is not based on sound principles of construction.
>
> (Masini, 1970, p.30)

In his studies of structure Gaudi used huge models as diagrammatic illustrations of the loads and forces. Gaudi attached a series of wires to a roof, weights proportionate to the loads which the elements of the building would have to support would be attached to the wire. As a result of gravity pulling on the weights the wire sections would take up the position corresponding to the demands of the forces exerted upon it. These models would be photographed and turned upside down and Gaudi then elaborated his designs from drawing over the photographs. Upside down the model shows the curve of the arches and columns as dictated by the loads and stresses these curves are the logical structural lines of the arches and columns. (Plate 4.3)

By using such livelier methods of analysis rather than representing plans of buildings in elevation and section; Gaudi achieved a truly sculptural sense of architecture. Working closely with such models stimulates imagination and the creative facilities; giving Gaudi an extraordinary three dimensional vision of space.

The hyperbolic curve expressed by the laws of nature in the funicular models typifies Gaudi's exploration of space which was primarily that of expanding space, portraying the feeling of contrived forces on the point of explosion. The hyperbolic curve is such an outgoing curve. This hyperbolic curve can be seen in a hens egg. The egg's shape consists of a hemisphere with a hyperbolic cone connected at its axis. This shape is the result of its passing through the peristaltic tube where motion takes place by waves of contraction and relaxation. The egg is a streamlined structure produced by forces exerted upon it.

If the Laminar lines of flown in the peristaltic tube are equated with the forces of gravity, loads an stresses upon the wire in Gaudi's funicular model a comparison can be seen. Both forms are altered directly by the forces upon them to produce a form that allows easy passage of these forces, (Laminar flow, gravity, loads and stresses) this being the hyperbolic curve which is an extremely strong curve. This can be tested by applying force vertically upon an egg from the pointed to the rounded end;- the egg will refuse to break.

The hyperbolic arch was used in gothic construction to replace the round groin arches of the romanesque. Being rounded the groin arch exerted more horizontal pressure on the supporting walls than the parabolic arc whose thrust is closer to the vertical. Gaudi recognised such structural principles of gothic architecture. Gaudi succeeded where gothic revivalists failed, by re-examining and recreating the concepts of gothic architecture putting forward challenging new idea.

The structures used by Gaudi become expressive like a natural growth, emulating and rivalling nature and the forces of creation, as he says:-

> Originality lies in re-examining the most remote fundamental concepts, true originality lies in is going back to the origins. Thus the original person is the one who with his own means returns to the simplicity of the earliest solutions.
>
> (Dominion. 1991, p.224)

Gaudi took the hyperbolic curve customary in Catalan and gothic architecture and recreated it from its original state into something with its own expression, guided by natural expansion it expands and contracts, contorting itself as if ready to explode.

The give, flying buttress and buttress tripartite gothic structure upon which thrust are balanced and broken down and re-employed in a hyperbolic-parabolic spatial element. By angling the supporting columns the interposed elements which divide or balances the thrusts, retarding the trust and upward impulse are cancelled out and re-employed in a new static structure

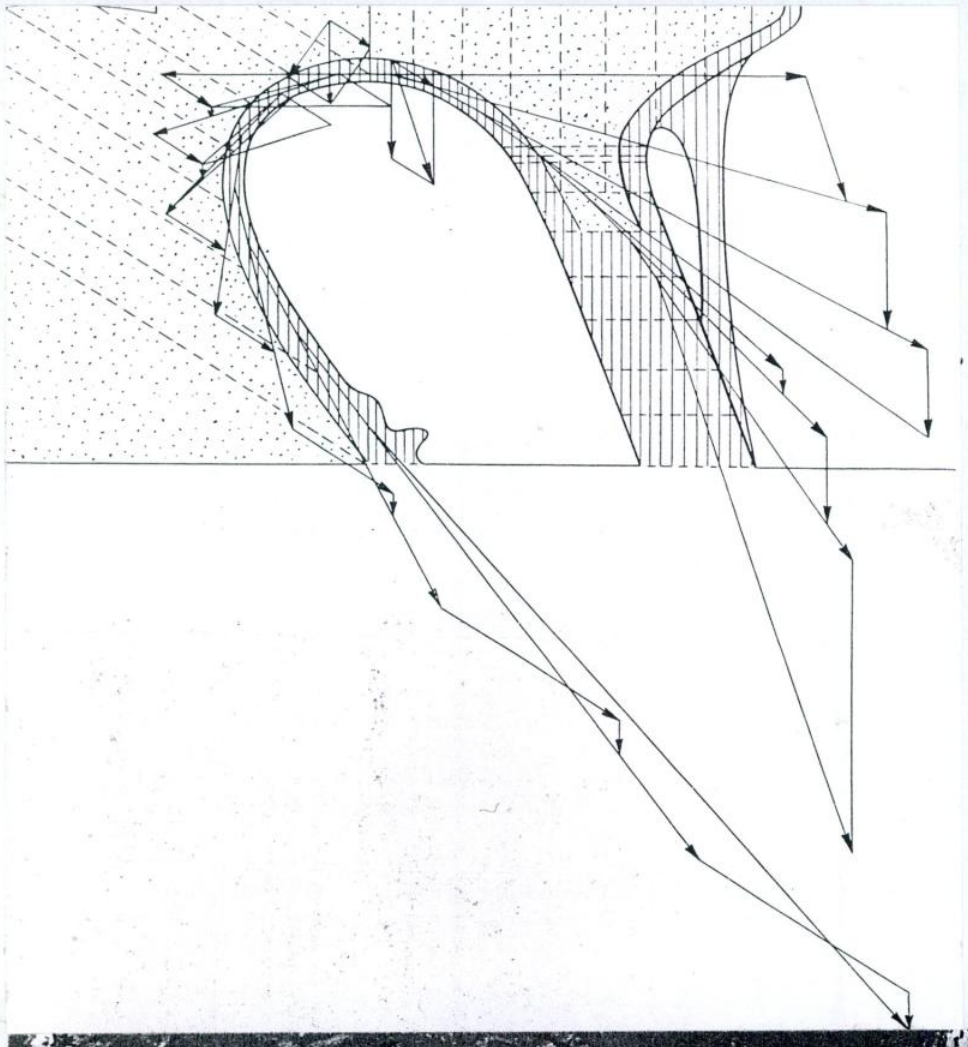


Plate 4.4 - Parc Guell Viaduct cross-section showing loads and stresses.

Plate 4.5 - Parc guell Viaduct.

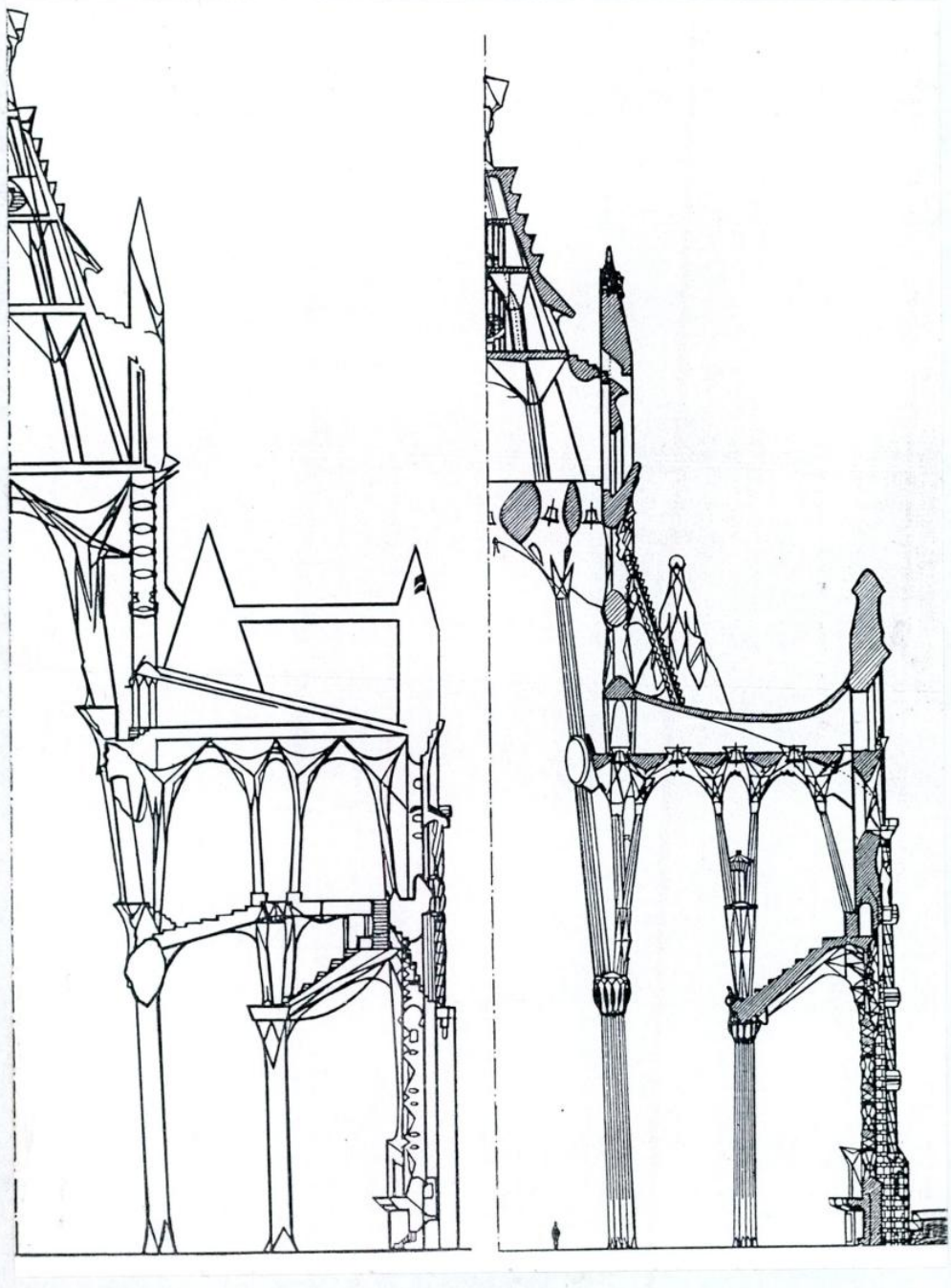


Plate 4.6 - Cross section of the Sagrada Familia showing the tilted columns.

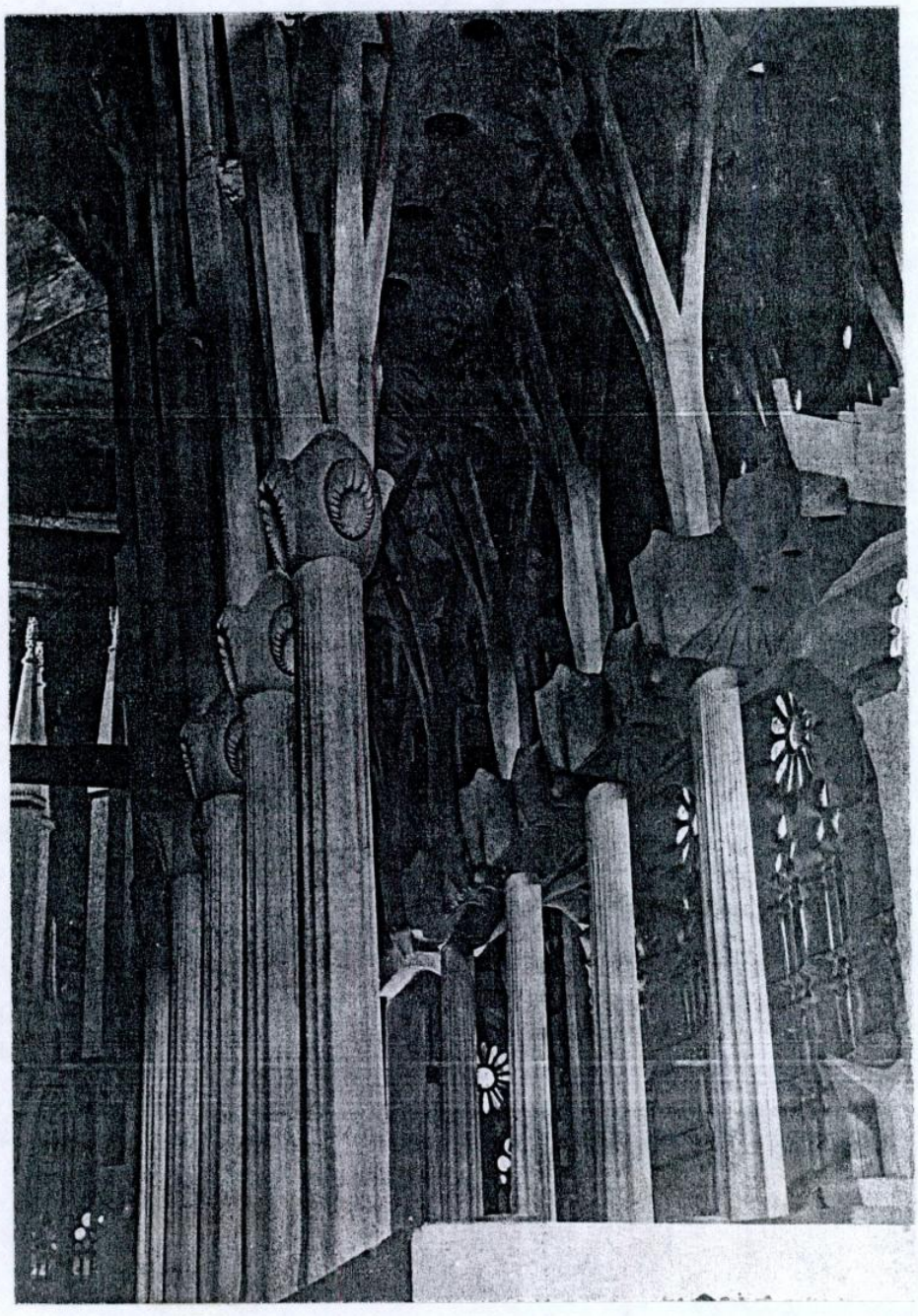


Plate 4.7 - Detail view of the final scale model showing the aborescent columns.

unburdened by supplementary loads.

The use of the tilted column gave Gaudi the key to modern gothic architecture. Such tilted columns follow the direction of the forces and loads eliminating the needed for buttressing.

How the most efficient shape and angle of such a tilted column is found can be seen in a diagram of the cross section of the arch in the Parc Guell, the diagram shows the loads and stresses explaining how Gaudi determined the resulting load which tilted column takes its angle from. (Plates 4.4, 4.5) The Parc Guell shows how a nature based variety of design can be achieved.

As the columns in the Sagrada Familia rise towards the roof they divide into several branches at certain heights. Unlike gothic columns and vaulting each branch of the column and the column itself independently supports one particular section of the superstructure (roof and vaulting). From the top down the branches carry first the load of the roof section. Each roof section has a centre of gravity the resultant of the forces and loads are directed towards the main column. Then come the branches supporting the vaulting below whose loads and forces are directed towards the base of the column, where the whole system becomes united by a straight but tilted line following the direction of the resultant loads and stresses. (Plate 4.6) Interestingly the points of Junction between the branches and the vaulting and the main column is nodular like the joints of bones. (Plates 4.7)

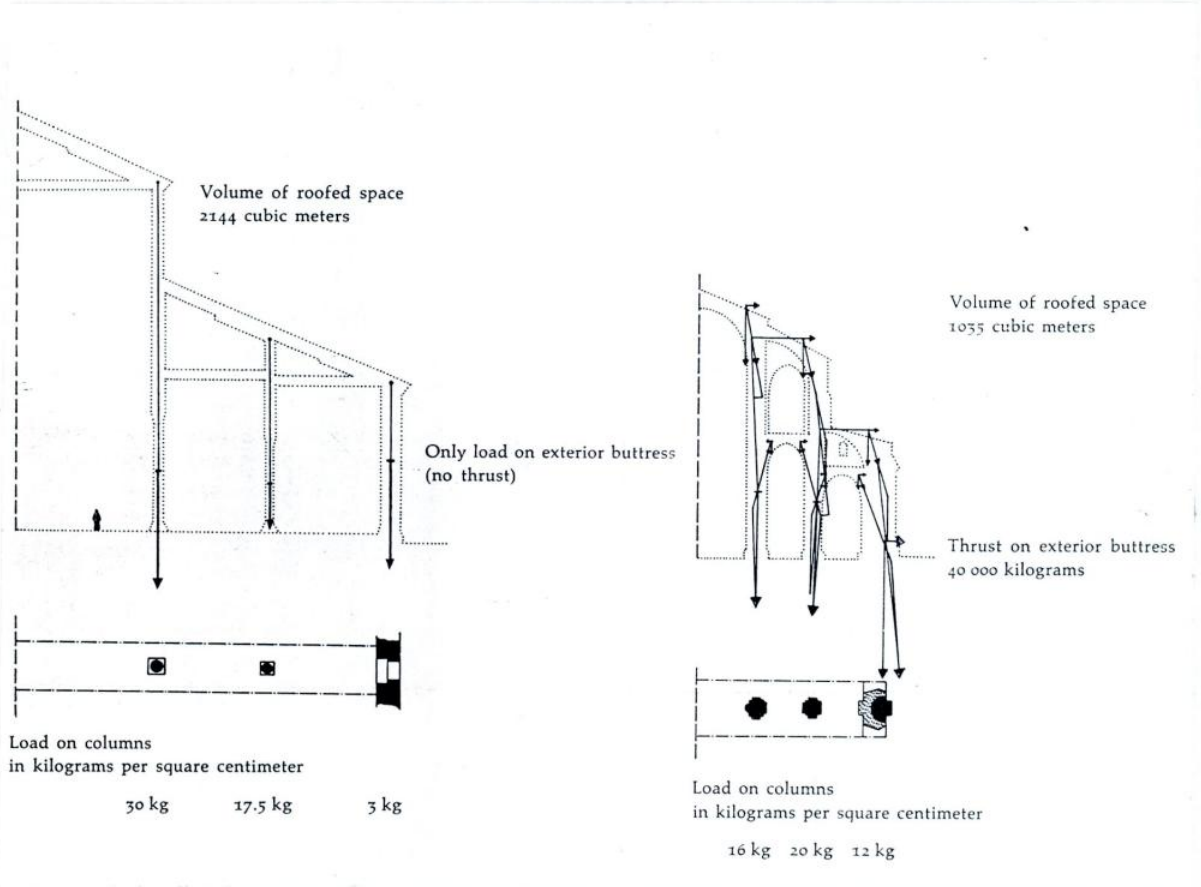


Plate 4.8 - Cross section of St. Pauls outside the walls (Rome)
Cross section of Saint Sernin (Toulouse) showing stress and load diagrams.

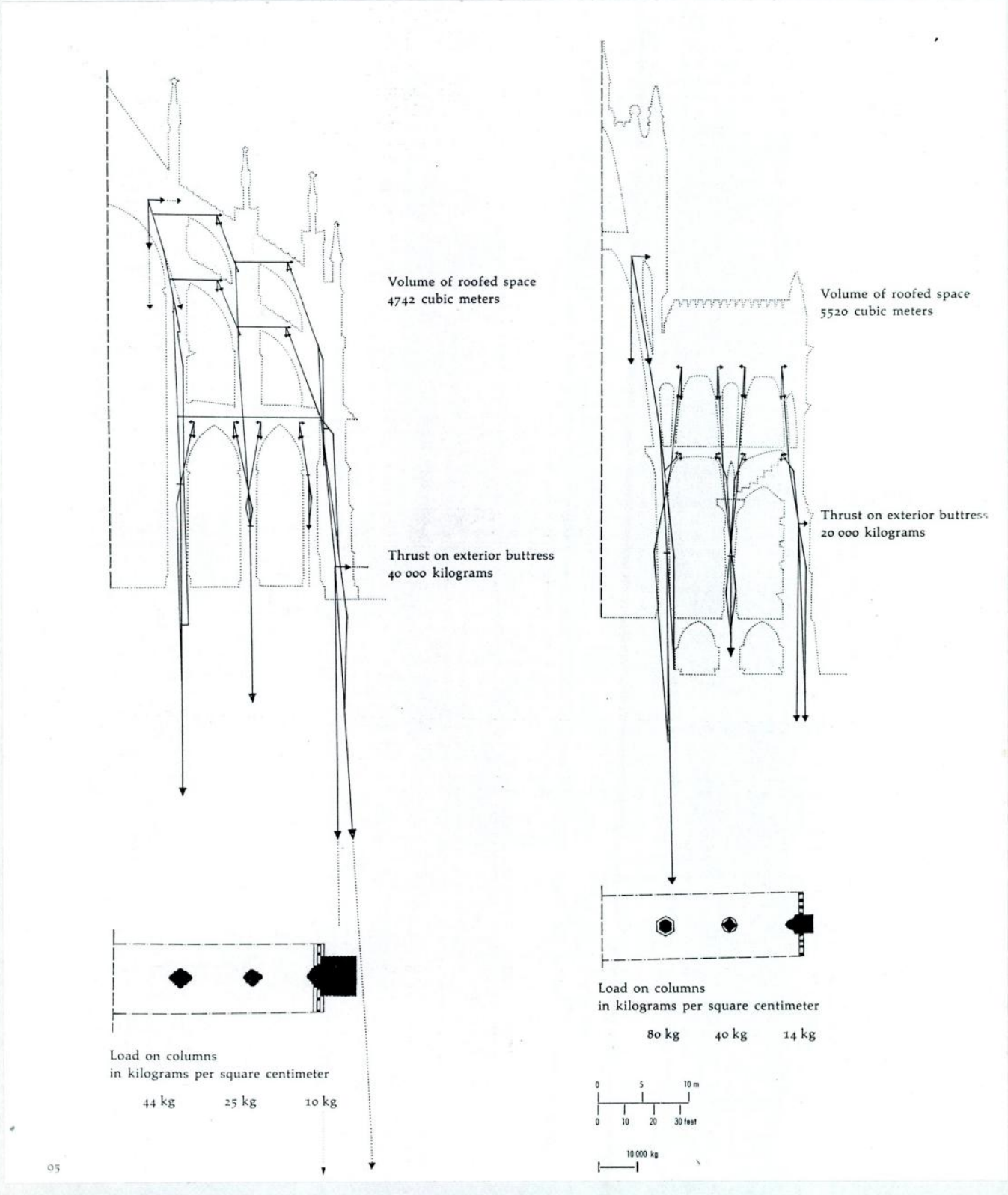


Plate 4.9 - Cross section of Cathedral (Cologne) and the Sagrada Familia showing stress and load diagrams.

Plate 4.10 - Four Towers of the Sagrada Familia

A comparison of the cross section of St. Pauls outside the walls (Rome), Saint Sernin (Toulouse), Cathedral (Cologne) and the Sagrada Familia in terms of stress and load diagrams illustrates evolution of church construction. The illustration highlights clearly that Gaudi's Sagrada Familia is superior to the preceding designs, being lighter than the gothic cathedral and by redistributing the loads and thrusts using the tilted column which is not dependant upon buttressing (Plates 4.8, 4,9)

One of Gaudi assistants in the Sagrada Familia Domingo Sugranes asserted in an article 'static disposition of the temple of the Sagrada Familia' that the structure of the church was not found casually but was the result of years of research to free gothic construction from its defects. This new structured system was...

> One more step forward, a new advancement, in the long process of evolution that starting in the old basilicas with their wooden trusses reached its high point in the great gothic cathedrals.
>
> (Surgranes, 1923, p.20)

The structure of the towers of the Sagrada Familia are light and graceful considering the material used. (Plate 4.10) Their form and section are those demanded by their height. Seashells may have inspired their helical development. (Plate 4.11) Since in both cases the path of revolution of the equiangular curve revolves about a plane parallel (more askew in the shell) to the axis gaining the helical character:- Helico spiral this spiral can be seen in the stairs of the towers (Plate 4.12, 4.13) The walls of the towers are pierced by openings which are punctuated by horizontal masonry which act like

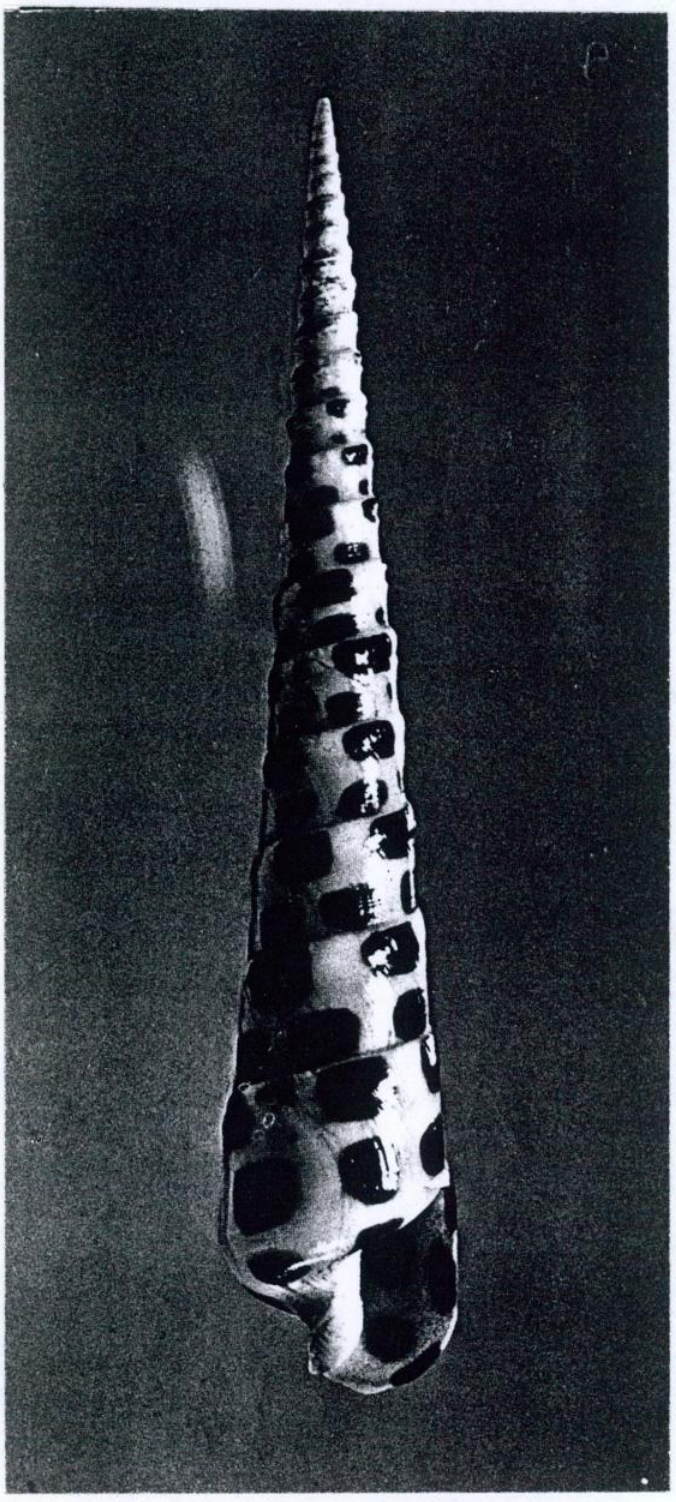


Plate 4.11 - Terebra Subulta

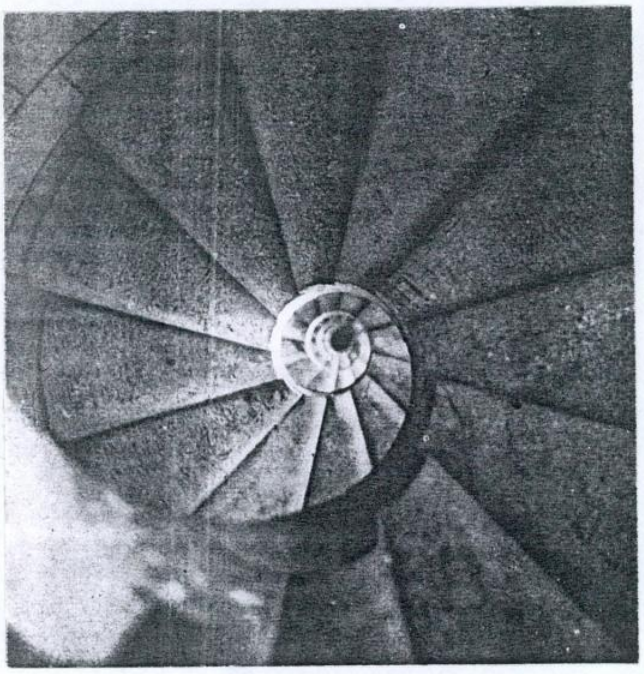


Plate 4.12 - Tower of Sagrada Familia - Interior detail showing the stairs.

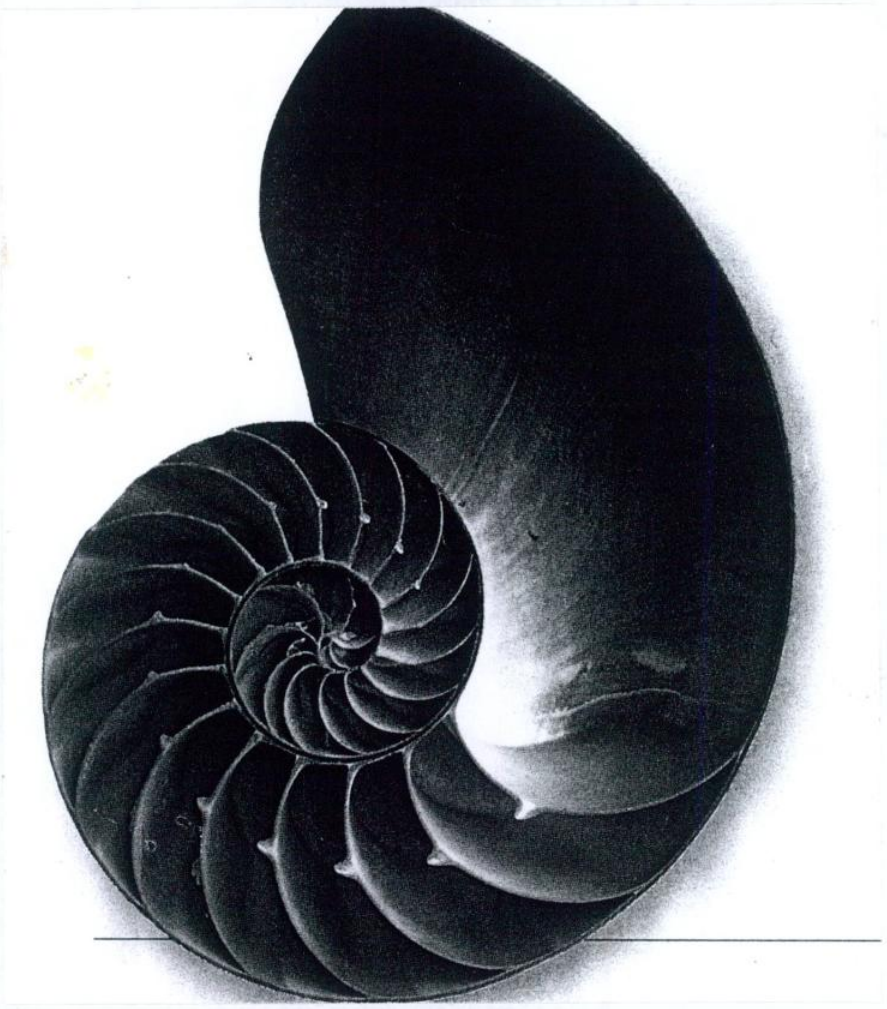


Plate 4.13 - Cross section of the Nautilus showing the equiangular spiral.

louvres protecting the interior against rain. Gaudi said that

> The form of the church's towers, vertical and parabolic, is a union between gravity and light.
>
> (Descharnes & Prevost, 1971, p.145)

But the helical form itself played a double role of transforming sound and light. Gaudi was searching for ways of reproducing the sounds of winds at the limits of human perception, as Francesco Pujols wrote in 1914

> So let Gaudi make a wind tower for the four winds that will show... their direction like the rose of the winds and will whistle and howl like the wind themselves...
>
> (Descharnes & Prevost 1971. p.143)

It is clear that structural models in the natural world portraying fitness for purpose can be used for man made construction. Gaudi recognised this and employed its fundamental teachings; imbuing his structures with vitality and life without the need for superfluous decoration. Thus making his structures sculpturally plastic with a composition in which every detail plays a functional and aesthetic role in the totality.

This was possible through a close relationship with materials as can be seen by the amount of models Gaudi built. The constantly changing sections of the vaults require sculptural techniques and perception of space, rather than conventional orthogonal plans.

> Gaudi anticipated certain later engineering discoveries, and many of his forms heralded the light reinforced concrete shells of today.
>
> (Sweeny & Sert, 1960, p.144)

CONCLUSION

The natural world has a variety of designs that portray harmony with their environment with fitness for purpose. Man can only hope to emulate never better such designs. Through the study of nature to the point of deriving solutions and principles that have applications in the man made world, highlights the importance of the natural world as a source of information. Not to look at nature is to turn away from the answer to a question.

Providing we don't destroy it nature can go on being a benefit to mankind indefinitely.

By using forms derived from the world of nature an object can obtain an appealing aesthetic without the need for further decoration. The use of organic forms remind us that we are human and a member of the natural world. Many of those organic forms remind us of our sensuality and become exciting objects to perceive. Being atavists at heart any pantomime of sex reminds us of our own sexuality.

An organic form expresses life and feeling. It is important to express a closeness to feeling in design if people are to find an object appealing and agreeable. When designing with the senses in mind the designer is essentially designing for people who are the most important factor if a design is to succeed.

During the course of the twentieth century architecture was stripped to its bones. This may have been a necessary therapy in reevaluating form and reemphasising sound structure.

It has been shown that although this rationalist approach to architecture headed by Mies van de Rohe, who was its greatest exponent, proposed solutions that may have seemed right at the time were, in fact, anti-human resulting in lifeless neighbourhoods such as the Pruitt-Igoe project in St. Louis.

There is a need for a less rationalistic expression that allows liberty for extra technical expressiveness. A building must allow life to dwell within its frame, not impose its will like a machine upon life.

It is clear that to achieve a harmony between the people who inhabit a building and the building, the building must express life showing that it was built by and for people. In the case of the TWA Terminal by Sarrinen that such as expression of life within an expressive architecture produces a more congenial form of habitat.

Sarrinen like Gaudi points to a new direction in architecture with the use of nature. Without an understanding of nature Gaudi nor Sarrinen would not have evolved such forms that express a natural vitality and variety of animation.

The points of view and solutions found in nature are put forward as prompters, opening the imagination. Nature as with the solutions found by designers in nature are personalised being suited to their purpose. We should emulate nature in using her solutions and the designers in their approach, not merely copy since to copy is to fail to understand, as Le Corbusier says.

"Friends nature says to us 'psst-psst!"

(Sweeny & Sert, p.137)

CONCLUSION

I encompassed
knowledge in
the branches of
my mind.

Understanding and
knowing why
I arose...
Stepped forward
with a gainful
knowledge of the
future.

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