THE INFLUENCE OF STEEL AND PLASTICS ON MODERN CHAIR DESIGN

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BY

GERTRUD ANNA-MARIA WINKELMANN, M.A.

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TABLE OF CONTENTS

TABLE OF CONTENTS-Cont'd.

LIST OF ILLUSTRATIONS

INTRODUCTION

When industrialization started to become prevalent in the manufacture of every-day products, in the mid-1800s, and the technological progress began inevitably to infiltrate all aspects of life, chair design as well was strongly influenced by the new production methods and the newly developed material: steel.

With the consumer demand for inexpensive, functional chairs, the design concept for chairs changed from being mostly aesthetical to being geared toward industrial design and functionalism. This tendency was supported by the restructuring of social classes, which found its expression in all areas of design. The improvement of steel and steel tubes enabled designers to approach and successfully carry out new principles in chair design, such as the cantilever construction and light-weight tubular steel chairs.

Plastics became widely available only after the second World War, and offered themselves as ideal materials for the use in chair design. With these new materials and their technology, chair design entered into a new phase. The possibilities for new innovative forms and shapes of chairs which could be industrially mass-produced, increased with the refinement and perfectioning of plastics and their production technology. As in the design of metal chairs, plastic chairs also reflected the social changes and answered to the consumer's demands.

The development of industrially produced metal and plastic chairs, and the intent of the designers to create inexpensive functional chairs, led to the change of the criteria for good chair design. The mass-manufacture of metal and plastic chairs limited the application of decoration and ornamentation. Subsequently, the integrity of materials, clean lines and smooth surfaces, as well as ergonomics and sitting comfort were emphasized in modern chair design; thus creating an harmonious synthesis of functionalism and aesthetic appearance in sophisticated simplicity.

CHAPTER I

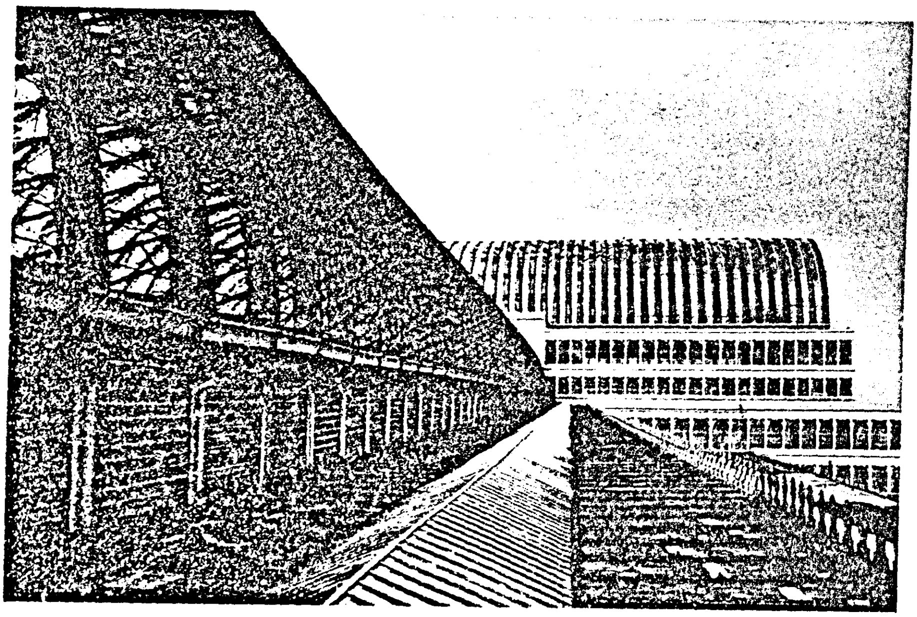
METAL CHAIRS

Premises for Metal Chair Design in Sociological and Technological Developments, Art Movements, and Architectural Trends

In examining the influence of metal on the development of chair design, it is essential to consider the underlying sources and premises, which were invariably tied to furniture design, such as: the advancement of industrialization; the changes in society and the resulting social consciousness of designers and art and design movements; and all the trends in architecture.

While science and technology furthered industrial development, the economy and international trade, they also caused the industrial revolution and subsequently the exploitation of the workers. The evolution of massive industrial areas in and around the cities led not only to the beginning of a democratic society, but also to the increase in the differences between social classes. This difference spurred socialist ideas, which for the first time, were published in the writings of Karl Marx, in 1859. In the industrial countries, the first labor unions were organized to secure wages and improve working conditions. The rapidly growing working class also influenced the ideas of architects and designers. The designers attempted to meet the needs of the laborers by designing for inexpensive mass-production, while, as Henry Cole stated, trying to achieve a "union of fine arts and manufacture"[1] and to "produce in each article superior utility, select pure forms."[2] Some of the designers hoped that this collaboration between designers and industry would improve the taste of the public.

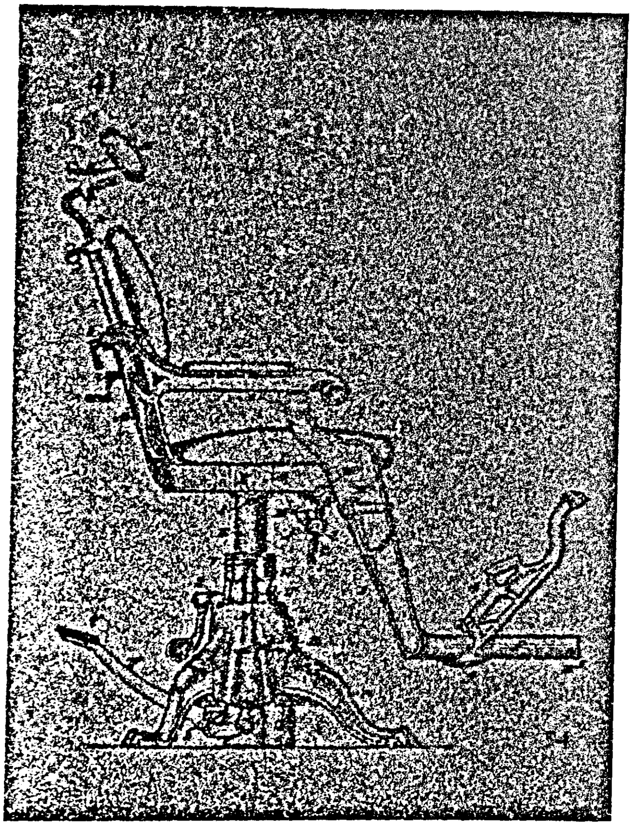
The production of new elementary materials needed for mass-production was greatly improved by new methods, such as Henry Bessemer's procedure to convert pig iron directly into steel in 1855-1856. Bessemer's process raised steel production levels and subsequently opened new channels for metal, and related industries. The qualities, peculiar to steel, led to innovations in design and to new possibilities of its application in the field of architectural and furniture design. Prefabricated, mass-produced structural elements of buildings, such as those used in Joseph Paxton's Crystal Palace of 1851 (pl. 1), slowly led to the avoidance of historical styles of both architecture and furniture.



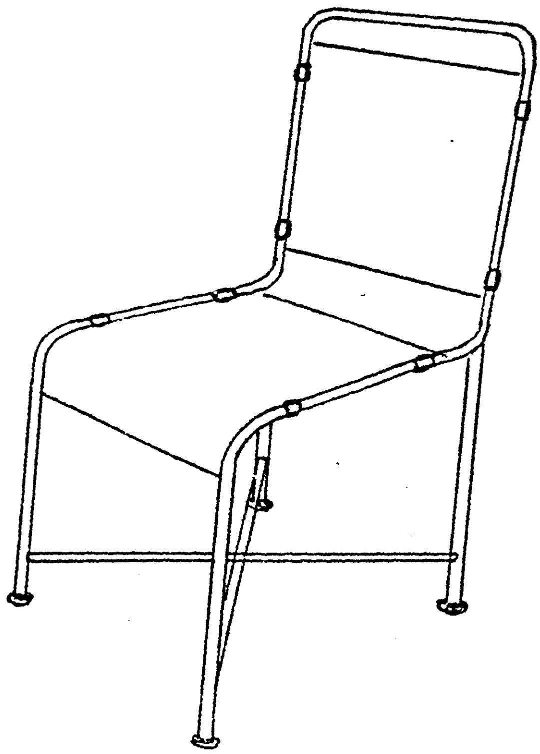
Pl. 1. Crystal Palace, Joseph Paxton, 1851, In: Pevesner, Sources of Modern Architecture and and Design, p. 11, no. 1.

The production of metal chairs began with the development of numerous patent chairs invented in the United States, since 1836[3] (pl. 2). The early patent chairs were mainly constructed of wood, except for the mechanisms that facilitated their reclining, rocking, and revolving. These mechanical devices were first made from steel, using carriage springs for resilience. The first patent was followed by a large number of others, gradually utilizing more and more metal parts for the various adjustable elements. According to the nineteenth century taste, mechanized chairs with more mechanical gadgets were preferred. Their designers were concerned with the various mechanical functions, rather than appearance or integrity of material.

In Europe, the first mass-produced steel chairs came on the market at the same time and soon became very popular. These chairs, as well as other furniture pieces made from iron or steel with an enamel finish, were generally used outdoors, since they withstood the weather conditions far better than the traditional wooden chairs. These chairs were also used in strictly utilitarian environments, such as hospitals (pl. 3), kitchens, and servants' quarters, as they were easily kept hygenic.



Pl. 2. Dentist Chair, U. S. Patent 1879. In: Mang, History of Modern Furniture, p. 41, no. 54.

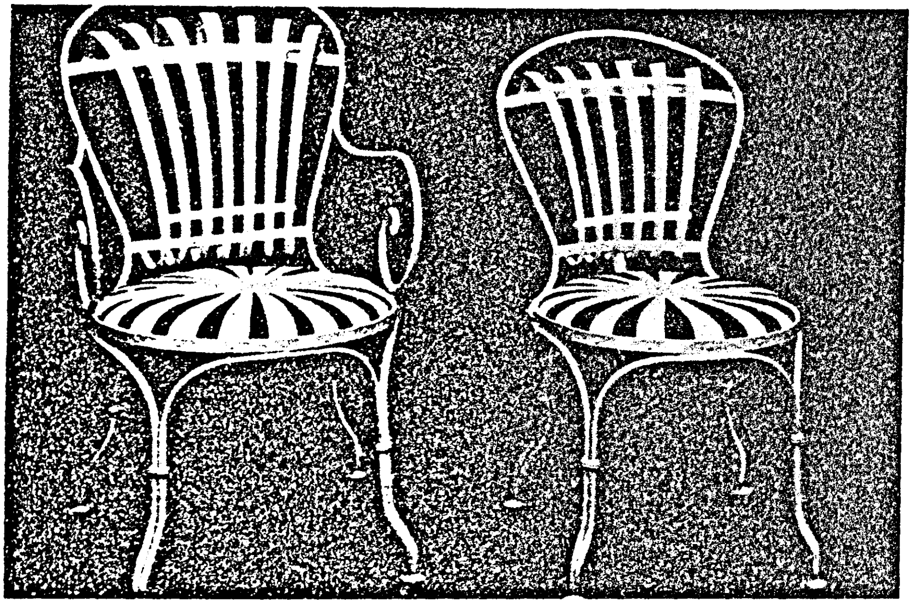


Pl. 3. Hospital Chair, about 1850.

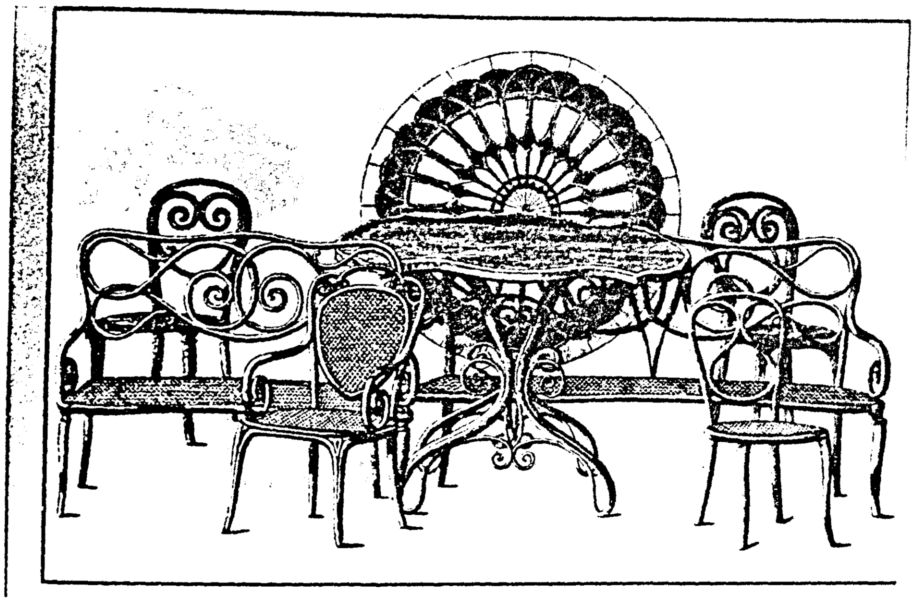
While, as Giedion stated, ". . . in America the ideas of 1850 had long since frozen around purely technical aims,"[4] in Europe, the chair designs of the second half of the nineteenth century were determined by the various arts and crafts movements and suitability for mass-production. Each, in its own way, searched for new designs, uninfluenced by the traditional elaborate ornamentation and complied with the integrity of materials and manufacturing processes used. Unlike the American patent chair designers, the European chair designers were very little concerned with sitting position or comfort, but with appearance, durability, and cost. These considerations were a break-through in the long-lasting French and English iron garden chairs, which were mass-produced, and therefore inexpensive. They were already very popular in the 1850s and 1860s, as can be seen in a number of Impressionist paintings. These garden chairs were made from iron or steel. In some models, the seat and back consisted of wooden latches. Most of them could be folded or stacked, which was a great advantage for storage. Although these chairs were constructed from quite modern materials, such as steel strips, rod, or wires, they were only one link in the chain that led to the rational designs of the 1920s. The anonymous designers of these iron and steel chairs were strongly influenced by the traditional forms. Yet, they mastered the challenge the new materials posed and were able to find a way to produce a well-balanced synthesis of form, function, and material without neglecting the taste of the consumer.

The construction of the garden chair of about 1850 (pl. 4), today at Casa GMBH, Munich, still shows a strong similarity to the early Thonet bentwood chairs (pl. 5, pl. 6, and pl. 7). Its legs are formed out of two parallel steel rods held together by small collars, and branching sideways to form the four seat rails. The arm rests of the chair are curved in generous volutes; the back posts and top rail of the back rest are bent in an upside-down lyre-like form supporting the back of the sitter with vertical convex steel bands. The seat of the chair, like the back slats, consists of resilient steel strips, the wider ends of which are anchored in the circular steel band at the perimeter. These steel strips are tapered toward the center of the seat where they meet.

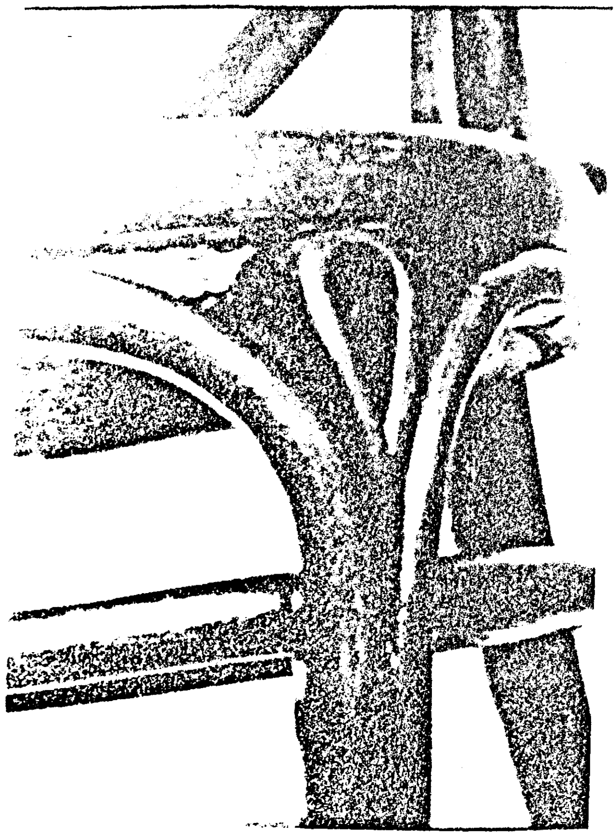
Also, somewhat similar to the Thonet model (pl.8), is a rocking chair of 1850 made from flat metal bands (pl. 9). The resilience and strength of the material



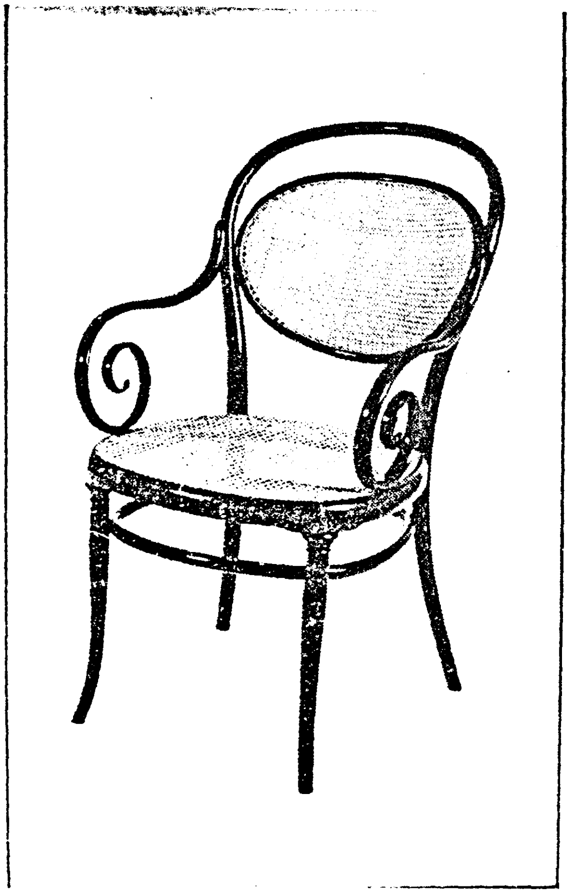
Pl. 4. Garden Chair, 1850. In: Eckstein, Der Stuhl, p. 142.



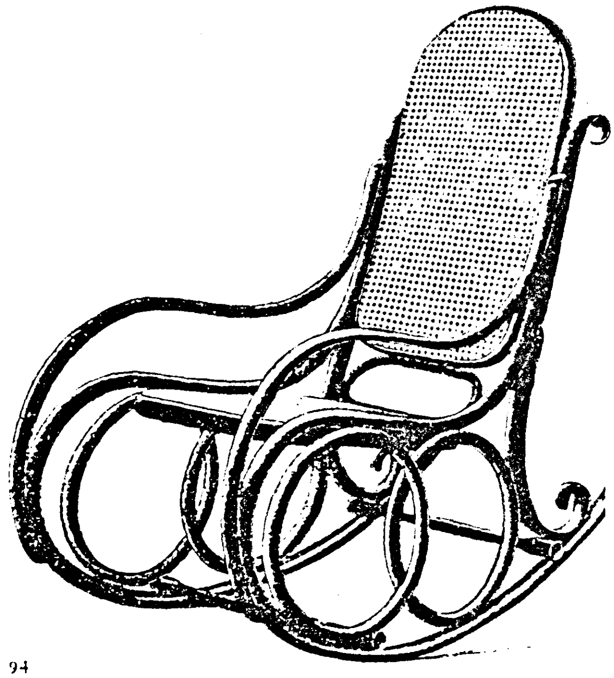
Pl. 5. Collection of Bent Wood Furniture by Thonet, 1850s. In: Bangert, Thonet Moebel, p. 69.



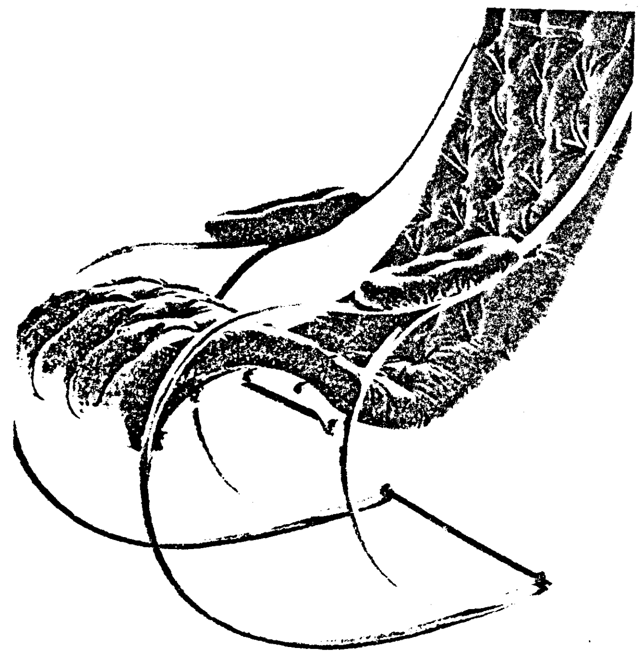
Pl. 6. Thonet Chair, 1850s. Detail: Top of chair leg and seat rail, joined without screws. In: Bangert, Thonet Moebel, p. 127.



Pl. 7. Armchair, Thonet, 1859.
In: Bangert, Thonet Moebel, p. 115.



Pl. 8. Thonet Rocking Chair No. 7027, about 1860. In: Mang, History of Modern Furniture, p.53, no. 94.

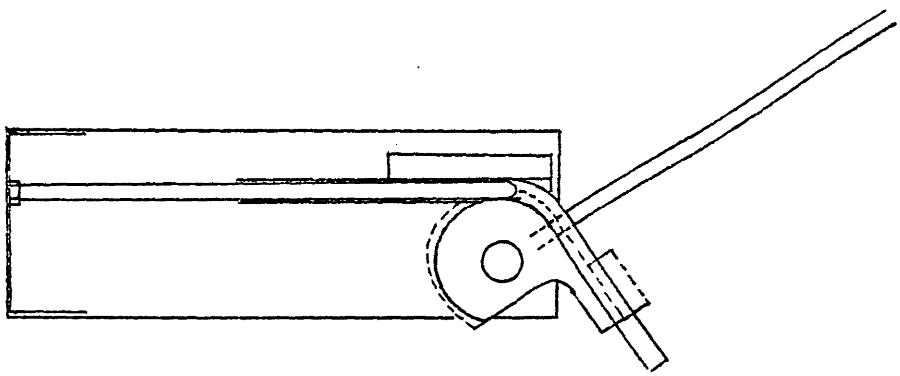


Pl. 9. Iron Rocking Chair, about 1850, Munich, Die Neue Sammlung, In: Eckstein, Der Stuhl, p. 141.

and its appropriate use in compliance with its physical properties, give the chair its solidity despite the wide sweeps of the iron band and the lack of supports between the seat and the rockers. Both of these metal chair designs were still principally based on the construction methods of wooden chairs, namely on the methods developed by Michael Thonet in the use of bentwood in mass-production.

One of the disadvantages of the early metal furniture was its weight when made from steel rods. The early tubular chairs made from gas pipes were heavy since all curves of the tubes had to be reinforced with solid metal cores to keep the walls of the tubes from collapsing and from losing their strength and resilience. The solution to these problems came with the invention of the Mannesmann tube in 1885. The Mannesmann tube was seamless and lighter than the gas pipes formerly used, and it could be bent by mandrel bending while cold (pl. 10), without a deformation of diameter.

It was at this time that the properties peculiar to steel started to be more widely appreciated. Besides the inherent weather resistance of metal, when given an enamel finish, it was also recognized that metal,

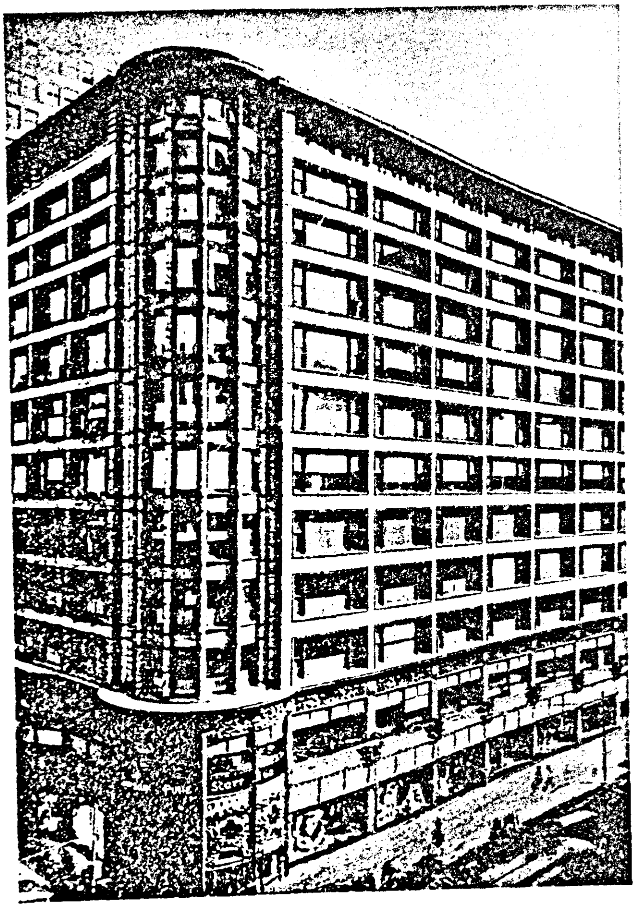


Pl. 10. Mandrel Bending

different from wood, could be produced with a guaranteed consistency in quality by means of the technological progress of the metal industry. With this technological progress, innovations in architectural design became possible, which in turn influenced the development of chair design.

The outstanding qualities of metallic construction were proved in the buildings of Emanuel Viollet-le-Duc, Henri Labruste, J. B. Bunning, and Sir Gilbert Scott, who had agreed on the fact that "modern metallic construction opens out a perfectly new field of architectural development,"[5] but they could or would not divorce themselves from historical exteriors. Only with the architects Burnham and Root, Holabird and Roche, Louis Sullivan and the beginning of the Chicago School in the late 1800s, was there a fresh approach to the problems of modern architecture, as well as the courage to use the new construction techniques that were available with ferrous materials (pl. 11). The members of the Chicago School were the first architects who truly parted with the traditions and open-mindedly searched for logical functionalism in architectural design and construction.

It was in Vienna that the new architecture first began to gain footing on the European continent.



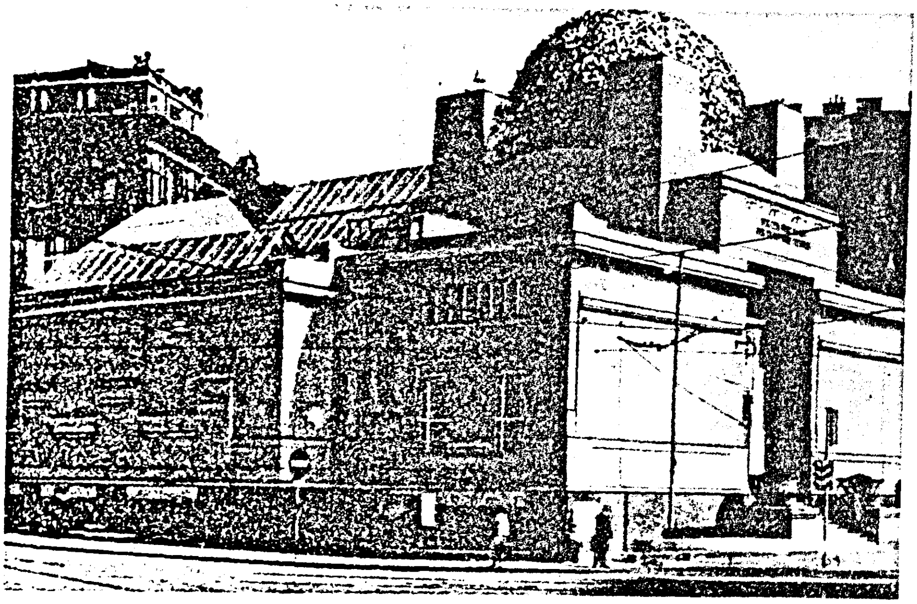
Pl. 11. Carson Pirie Scott store, Chicago, 1899-1904, Louis Sullivan, In: Pevsner, Sources of Modern Architecture and Design, p. 141.

Joseph Ohbrich's (pl. 12) and Otto Wagner's buildings were reduced to geometric shapes while preserving the elegance of Art Noveau. In the Vienna Savings Bank of 1905 (pl. 13), Otto Wagner realized his ideal that ". . . architecture should reflect modern life in modern materials."[6] Nicolaus Pevsner stated in this context that the Postal Savings Bank was part of and contributed to the creation of the twentieth century:

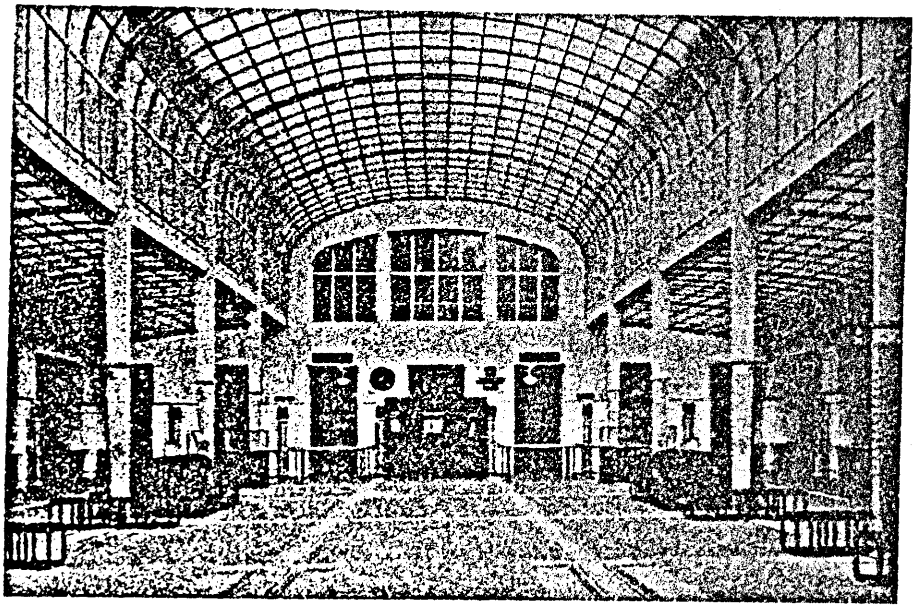
> . . . out of the new materials and their authentically integrated use, out of the antihistoricism of Art Nouveau and out of William Morris' faith in serving people's needs.[7]

The social implications of the new trend were even more prevalent in Germany. Richard Riemerschmid and Karl Schmidt had founded the Deutsche Werkstaetten in 1897 and two years later began to concern themselves with the design and mass-production of inexpensive wooden furniture, which was first shown in 1905 under the motto: "From the spirit of the machine."[8] Riemerschmid's chairs (pl. 14 and pl. 15) were industrially produced and showed a close relation to Art Nouveau on one hand, and on the other hand to the late Jugendstil.

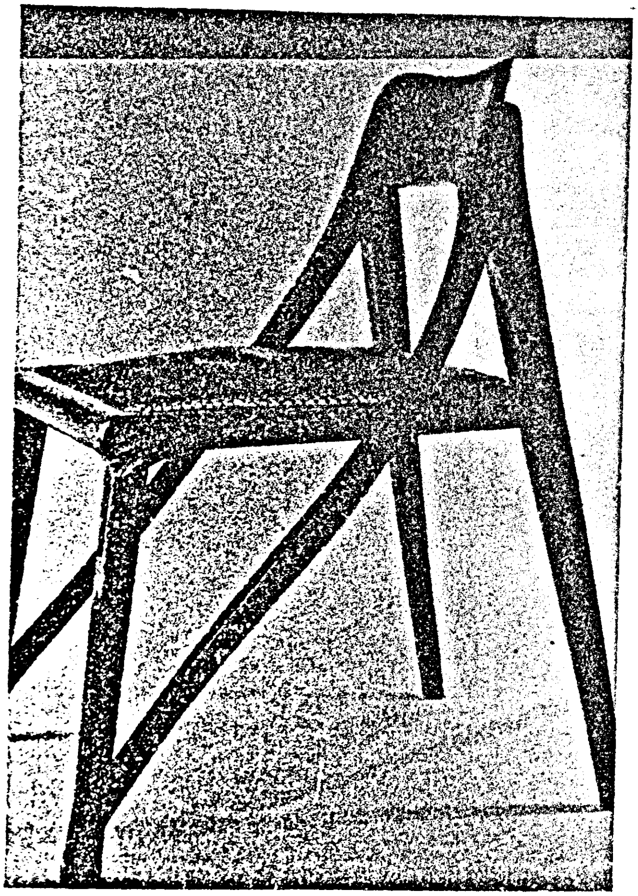
The awareness of the new materials and the social consciousness gave the incentive to the founding of



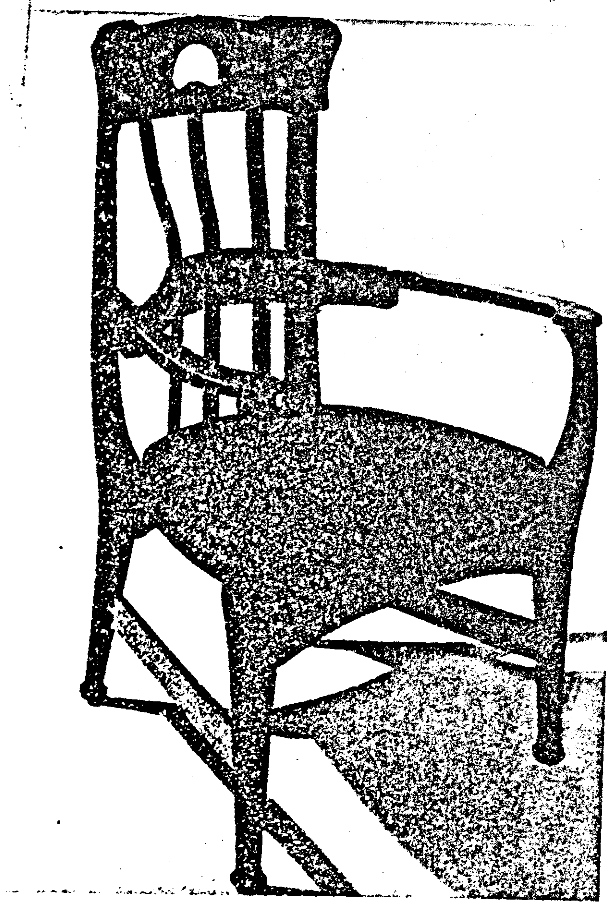
Pl. 12. Exhibition Hall for the Secession, Vienna, 1898, Joseph Olbrich. In: Pevsner, Sources of Modern Architecture and Design, p. 141.



Pl. 13. Postal Savings Bank, Vienna, 1905, Otto Wagner. In: Pevsner, Sources of Modern Architecture and Design, p. 165.



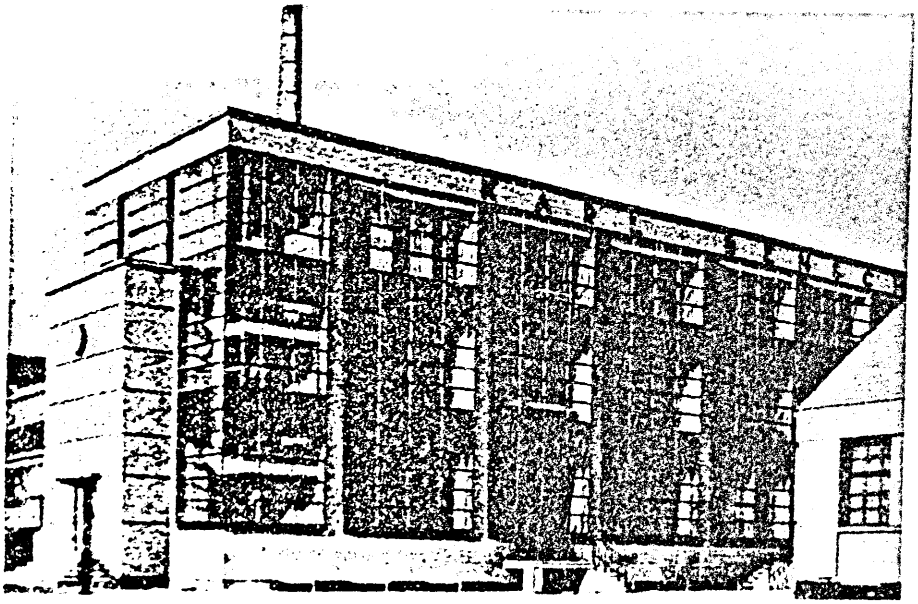
Pl. 14. Side Chair, 1899, Richard Riemerschmid. In: Pevsner, Sources of Modern Architecture and Design, p. 172, no. 170.



Pl. 15. Armchair, 1903, Richard Riemerschmid. In: Pevsner, Sources of Modern Architecture and Design, p. 85, no. 80.

the German Werkbund, established by Hermann Muthesius in 1907. Its aim, as expressed in the statutes, was to "extend its patronage to industrial work by creating a synthesis between art, craftsmen and industry."[9] The German Werkbund was to be highly influencial, and other European countries followed Germany's example; subsequently, the Austrian Werkbund was founded in 1910, the Swiss Werkbund in 1913, and the Design and Industries Association in England in 1915.

In 1911-1916, the Fagus Factory, designed by Walter Gropius (pl. 16), was built. This building, based on cubist principles, was not only the first consistent design of the non-load bearing glass and steel curtain wall construction in Europe, but it also represented the social change that had taken place. It allowed light and visibility, showing the rising concern of the employer with good working conditions, resulting from the growing self-confidence of the laborers. Like Sullivan's buildings in Chicago (pl. 11), the design of the Fagus Factory emphasized functionalism. With the absence of any ornamentation, Gropius' Fagus Factory surpassed Sullivan's buildings in transparency. Gropius characterized the new construction method when he said:



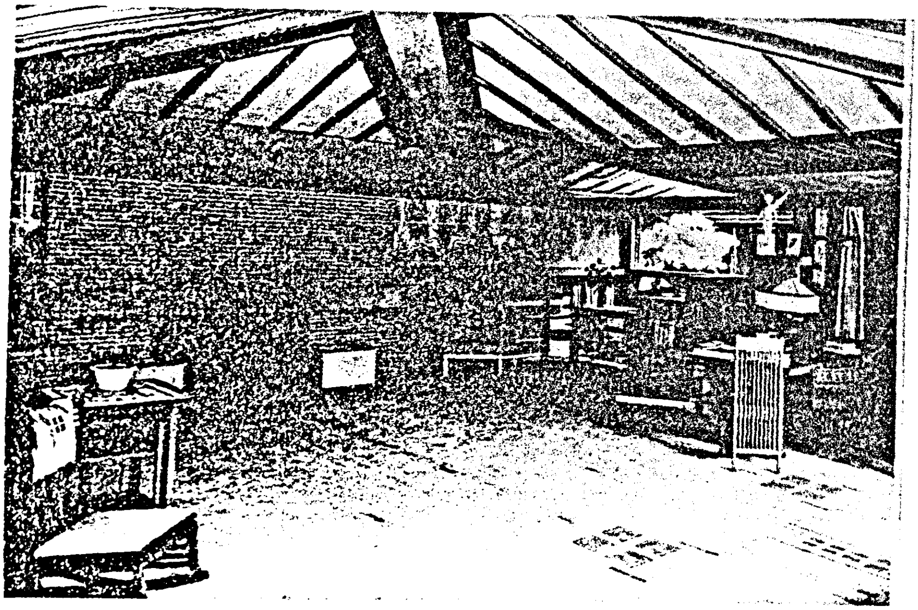
Pl. 16. Fagus Factory, Alfeld and der Leine, Walter Gropius, 1910. In: Pevsner, Sources of Modern Architecture and Design, p. 176.

> The purpose of the wall which is stretched between the supports is now only to keep out rain, cold, and noise. I am enthusiastic about the thought, to achieve the illusion of suspended lightness of the building-mass with the means of the new way of construction.[10]

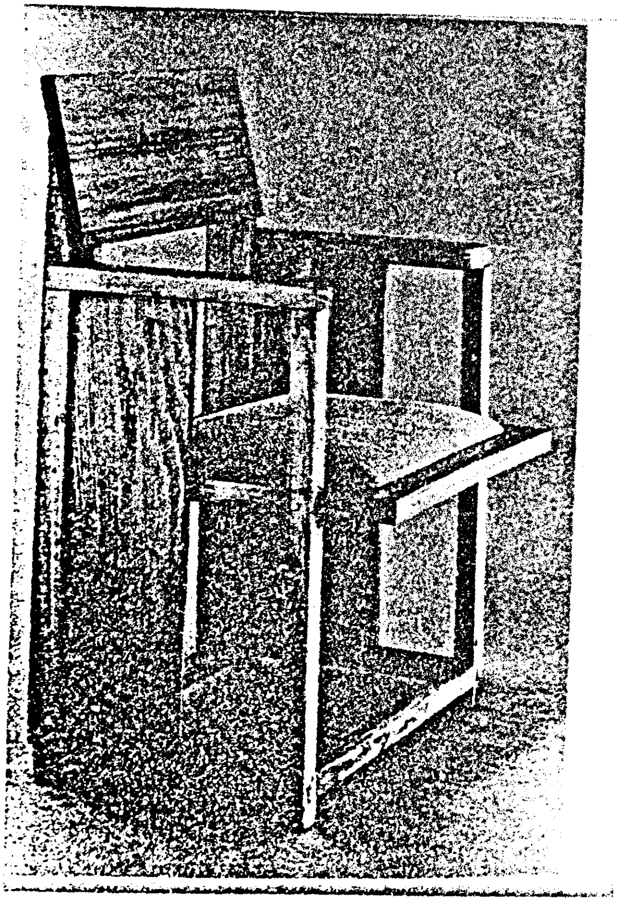
The same criteria of lightness and transparency were to manifest themselves during the following decade, first in wooden, and shortly thereafter in tubular chair design. The development of architecture though, was definitely trend-setting, both in Europe and in the United States, where Frank Lloyd Wright had mostly engaged in designing residental building since 1891. Wright advocated that a building should fit into its natural surroundings, and be designed from inside out, with a new concept of interior spaces freely inter-relating. He demanded simplicity, plasticity of form, continuity of line, and integrity:

> Form and function (thus) become one in design and execution if the nature of materials and method and purpose are all in unison.
>
> This interior space-concept, the first broad integrity is the first great resource. It is also a true basis for general significance of form.[11]

Wright's philosophical approach to new space concepts and his emphasis of unity of form, function and materials created the necessity of new furniture, which he designed himself (pl. 17 and pl. 18).



Pl. 17. Avery Coonley House, Living room, Frank Lloyd Wright, 1908. In: Mang, History of Modern Furniture, p. 89, no. 177.



Pl. 18. Armchair, Frank Lloyd Wright, 1904. Museum of Modern Art, New York. In: Mang, History of Modern Furniture, p. 88.

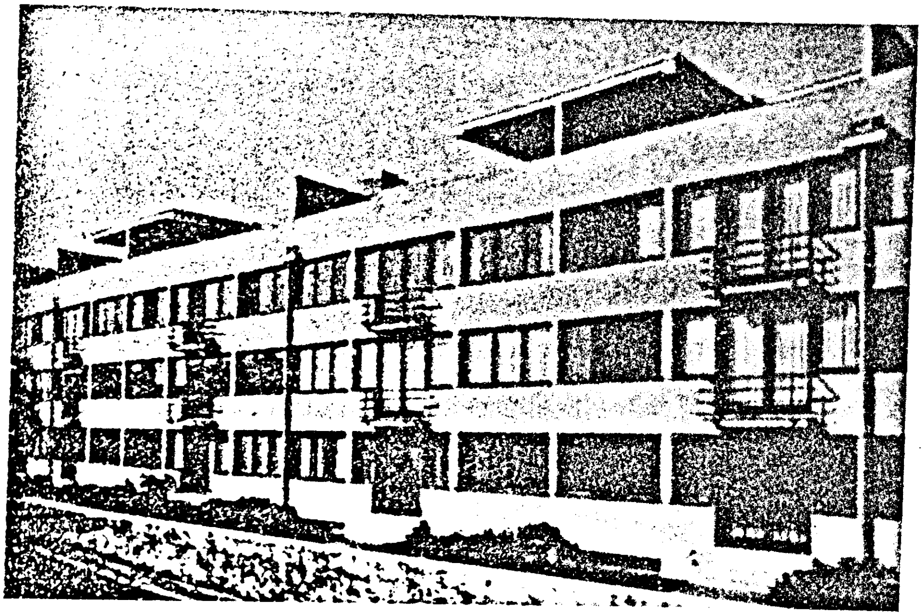
Frank Lloyd Wright's influence was strongly felt in Europe after his works and ideas had been published in 1910. But Cubism has to be regarded as an even stronger catalyst. The impact of Cubism becomes apparent in J. J. P. Oud's design for terraced housing in Scheveningen, Holland, in 1917, and the newly evolved Dutch movement De Stijl (1917). Both cubic shapes and the interrelation of planes become characteristic for architectural as well as interior and furniture design of this movement.

In 1919, Walter Gropius founded the Weimar Bauhaus. The aim of this academy of fine arts and crafts was to re-establish the idea of the "Total Work"[12] by integrating architecture, interiors, art, and products of every-day use. Furniture design in general, and chair design in particular, also became

> . . . bound up with the spatial concept of the new architecture. It is a furniture of "types" not of individual pieces. It is the work, with a few exceptions, of the architects who, at the same time, became the leaders of contemporary buildings.[13]

While the first World War (1914-1918) had interrupted the development of the new approach to design, it also reinforced the social consciousness, particularly in Germany, which had been defeated and needed not only to rebuild its cities, but also its economy. Consequently, the socialist movement and the strength of the labor unions grew rapidly in the 1920s and so accelerated the modernist development by need, as well as by ideology. The building of mass-housing, employing prefabricated architectural elements and reinforced concrete, the mass-production of furniture and other every-day products was promoted.

Both the Bauhaus in Dessau and the German Werkbund tried to set standards in architecture and design. The Werkbund organized exhibitions, such as the 1914 Cologne Exhibition. In projects like the 1927 Weissenhof Housing Project in Stuttgart (pl. 19), also carried out by the Werkbund, it became possible to realize ideas and extend the influence of the Werkbund beyond German borders. This was accomplished by engaging an international group of architects and designers in the architectural as well as furniture design, under the leadership of Ludwig Mies van der Rohe, then vice-president of Werkbund. It was also in this project that the first innovative tubular steel chairs were designed and used by J. J. P. Oud, S. van Ravensteyn, Mies van der Rohe, Marcel Breuer and Mart Stam. All of



Pl. 19. Weissenhof Housing Project, Stuttgart, 1927. In: Heyer, Architects on Architecture, p. 29.

them were architects involved in the interior and exterior design of the Weissenhof Project.

One of the participants in the Weissenhof Housing Project was Charles Edouard Jeanneret, generally known as Le Corbusier. His designs in architecture and furniture were closely related to Cubism. He regarded architecture as having its base in modern technology. His buildings were multiple-view cubic shapes consisting of reinforced concrete and generously spaced window surfaces, always built in consideration of the surroundings. In 1926, he proclaimed the Five Points Toward a new Architecture, in which he advocated:

> The freestanding column, freeing the ground level; the external and internal wall independent of the structural skeleton; the open plan allowing flexibility in the organization of space; the free facade, resulting from these former considerations; the roof garden, positively utilizing all aspects of a building.[14]

Le Corbusier's "New Architecture" demanded furniture which followed similar principles. After using Thonet chairs in his earlier interiors, he began designing furniture himself.

Le Corbusier's belief that the age of the architect was coming[15] was to prove itself in the fact that architects not only became the determinators in the building industry and city planning, but also became trend-setting in furniture design in general and chair design in particular.

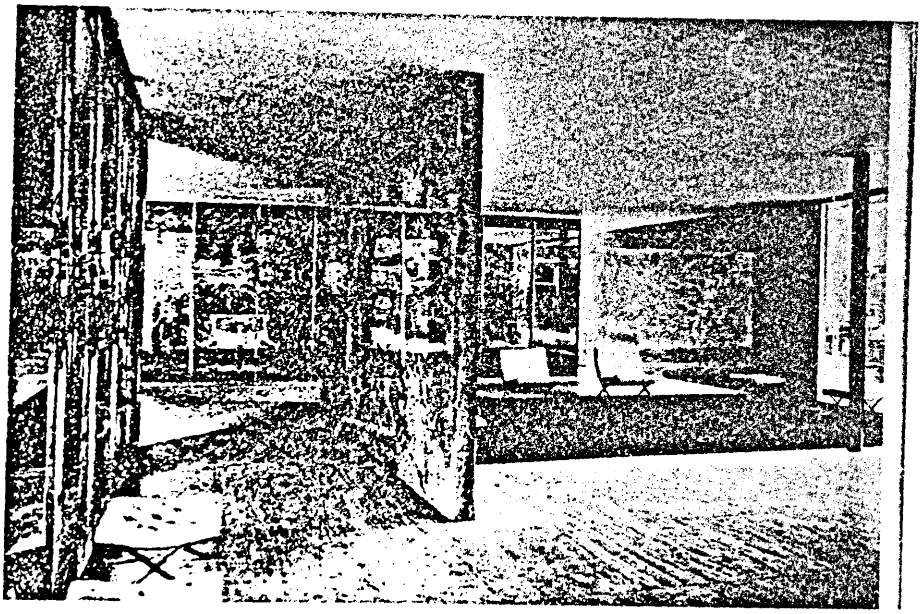
Under Gropius, the Bauhaus moved to Dessau in 1925-1926 into a newly built complex, designed by Gropius, reflecting the influence of Cubism and complying with the Bauhaus Manifesto of 1926, which stated:

> The Bauhaus wants to serve in the development of present-day housing, from the simplest household appliances to the finished dwelling.[16]
> The creation for all standard types for all practical commodities of every-day use is a social necessity . . . . The products reproduced from prototypes that have been developed by the Bauhaus can be offered at a reasonable price only by utilization of all modern, economical methods of standardization (mass-production by industry) and by large-scale sales.[17]

One of the outstanding people who contributed to the new movement in architecture and design was Ludwig Mies van der Rohe. In his

> . . . edict 'Less is More', implying the elimination of the irrelevant, and the disciplined simplicity of the essential--later to be particularly associated with Mies' architecture--came from Behren's office[18]

where he had worked in 1908. This edict also manifested itself in his chair designs. After designing the German Pavillion in Barcelona in 1929 (pl. 20), including the furniture in it, Mies became the director of the Bauhaus



Pl. 20. German Pavilion, World Exhibition, Barcelona, 1929, Ludwig Mies van der Rohe. In: Glaeser, Ludwig Mies van der Rohe, p. 46, no. 47.

in 1930. In his working thesis of 1923, he had written: "Create form out of the nature of the task with the means of our time."[19] One year later, he wrote on Industralized Building:

> I see in industrialization the central problem of building in our time. If we succeed in carrying out this industrialization, the social, economic, technical and also artistic problems will be readily solved.[20]

His statements became apparent in his architectural as well as his furniture design, which achieved its distinction by the highly economical use of high quality materials and their absolute truth to function and to the properties of the materials.

The Development of Metal Chairs between the World Wars

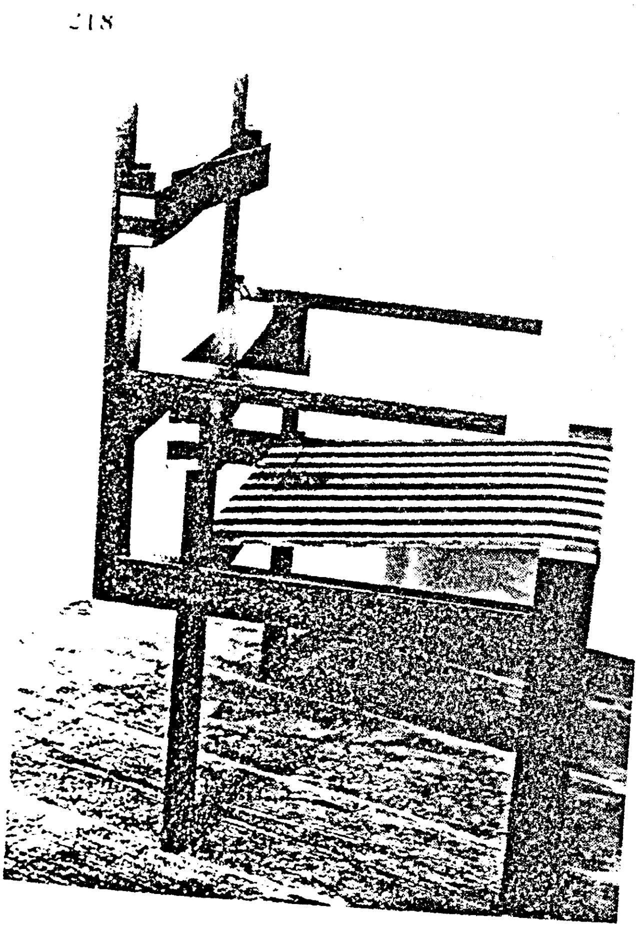
The most avant-garde designs were produced by the various designer organizations of Europe, mentioned previously, with the exception of the mechanized patent chairs of the United States and the early iron and steel chairs of the late nineteenth century. When in the 1920s aesthetics changed in favor of modernism and clear lines, cubic shapes and uninterrupted shapes became the new ideal. The technological development in the field of the iron and steel industry provided the materials for innovative chair design that met the requirements of complementing the new trend in architecture. Members of the Werkbund, as well as the Bauhaus, began to experiment with steel tubes, flat steel and steel rods. In taking advantage of the properties of steel, the tensile strength, resilience, visual lightness and smooth shiny surfaces, they designed a new generation of chairs, which, in retrospect, do not seem to have lost any of their modernism.

Hungarian-born Marcel Breuer became a student of industrial and interior design at the Bauhaus in Weimar, 1920. In 1925, he was made head of the Bauhaus workshop at Dessau Under Gropius.[21]

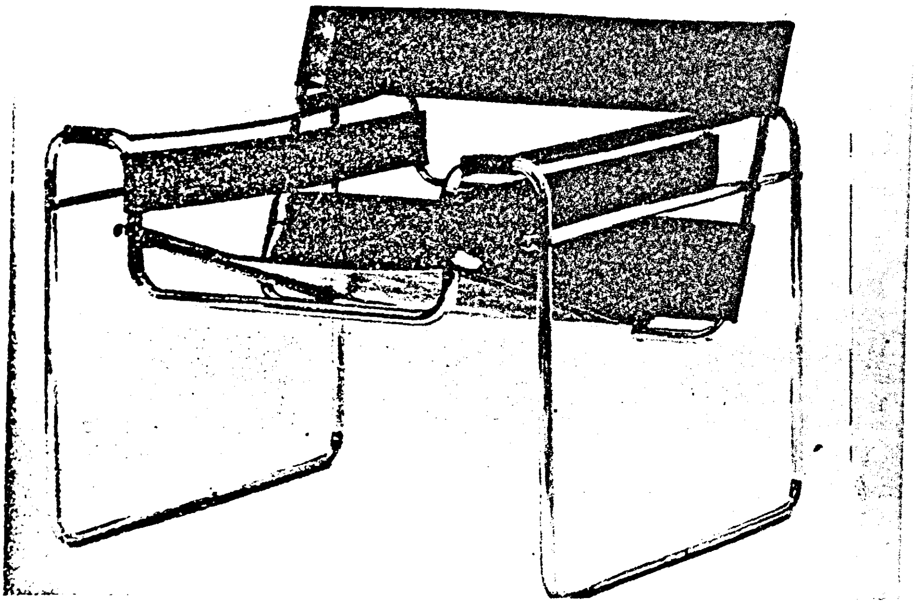
Marcel Breuer had experimented with chair designs since he had joined the Bauhaus. His early attempts in wood (pl. 21), to develop a new chair, slowly led to his innovative tubular steel chair.

In comparison with Breuer's complicated wood structures, with their canvas seats and back rests of 1922, the design of the 1925 Wassily chair (pl. 22) represents a very similar but simplified idea in a new material that emphasized the tendency toward lightness and transparency. Breuer stated:

> The combination of stretched fabric and flexible frame I hoped would make the chair more comfortable to sit on and keep it from looking clumsy. I also tried to achieve a certain transparency of form and along with it an optical as well as physical lightness.[22]



Pl. 21. Armchair, Marcel Breuer, 1922. In: Mang, History of Modern Furniture, p. 107, no. 218.



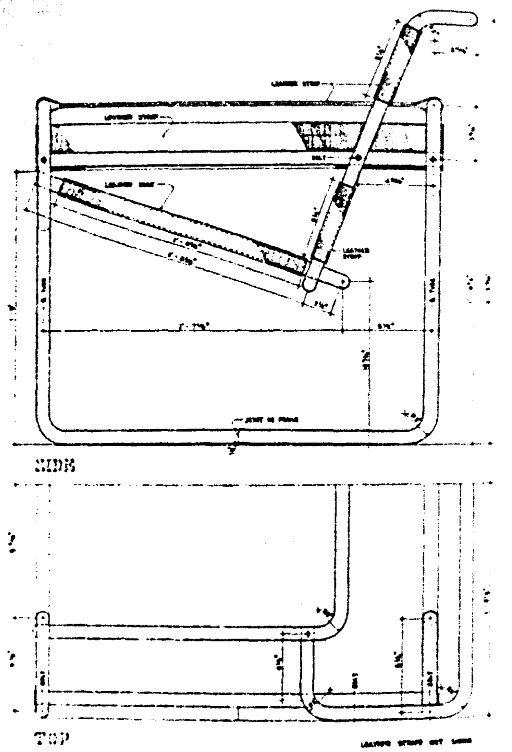
Pl. 22. Wassily Chair, Marcel Breuer, 1925.
In: Meadmore, The Modern Chair, p. 41.

The Wassily chair was Breuer's first tubular steel chair. This, as well as his subsequent designs for tubular steel chairs, were geared toward mass-manufacture. As Breuer said himself:

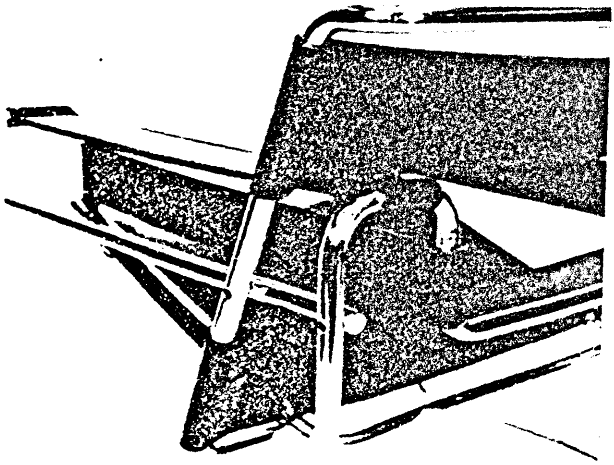
> Mass-production and standardization had already made me interested in polished metal, in shiny and impeccable lines in space as new components for our interiors. I considered such polished and curved lines not only symbolic of our modern technology, but actually technology itself.[23]

Its construction consisted of six elements of bent tubular steel which were bolted together (pl. 23). The main supports were made up of a combination of connected U-shapes. The lateral runners along the bottom were features of design that not only improved the stability and continuity of line, but were also easier on flooring, by distributing the weight along the glide runners. The Wassily chair was not based on resilience of its steel structure, but on the elasticity of the stretched fabric of the seat, back rest, and arms (pl. 24).

The construction of the chair is intricate and complicated, and hardly related anymore to chairs constructed of wood. It appears transparent, since the seat, the arms, and the back are suspended in space, and the supports are not directly attached to any of the planes, forming a solid connection with the ground.



Pl. 23. Wassily Chair, construction drawing. In: Meadmore, The Modern Chair, p. 42.



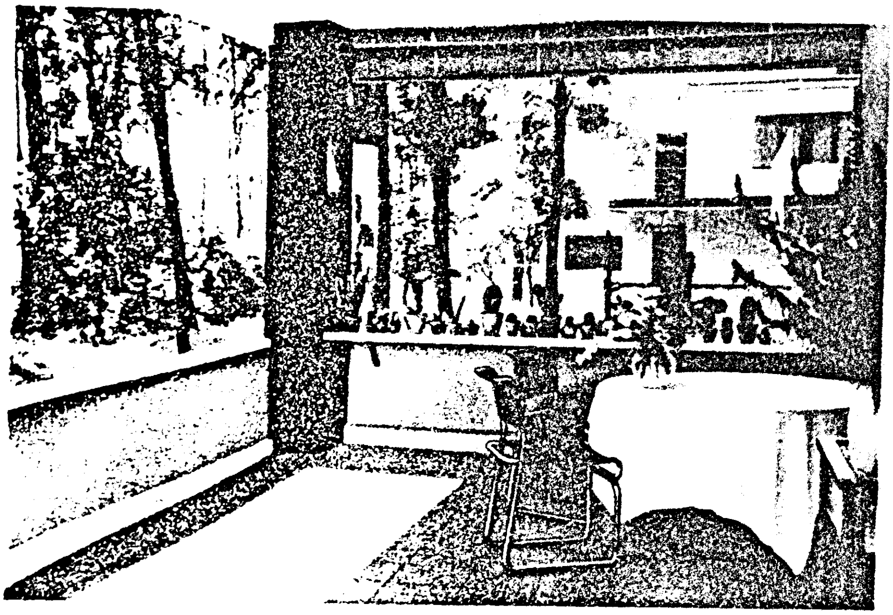
Pl. 24. Wassily Chair, detail. In: Meadmore, The Modern Chair, p. 43.

This effect could only be achieved with steel construction, taking advantage of the strength of cold drawn and cold bent, seamless tubes, particularly the way in which the frame of the back requires high tensile strength in spite of its lightness. The cold drawn, seamless steel tube, developed in the first decades of the 1900s, in comparison with hot rolled tubes, is not only lighter, due to thinner walls, but also has greater tensile strength and a better surface finish. The evenly bent tight curves would hardly have been possible to achieve without the technological advances in the working of steel tubes, such as mandrel bending which prevents the inner surface of the bent tube from collapsing and buckling and the outer surface from breaking under the tension. Breuer developed the Wassily chair outside the Bauhaus workshop. It was first manufactured by Standard Moebel of Berlin, later produced by Thonet and after the Second World War, reproduced by Gavina S. P. A., Milan, an affiliate of Knoll International, New York.

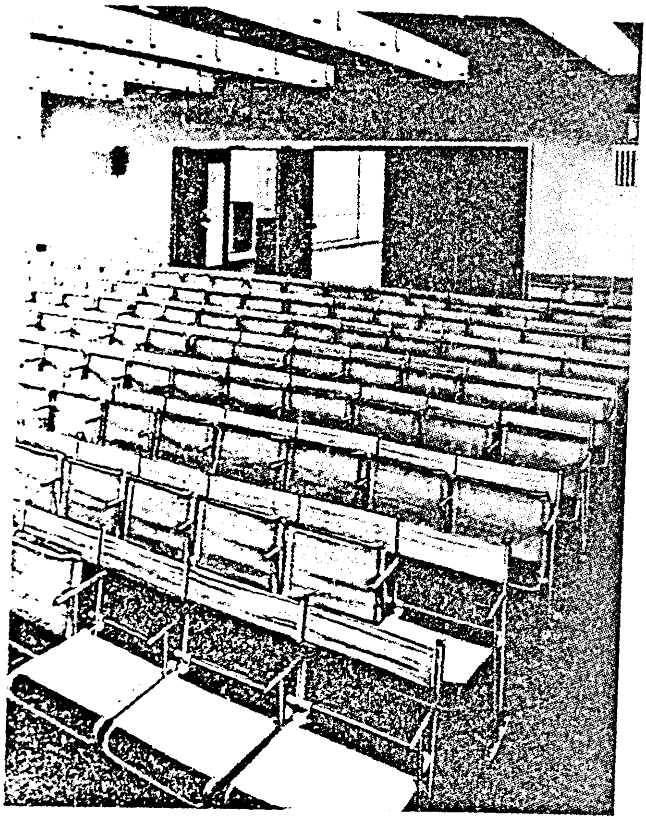
While the steel frame of the Wassily chair was a complicated construction, Breuer's designs of the next year, the 1926 side chair and the chairs for the Bauhuas auditorium were much simpler. They only relate to the construction of traditional wood chairs insofar as the vertical supports of the back rest are extensions of the rear legs, as in most wooden chairs.

In the case of the side chair (pl. 25), Breuer simplified the structural elements considerably. The top rail, the vertical supports in the back, the glide runners, the front legs, and the seat rail in the front are made out of one continuous seamless steel tube. The side rails and the back rail of the frame, over which the canvas seat is stretched, consists of one piece of tubing. This seat frame is connected to the vertical supports in the back and rests with a second seat rail on the seat rail of the supporting element in the front. In this side chair, Breuer achieved an even greater lightness than in the Wassily chair. The trend toward the most simplified lines and the reduction to the absolute essential elements of a chair became obvious.

In the chairs for the Bauhaus auditorium (pl. 26) another of Breuer's design goals becomes apparent: portability. The seat of this chair can be folded up to the back rest and is constructed in a way of cantilever without vertical supports in the front when folded down. The cantilever construction, made possible by the resilience and strength of the steel tubing, enhances the impression of lightness and transparency, as well as the



Pl. 25. Side Chair, Marcel Breuer, 1925-1926, Gropius House, Dessau. In: Mang, History of Modern Furniture, p. 110, no. 226.



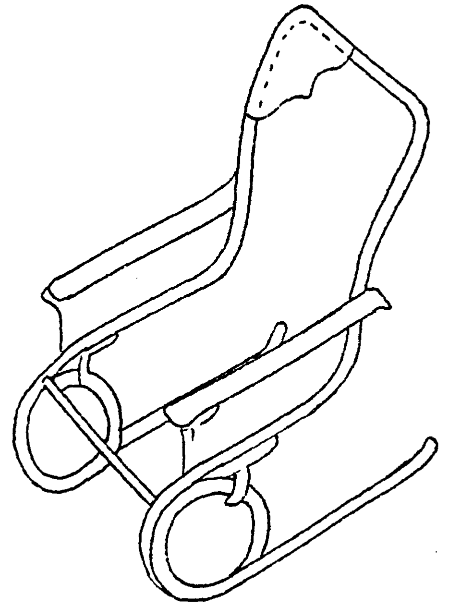
Pl. 26. Auditorium Chairs, Marcel Breuer, 1926, Auditorium of the Dessau Bauhaus. In: Mang, History of Modern Furniture, p. 111, no. 231.

desired effect of mobility and portability. Breuer stated in 1927:

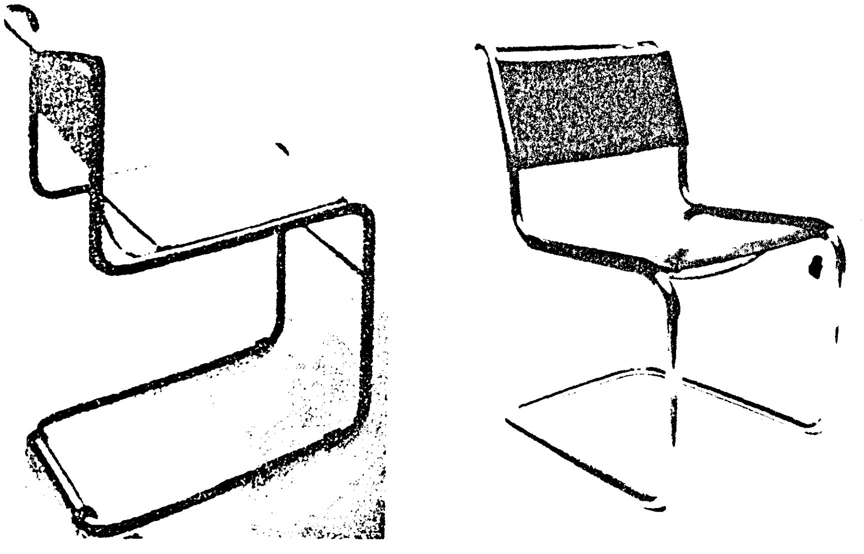
> And so, we have furnishings, rooms, and buildings allowing as much change and as many transpositions and different combinations as possible. The pieces of furniture and even the very walls of a room have ceased to be massive and monumental, ... Instead, they are more opened out, or, so to speak, drawn in space. They hinder neither the movement of the body nor of the eye.[24]

The idea of lightness, transparency, and mobility was carried even further with the development of cantilever chairs. In 1926, Mart Stam and Mies van der Rohe each designed a cantilever chair using a continuous steel tube. The question as to who was the true creator of the idea is hard to answer; the more so since in the United States, a patent was obtained for a resilient cantilever chair in 1922 (pl. 27). The American patent of 1922 was based on the resilience of a spiral on each side beneath the front of the seat, which led directly into the lateral glide runners.

Mart Stam's Sans-Fin chair design (pl. 28) of 1926, which was used in the Weissenhof Housing Project in Stuttgart, though, was not resilient, since he had used a thick heavy gas pipe with steel core linings to support the curves. This thick walled tubing has to be worked while hot and becomes rigid when cooled off. The steel core linings are used to keep the walls of the tube from



Pl. 27. Cantilever Chair,
U. S. Patent.

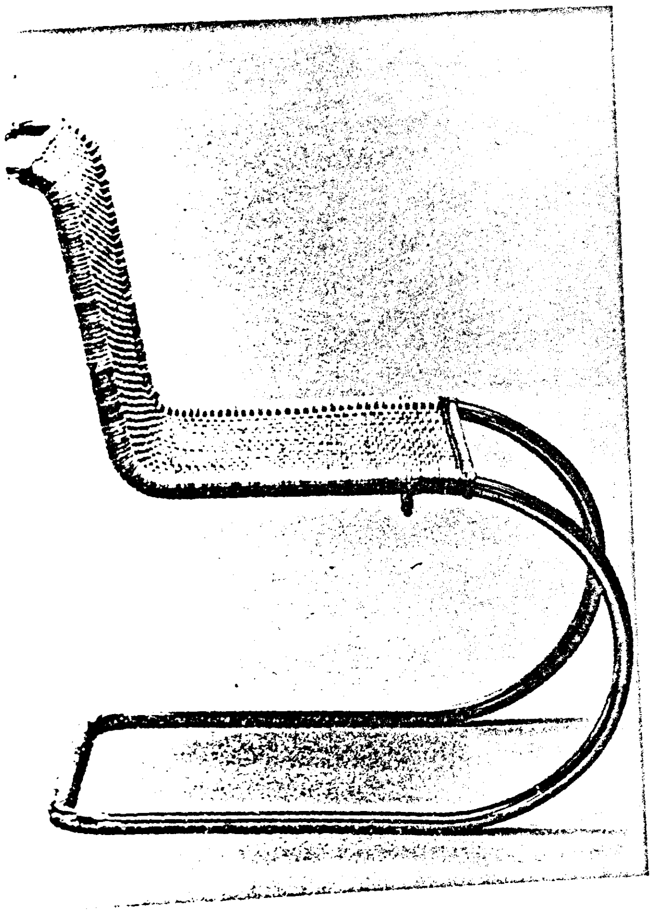


Pl. 28. Cantilever Side Chair, Mart Stam, 1926. In: Meadmore, The Modern Chair, p. 54.

buckling or cracking, when being bent in tight curves, and so insuring the stability of the curves.

Mies van der Rohe's design for his resilient cantilever chair of the same year, 1926 (pl. 29), was supposedly inspired by a sketch of Mart Stam's design. Mies' chair was made from the resilient cold drawn seamless steel tube with emphasized large one-fourth circles on each side of the seat. The entire frame of the chair is made from one continuous steel tube. The seat and the back rest are made from leather, and in the original model, Mies used cane, which is fastened around the lateral horizontal tubes. Due to its resilience, Mies' chair is very comfortable. But unfortunately, it is also quite impractical if intended to be used as a dining chair because of the large one-fourth circles which do not allow it to be drawn close to the table.

In comparing Mies' resilient chair with Stam's chair, it becomes apparent that the properties of the materials used not only cause the two chair designs to differ structurally, but also in sitting quality. In these first cantilever chairs, resilient or not, it also becomes evident that the same construction, built out of wood, would have been impossible at the time. The grain of solid, unmanipulated wood does not allow a

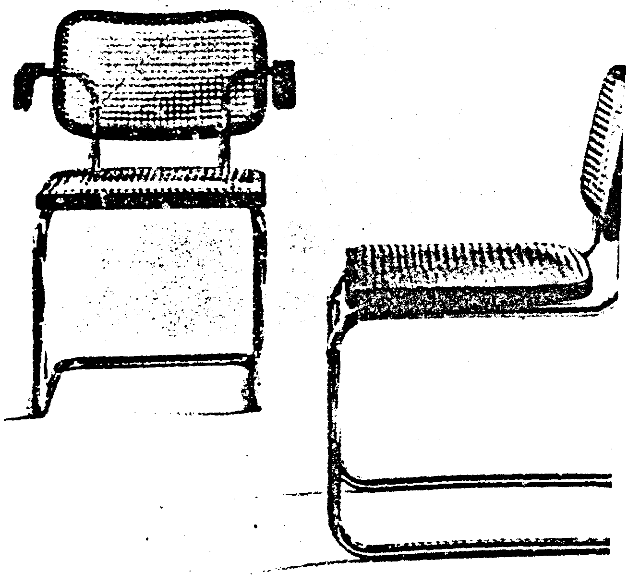


Pl. 29. MR Chair, Mies van der Rohe, 1928. In: Meadmore, The Modern Chair, p. 45.

hovering frame construction, since it cannot withstand the thrust which the weight of the sitter would impose on the structure. The only design and construction method for a bent wooden chair frame similar to the tubular frame can be seen in Michael Thonet's bent-wood chairs, although the thin wood elements could not be solidly constructed as a cantilever chair without intermediate supports between seat and runners. Only after considerable progress in the method of laminating and bending wood did Alvar Aalto successfully design and construct a wooden cantilever chair in 1940.

The first tubular steel chairs, including the innovative cantilever chairs, were shown in the Weissenhof Housing Project in Stuttgart in 1927. Most of the chairs were prototypes and not yet industrially mass-produced, but the idea of tubular, as well as cantilever chairs, was taken up by a number of designers, and the increase of tubular chair designs at the Prague furniture show that spring was notable.

Also, Marcel Breuer came out with a new cantilever dining chair and armchair design (pl. 30), after leaving the Dessau Bauhaus for Berlin in 1928. His new design was bought by the Thonet Brothers and its manufacture started in 1929. Breuer's cantilever dining

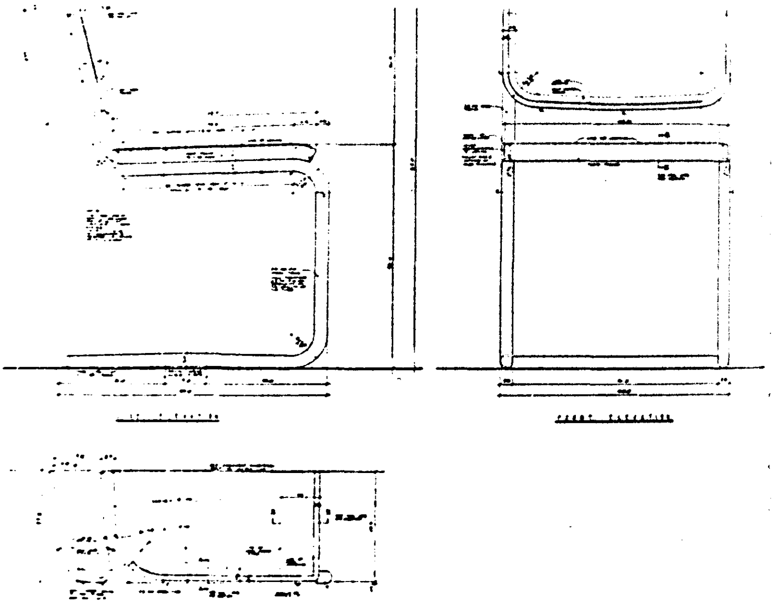


Pl. 30. Cesca Side and armchair, Marcel Breuer, 1928. In: Meadmore, The Modern Chair, p. 53.

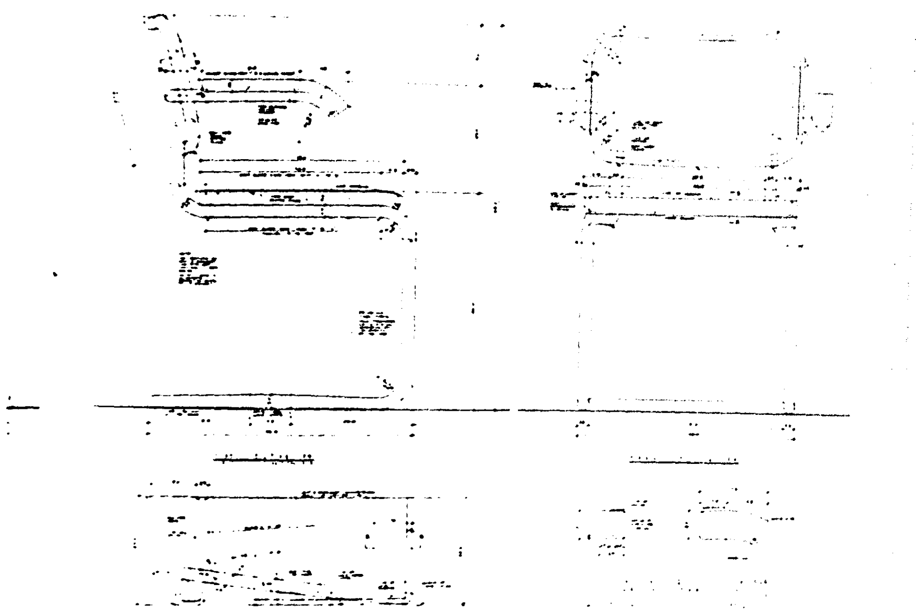
chair is similar to Stam's chair Sans-Fin (pl. 28). The question of the authorship was never satisfactorily answered. According to Hans Wingler, Director of Bauhaus Archive in Berlin, the structure of the frame was Stam's idea, the seat and back Breuer's.[25] Breuer's cantilever chair was made out of cold drawn seamless steel tubes, and was therefore resilient (pl. 31). Its shape is, in comparison to Mies' chair (pl. 29), cubical. The U-shaped base, consisting of runners, merged into straight front legs, which are curved tightly at seat level to become lateral seat rails and then curve again into vertical side supports for the back panel. The seat and the back rest are caned beechwood frames.

The armchair of 1928 (pl. 30) shows basically the same construction (pl. 32) as the dining chair. The arms are developed through an extension of the tubes which curve forward around the sides of the back panel.

Mies was still concerned with the static and stability of the cantilever construction, since he was uncertain of the performance of the material. In comparison, Breuer's design shows in the restraint of its form more familiarity with the resilient steel tubes and the statics in cantilever chair design.

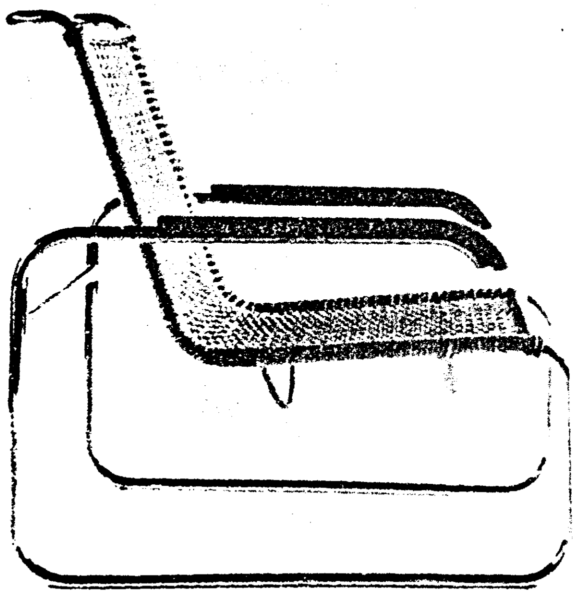


Pl. 31. Cesca, side chair, construction drawing. In: Meadmore, The Modern Chair, p. 54.



Pl. 32. Cesca, armchair, construction drawing. In: Meadmore, <u>The Modern Chair</u>, p. 55.

During the same year, 1928, Breuer designed his Lounge chair (pl. 33). It is structurally related to both the Cesca armchair (pl. 30) and Mies' MR chair (pl. 29). Like the Cesca chair, Breuer's Lounge chair is basically a cubic design. It appears self-contained since the front supports, the runners, and the back supports for the horizontally extending arms describe a rectangular line in side view. The back of the chair and the seat are titled backwards. The lateral seat rails are connected by two curved steel tubes underneath the caning to ensure the necessary stability. The vertical back supports of the arm rests are also connected by a horizontal steel tube just below the upper deflection, behind the back rest of the seat. The main elements of the frame consist of one continuous tube to which the cross stretchers are welded. Taking advantage of the progress of the steel-working technology, Breuer could create a frame structure without the use of any bolts or screws. The smooth, lusterous finish of the chrome-plated, continous steel tube makes an interesting contrast to the textured cane seat and back and the satin finish of the wooden arm rests. Breuer's Lounge chair



Pl. 33. Lounge Chair, Marcel Breuer, 1928. In: Meadmore, The Modern Chair, p. 57.

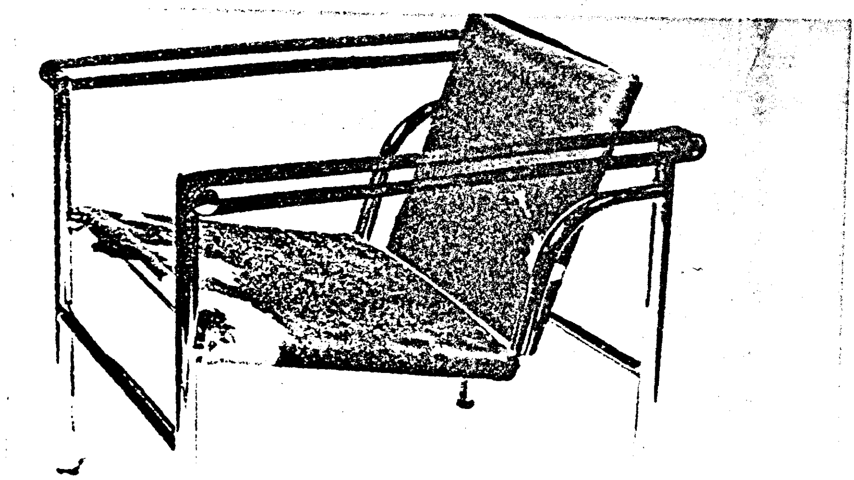
was produced until 1938 by Thonet, and only since 1970 has its production been taken up again.

As mentioned before, the new tubular steel furniture in general and chairs in particular initially evolved out of the functionalistic approach toward architecture and design of the International Style, and the creators of these chair designs were subsequently mostly architects. One of the very ingenious men was Le Corbusier. He only created a few pieces of furniture, the designs of which are characterized by his ideas of interior design and furniture design in relation to industrial society. Le Corbusier wanted his chairs to be regarded as utilitarian objects of everyday life, with a functional beauty aiming at anonymity. As Charles Jencks stated:

> Le Corbusier argued, decoration was being misused by almost everyone: to deceive and flatter, to distract people in their loneliness, to impress social snobs and to camouflage basic mistakes.[26]

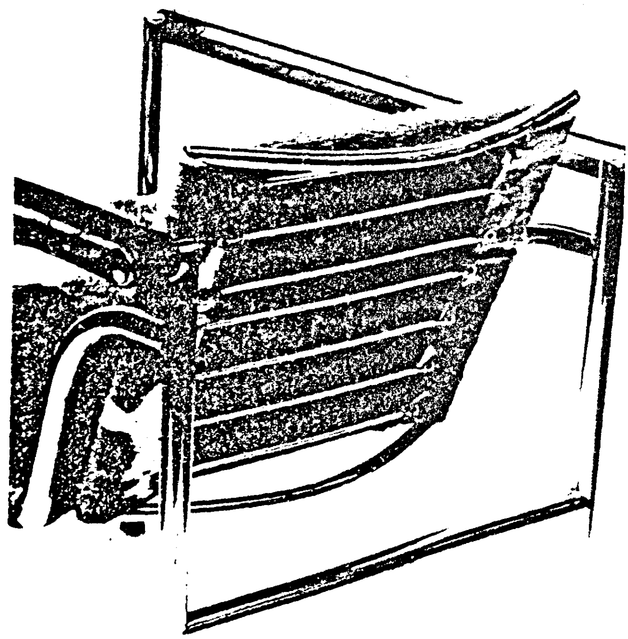
Subsequently, the furniture was to be subordinate to the architectural scheme and was not to interfere with the clear lines of his interior spaces.

In 1928, he designed the Basculant (pl. 34). This chair of chromium-nickel-plated tubular steel, although fairly complicated in construction, shows a design of



Pl. 34. Basculant, Le Corbusier, 1928. In: Meadmore, The Modern Chair, p. 57.

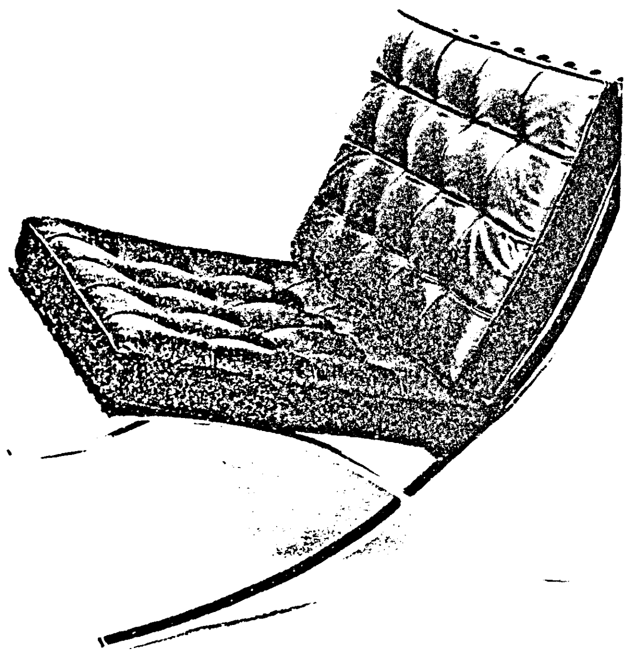
clear, simple lines. Its appearance is cubic, enhanced by the four vertical supports which extend beyond the height of the seat. They also serve as substructure for the arm rests, which consist of leather straps tautly stretched over short, horizontal metal tubes welded to the top of the vertical supports in an outward ninety degree angle. The seat and the back rest of calf skin seems enclosed between the four verticals. The two lateral steel tubes of the back rest pivot on a horizontal axis resting at two points in the bent tubes of the frame (pl. 35). The overall impression of Le Corbusier's Basculant is one of lightness and mobility. With the seat and back suspended in a solid frame, the Basulant is entirely in accordance with Le Corbusier's statement describing a chair as a machine for sitting, advocating that in architecture and design, the time of the engineer had come. In the Basculant, Le Corbusier did not take advantage of all the properties of cold drawn seamless steel tubes. Although he employed electric arc welding for the joints and, as in the seat construction of the Basculant, used the high tensile strength of the cold drawn steel tubes, he did not base his design on resilience as did Breuer, Stam, and Mies van der Rohe.



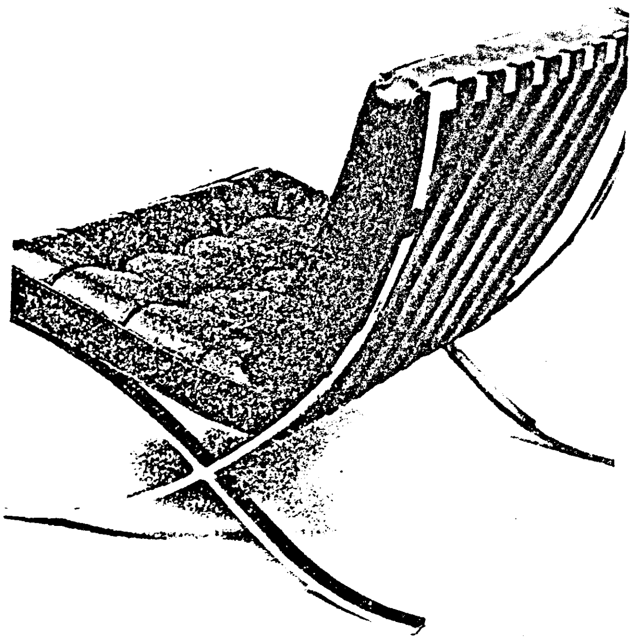
Pl. 35. Basculant, detail. In: Meadmore, The Modern Chair, p. 63.

When, in 1929, Mies van der Rohe was commissioned to design the German Pavilion for the World Exhibition in Barcelona (pl. 20), Mies also created a new type of steel chair made of flat steel bars.

The so-called Barcelona (pl. 36), a chair which was supposed to have enough dignity "to receive a king, a dictator, or an ambassador,"[27] could hardly be surpassed in elegance of line or sophisticated simplicity of construction. The double X-shaped frame consists of chrome-plated, flat steel bars, which are connected by electric arc welding at the point of section, and three solid traverse bars used as seat rails in the front and back and as top rail. The leather cushions rest on leather straps (nine for the seat, eight for the back), which are tapped and screwed into the inner edges of the traverse bars (pl. 37). The entire steel frame has a mirror finish. (Today it is produced out of stainless steel by Knoll International.) The concave curve of the lateral front legs and back supports and the soft S-curve crossing it at an obtuse angle, only connected at the two sections, could not have been manufactured without the use of the new technology in electric arc welding. The Barcelona is generously proportioned.



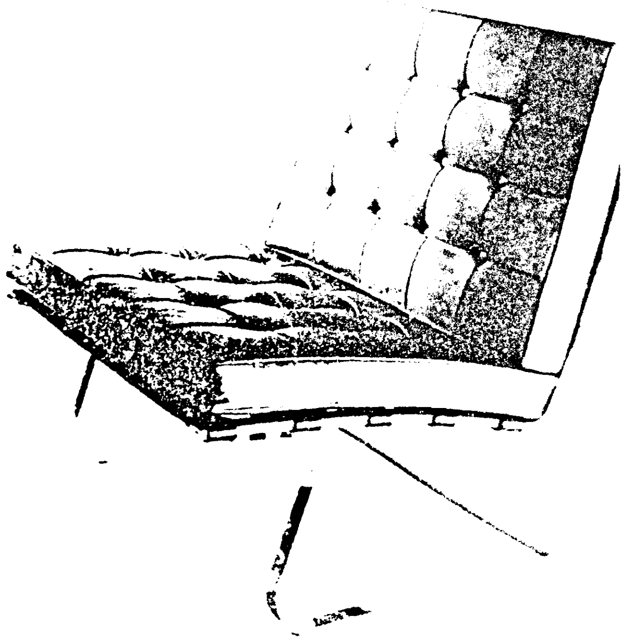
Pl. 36. Barcelona Chair, Mies van der Rohe, 1929. In: Meadmore, The Modern Chair, p. 73.



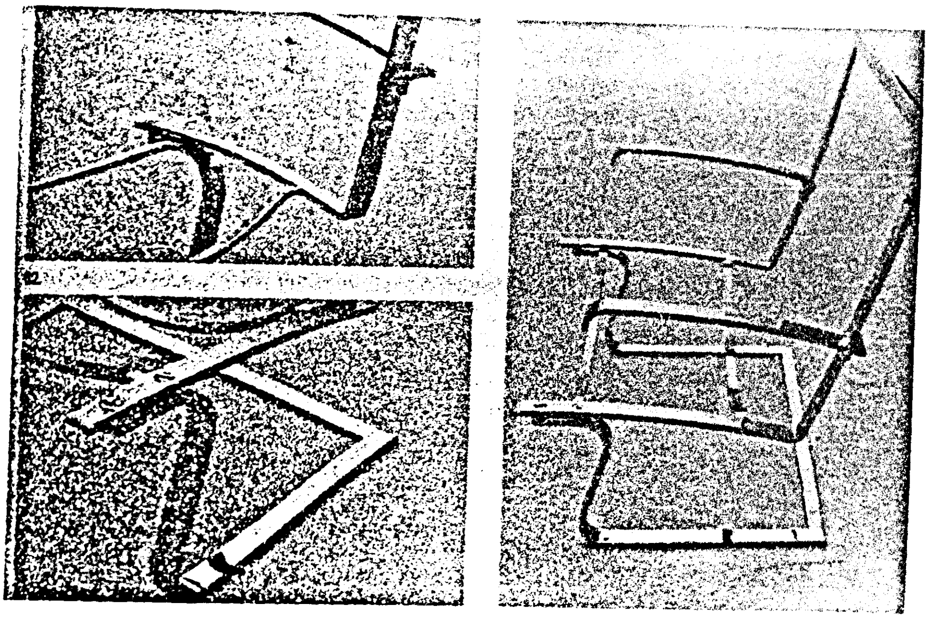
Pl. 37. Barcelona Chair, detail. In: Meadmore, The Modern Chair, p. 74.

Even though the frame only consists of seven pieces, it is very heavy by virtue of the thickness of the solid steel bars. The perfection of this design and its simplicity of line result in an understated elegance, which is in total congruity with Mies' advocacy of balance in design and precision in detail. It is also in accord with the postulates of the International Style of Mies' architecture.

During the same year, Mies designed two cantilever chairs for the Tugendhat House in Brno, Czechozlovakia. The so-called Tugendhat chair (pl. 38) is like the Barcelona, made from flat steel bars (pl. 39). The frame of the seat consists of two lateral bars which are bent in a ninety degree angle, a top rail and two bent stiffening rods underneath the seat. The arm rests are screwed to the lateral uprising back rests. The cantilever support of the chair is attached at the front ends of siderails with two screws on each side. It swings back in nearly vertical S-like curves, which extend into glide runners and are terminated by a flat floor bar. The leather cushions rest on leather straps, which are looped around the siderails and backposts, fastened and tightened by belt-buckles. All steel bars are chrome-plated and have a mirror finish. The tight ninety degree



Pl. 38. Tugendhat Chair, Mies van der Rohe, 1929-1930. In: Meadmore, The Modern Chair, p. 77.



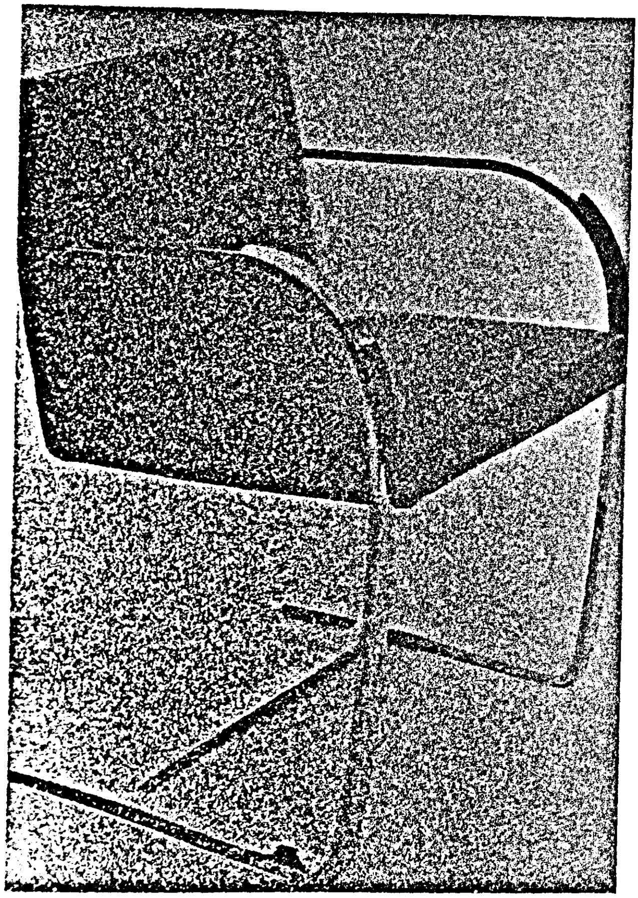
Pl. 39. Tugendhat Chair, frame, details. In: Glaeser, Ludwig Mies Van der Rohe, p. 57, no. 62-64.

angle curve of the lateral steel bars of the seat and back could only have the necessary solidity because Mies used cold rolled steel bars for the construction of his chair. The same is true for the resilient cantilever substructure.

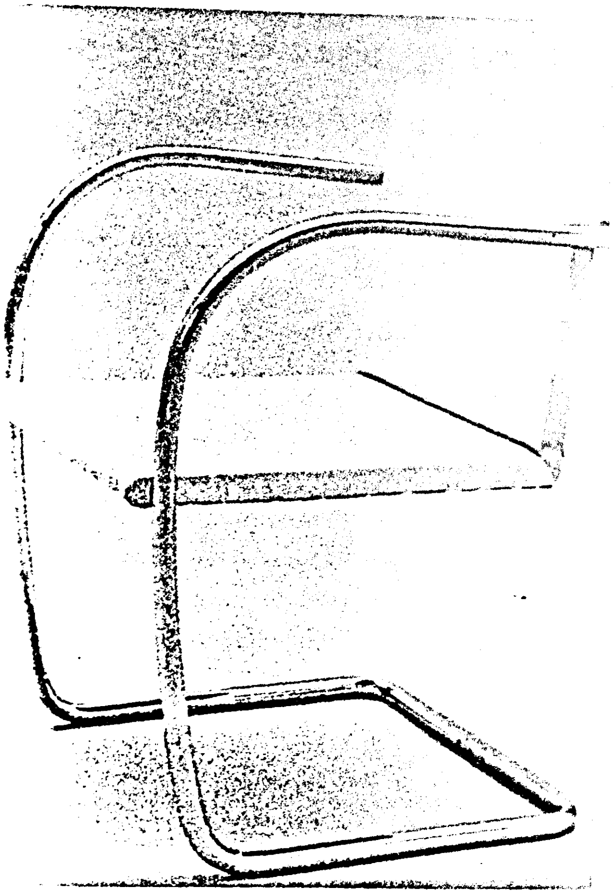
The Brno chair of 1930 (pl. 40), also made of chrome-plated steel, is reminiscent of the 1926 MR chair (pl. 29). The Brno chair was executed in two versions; one out of flat steel bars, for Mrs. Tugendhat's bedroom; the other out of steel tubes (pl. 41) for the coffee table behind the dining area of the Tugendhat House.[28]

The Brno chair of flat steel bars (pl. 40), consists of a supporting cantilever steel frame and a wooden seat and back construction, which is screwed to the attached angles of the steel frame. The steel structure is composed of two side elements, forming the arm rests, arm stumps, vertical front supports and glide runners, and a spacer between the runners.

The tubular version of the Brno chair (pl. 41) shows more flowing lines in its continuous chrome-plated steel tubing, which encloses the back rest of the chair and repeats this line in the floor bar determining the glide runners. The tubing is made out of two sections connected by dowels and screws. The wood



Pl. 40. Brno Chair, flat steel, Mies van der Rohe, 1929-1930. In: Meadmore, The Modern Chair, p. 80.



Pl. 41. Brno Chair, tubular steel, Mies van der Rohe, 1929-1930. In: Glaeser, Ludwig Mies van der Rohe, p. 63.

construction of the seat and back is attached to the steel frame by iron angles and metal studs which project from the frame.

In comparison with Mies' MR chair (pl. 29) and Barcelona chair (pl. 26), the Brno appears more self-contained. The relation between the seat and the mirror-finished steel frame enhances the strongly defined lines of the design. Mies' Brno chair lacks any unnecessary curves. Instead, it employs all the possibilities of the material in such an economical manner that functionalism and elegance form an effortless alliance.

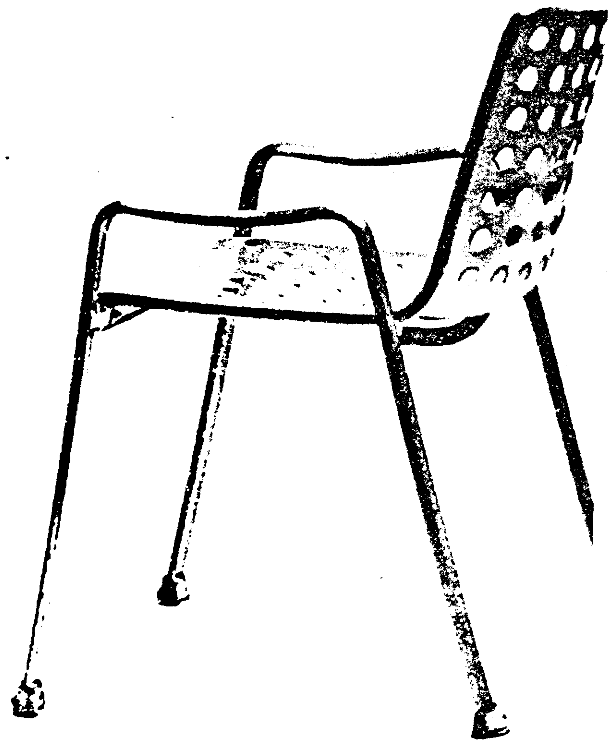
With the advent of the Nazi Regime, the atmosphere in Germany became less and less bearable for a great number of designers and architects. In 1932, the Bauhaus was moved to Berlin under its director Mies van der Rohe, and was closed down in 1933 by the Nazis. Marcel Breuer, Walter Gropius, Ludwig Mies van der Rohe, and many others emigrated to the United States, where they were welcomed as teachers at various universities.

Due to the limitations the Nazi Regime imposed on the designers and architects in Europe through the following years and the destruction of the industry in most European countries during World War II, the design centers, Germany and France, lost their dominating positions.

Only few new relevant chair designs for metal chairs were developed between 1935 and 1945. The most outstanding, and later most influential, example of that period was Hans Coray's Landi chair, which he designed in 1938 for the Swiss National Exhibition in Zuerich.

Coray used two varieties of aluminium for his Landi chair (pl. 42), taking advantage of the latest progress of aluminium processing technology. The Landi chair was the first chair made entirely from aluminium. The perforated seat and back of the Landi consists of an aluminium shell, cast of an aluminium that was made strong and resilient by means of heat and chemical hardening treatments, also resulting in a crystalline surface finish. This aluminium shell was screwed to the supporting substructure, which was made from a differently treated aluminium to ensure the necessary rigidity of the legs. It was produced by P. & W. Blattmann in 1930.[29]

The idea of a shell instead of a separate seat and back was later taken up by Scandinavian designers as



Pl. 42. Landi chair, Hans Coray, 1938. In: Meadmore, <u>The Modern Chair</u>, p. 97.

Aalto, Jacobson, and Sarrinen, who applied it to their molded wood and plastic chairs.

The Technological Aspect of Metal Chairs in Relation to Industry and Design after World War II

The center of post-war metal chair design developed in the United States, the country in which a great number of leading European designers had found refuge during the 1930s.

The American metal industry had made enormous progress in the development of new steels during World War II. As Fisher says in his book The Epic of Steel:

> If the War (World War I) did not signalize any revolutionary metallurgical developments, it did affect the commercial status of alloy-steels by bringing into production many varieties whose compositions were known (often since the nineteenth century) but had been manufactured previously only in moderate amounts. By the end of the war, the steel industry was in a position to produce a wide variety of alloy-steels in quality and quantity unavailable on the market before the conflict."[30]

In order to reduce production cost as well as the weight of carbon steel, metallurgists in the United States and Europe began to further the development of alloy-steels, using various alloying elements to increase tensile strength. They also developed high-strength low-alloy steels with a higher corrosion resistance than carbon steel in 1934 (United States Steel Corporation).[31]

Contrary to the European steel industry, the American steel mills and manufacturing companies were not forced to interrupt production either after World War I or World War II and were able to adjust quickly to peace-time needs. During World War II, due to the blockade of the import of raw-materials, particularly alloying elements (nickel, chromium, molybdenum, etc.) needed for the alloy-steel production, the Alloy Technical Committee was forced to find alternative methods in order to meet the demand of the weapon industry. These alternative methods were based on earlier research which resulted in the fact that only small amounts of alloying elements, when combined with heat treatments of the alloy-steel, produced as good a quality of alloy-steel as when larger amounts of alloying elements were used.[32]

The production of carbon steel as well as alloy-steels had to keep up with the increase in demand during and after World War II. The steel consuming industries, such as the automobile and transportation industries, the building and home appliances industry and the furniture industry not only had to be provided with the required quantity and quality of carbon and alloy-steels, but also with the appropriate technology for the coating of steel to achieve the desired surface finish and for the joining of metal elements. Like the transportation industry, the metal furniture industry was interested in the production of seamless tubes, bars, and sheets of alloy-steels. The reduction of weight, along with the increase of strength and toughness, made the new alloy-steels a desirable material for chairs. With the tightening supply and advanced cost of aluminium, the corrosion-resistant alloy-steels became particularly important for the manufacture of furniture. Yet, a great number of chair models were, and still are, manufactured of the heavier carbon steel which is usually coated with chrome, nickel or plastic. Somewhat later, a number of chair substructures were made from cast aluminium.

With the improvements of the materials, the technology of the various finishes also made some progress. Chrome and nickel plating was already in use during the 1930s. The plating process, though, was further mechanized and the electrolytic process was introduced in the late 1930s. While before the electrolytic process the steel elements were put through a hot-dip, in which a relatively thick layer of melted coating was applied, usually not quite evenly, the advantage of electro-plating was the decrease in the amount of the plating-metal needed and that a uniform, even coat could be guaranteed.

After the development of various types of plastics, the steel elements of chairs were often protected by a plastic coating. Usually the relatively hard and smooth vinyl was used for this purpose, since it is resistant to wear, abrasion and most chemicals. Vinyl-coated steels were introduced in 1954 by the Hood Rubber Company, a division of the B. F. Goodrich Company.[33] The lamination of steel and vinyl is extraordinarily strong. The vinyl was bonded to the steel under heat and pressure.

By 1959, the United States Steel Company had developed yet another bonding process, in which liquid vinyl was evenly distributed over cold-rolled steel in a continuous process.[34] These vinyl coated steel elements lend themselves very well for use in chair design.

Aside from the various innovative materials and technologies of finishing, new techniques in joining had been developed. Generally the elements of the chairs had been bolted or screwed to each other, or they were welded together by oxy-gas welding. This is a process "in which a jet of coal-gas, . . . is burnt in another jet of pure oxygen . . . .[35] The development of electrical resistance welding and electric arc welding, improved metal products in general and metal chairs in particular, since the flow of designs was no longer interrupted by screws, bolts, and rivets. The various welding methods are still used. The welding method to be applied depends on the thickness of the metal, the place of the joint, and the finish demanded in the design. Electric resistance welding can be applied in three different ways: as spot welding

> . . . in which fusion is limited to small areas; pieces being welded are pressed together between a pair of water cooled electrodes through which electric current passes during a very short interval so that fusion results over small areas at the interface of the pieces.[36]

as flash welding in which

> the parts to be joined are clamped together between electrodes and a heavy current passed through them. The heat may be generated either by the electrical resistance of the metals or by an arc flashing between them. In both cases the effect is to melt the tubes together where they touch.[37]

and as electric seam welding in which "the electrodes take the form of wheels between which the sheets are slowly passed."[38] Electric arc welding has the advantage of creating narrow joints requiring less finishing work. It is done by generating heat with an electric arc "formed between the welding electrode and the metals being joined."[39]

The above decribed joining methods, though, are sometimes undesirable as in the joining of light alloys. In these instances, adhesives consisting of synthetic resins are used.

The availability of the new materials and the progress of the innovative manufacturing technology greatly furthered the mass-production of furniture. The technological progress made during war-time production of military equipment and in the fast growing automobile and transportation industries was utilized in the furniture industry and served to advance chair design to a great extent. The purely functional designs, developed in the transportation industry in particular, offered inspiration to chair designers, not only in terms of materials and construction, but also in terms of innovative method of upholstery. Especially in the case of chairs consisting of a substructure and a metal seat shell, it was important for the sitting conform to employ new ways of upholstering that did not interfere with the clean lines and shapes of the designs.

The Development of Metal Chair Design after World War II

The Scandinavian countries, not affected by the social upheavals before World War II nor directly involved in the War, became the new center for very functional and economical furniture design. These pieces were greatly influenced by the Scandinavian woodworking tradition and the Bauhaus ideas of the Neue Sachlichkeit. The material used was mainly wood since its availability guaranteed inexpensiveness and the traditionally established wood furniture manufacturing industry promised quality of production. With the help of a new technology in various production processes, designs, formerly impossible to be carried out in wood, could now be realized. The new technology in wood processing later became influential in the designs of plastic furniture.

The designs from Scandinavia were well accepted in the United States, and rather more popular than the Bauhaus designs, since the trend in Scandinavian designs was in conformity with the consumer demand for so-called "organic furniture".

While Central Europe was recovering from the destruction of the war, the International Style was brought to a peak in the United States and returned back to the European Continent. After the process of rebuilding was mostly finished at the end of the 1950s the International Style lost its impetus in Europe and was succeeded by a fast growing influence which originated in Italy.

Italian architects and designers had not been totally suppressed by Fascism and subsequently were able to continue with the development of modern furniture design. Their new approach resulted in sculptural designs, which were often contrary to the total functionalism of the International Style. This movement, characterized by good designs of strong individualism and originality had great influence in Europe and the United States throughout the 1960s and early 1970s.

The production of chair frames, at the time of Breuer's and Mies' activities in Europe, still relying to a great extent on handwork, was now mechanized in most stages of the manufacturing process. The use of better machinery in the sheet metal, metal bar, and metal tube production and the use of dies for molding and stamping sheet metal into seat shells simplified and sped up the manufacture, and subsequently, lowered the production cost of some chair designs. In the United States, the Herman Miller Company and Knoll

International began the manufacture of metal furniture, supporting and encouraging new, original designs, while emphasizing the high quality of their products.

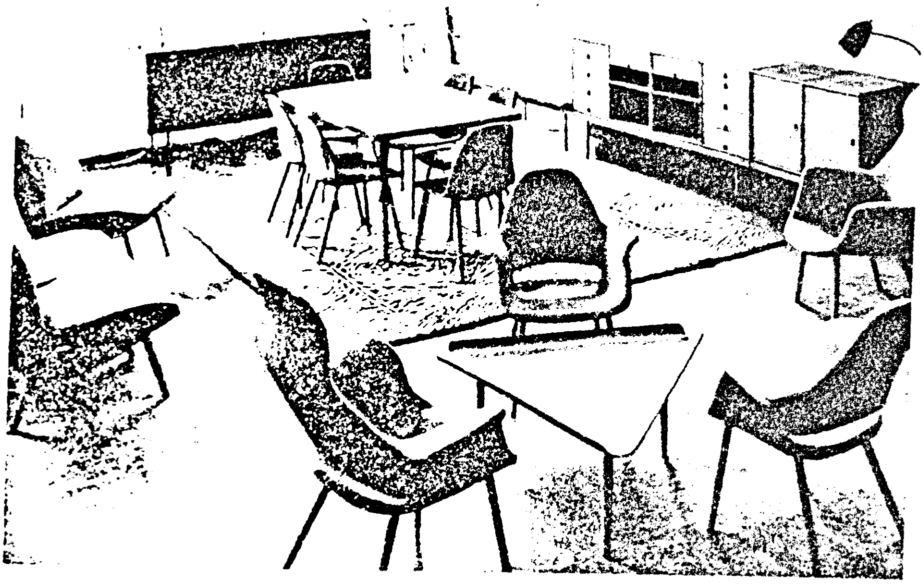
The Herman Miller Company, founded in 1905 in a small town near Grand Rapids, Michigan, began to manufacture only modern furniture in 1937 and became one of the leading producers of modern furniture. In 1946, George Nelson, an architect and designer, was appointed Design Director of the Herman Miller Company. According to his description, the principles of the company were:

1) What you do is the important thing
2) Design is an integral part of business
3) The product must be honest
4) You decide what you want to produce
5) There is a market for good design.[40]

To ensure high quality of design, material, and workmanship, Nelson enforced these principles, and the Miller Company experimented with their materials and tested various production processed extensively. As a result of the close collaboration of manufacturer and designer, which became trend-setting in the furniture industry, the products of the Miller Company distinguished themselves through their high-quality.

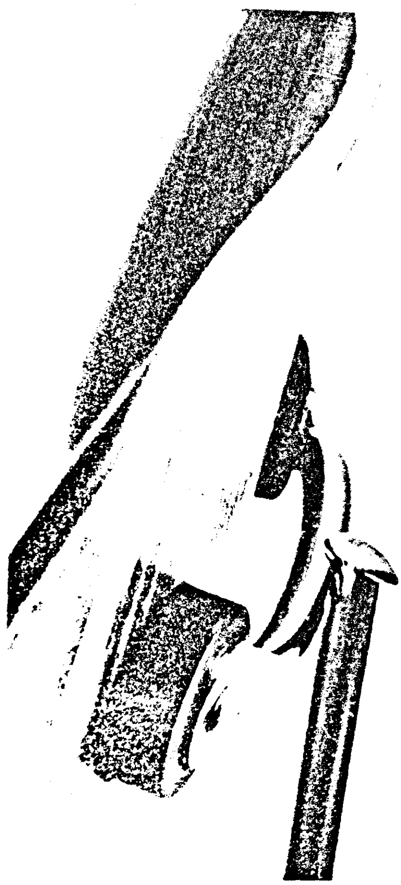
Charles Eames and Eero Saarinen were two architect-designers of the new generation, after Breuer and Mies. In 1941, they won the award of the Museum of Modern Art in New York for their seating and living room furniture (pl. 43) in a competition entitled "Organic Design". Charles Eames continued designing chairs and worked closely with the Herman Miller Company.

In 1946, Charles Eames' "LCM" chair (pl. 44), designed in 1944, was brought on the market by the Herman Miller Company. The molded seat and back panel of the chair are attached to a chrome-plated steel tube frame. This frame consists of two U-shaped elements for the front and back legs, an axle-like tube extending in a seventy degree angle upwards to hold the bow of the back panel and to connect the U-shaped tubes centrally by three electric-resistance welds. The back panel as well as the seat are screwed to the frame through a nut, embedded in circular rubber pads, or shockmounts, which are bonded to the molded plywood (pl. 45). In order to prevent the metal legs from scratching the floor, Eames at first capped them with rubber tips, which were later exchanged for permanent self-leveling nylon glides.[41] To achieve high comfort for the sitter, the seat of the chair is tilted as result of the difference in the height of the legs. The form of the plywood seat



Pl. 43. Living room for Organic Design Competition, Charles Eames and Eero Saarinen, 1941. In: Drexler, Charles Eames, p. 4.

Pl. 44. LCM Chair, Charles Eames, 1944. In: Drexler, _Charles Eames_, p. 24.



Pl. 45. LCM Chair, detail.
In: Drexler, Charles Eames, p. 24.

and back was designed according to the anatomical requirements of the human body in a sitting position.

The Herman Miller Company had invested much effort into developing the best method to produce the three-dimensional, molded plywood seat and back of the highest possible quality. Clement Meadmore stated that the LCM chair "was, both technologically and in its design, an exceedingly advanced chair" and called it "the very best in post-war design."[42] The LCM chair is characterized by high flexibility, transparency in design, and physical lightness. These properties are derived from the resilient tubular support of the back rest, the vulcanized rubber shockmounts, and the shape of the thin, molded plywood panels. The LCM chair is still considered to be the most typically American chair Eames designed. The hardware and mechanical elements are plainly visible, the construction is simple and logical and meets the requirements of functionalism and practicality. Eames' approach to the problems of chair design was described in his statement

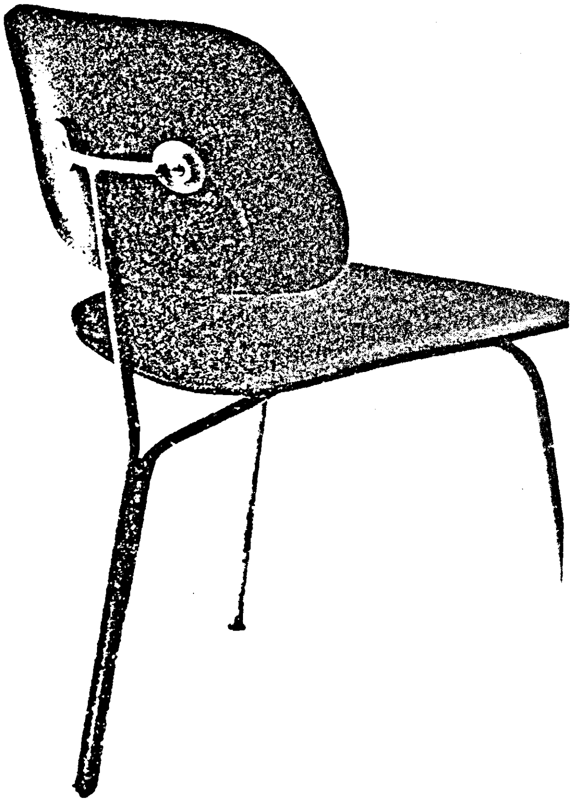
> that there is an inherent good in making the greatest use of the least amounts of material. It achieves its purpose by separating functions and defining them in the narrowest possible way, so that each will require a specific shape and material; . . . .[43]

During 1944, Eames designed a number of chairs which never went into production. He created two three-legged chairs (pl. 46 and pl. 47), much like the LCM chair (pl. 44) as far as the construction and form of the seat and back panel were concerned. He also created chairs with the projecting additional rear leg (pl. 48 and pl. 49), which allowed the sitter to tilt his chair back until the additional leg rested on the ground, much like a rocking chair, though more stable, more controllable.

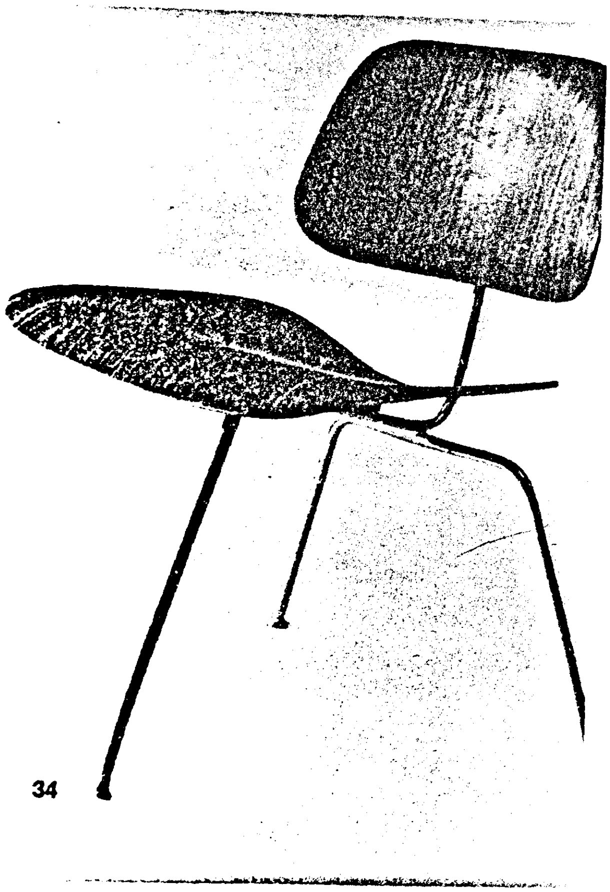
In 1948, the Museum of Modern Art in New York conducted the "International Competition for Low-Cost Furniture Design." Eames' entry made use of inexpensive sheet metal stamped in the shape of a shell (pl. 50). In the accompanying writing, Eames explained:

> Metal stamping is the technique synonymous with mass-production in this country, yet acceptable furniture in this material is noticably absent . . . . By using forms that reflect the positive nature of the stamping technique in combination with a surface treatment that cuts down on heat transfer, dampens sound, and is pleasant to the touch, we feel it is possible to free metal furniture of the negative bias from which it has suffered.[44]

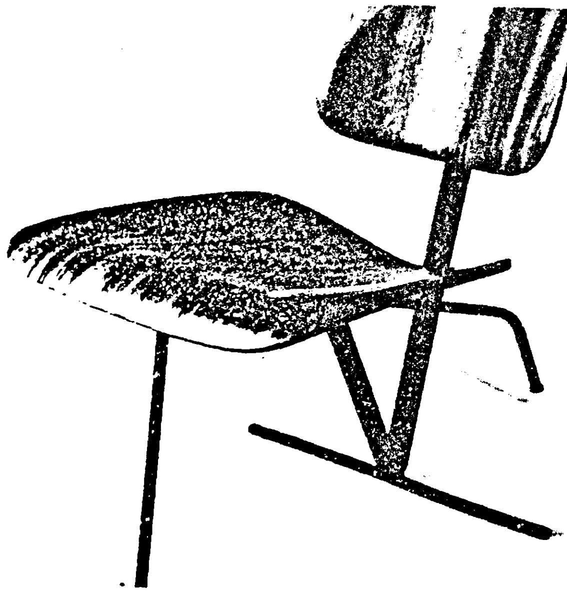
Eames won the second prize for his design. However, it was never put into mass-production with the designated



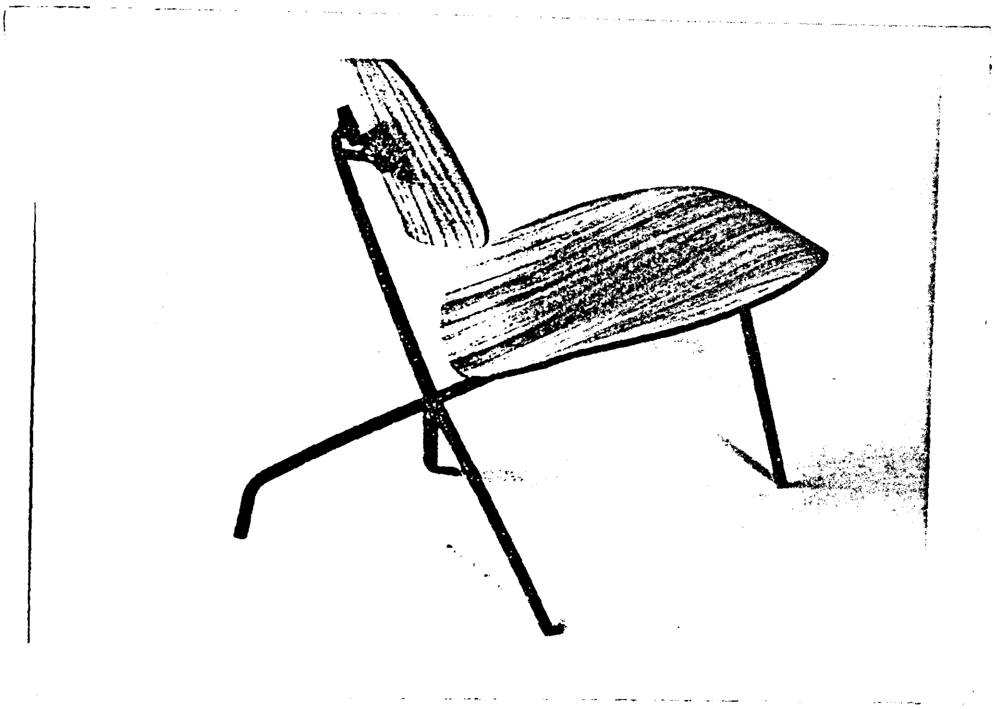
Pl. 46. Three-Legged Chair, Charles Eames, 1944. In: Drexler, Charles Eames, p. 21.



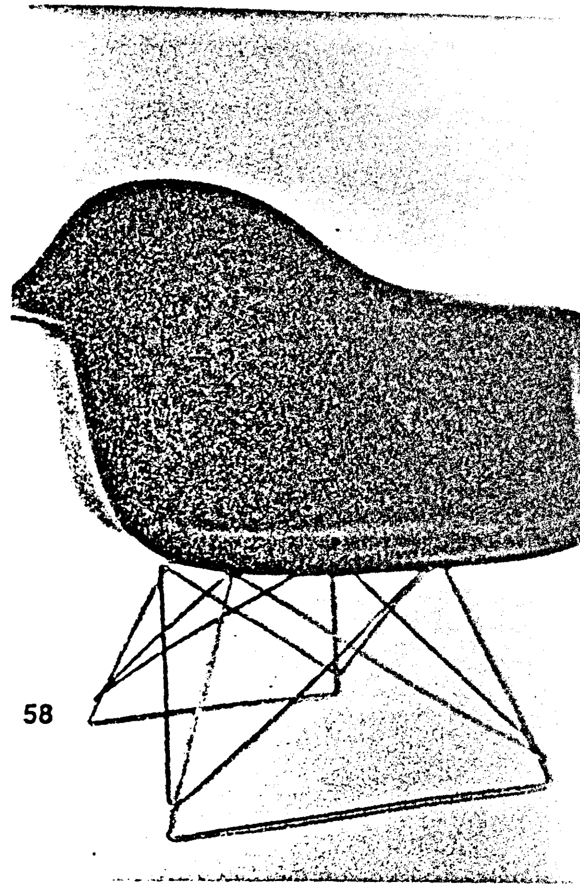
Pl. 47. Three-Legged Chair, Charles Eames, 1944. In: Drexler, Charles Eames, p. 21.



Pl. 48. Multi-Legged Chair, Charles Eames, 1944. In: Drexler, Charles Eames, p. 22.



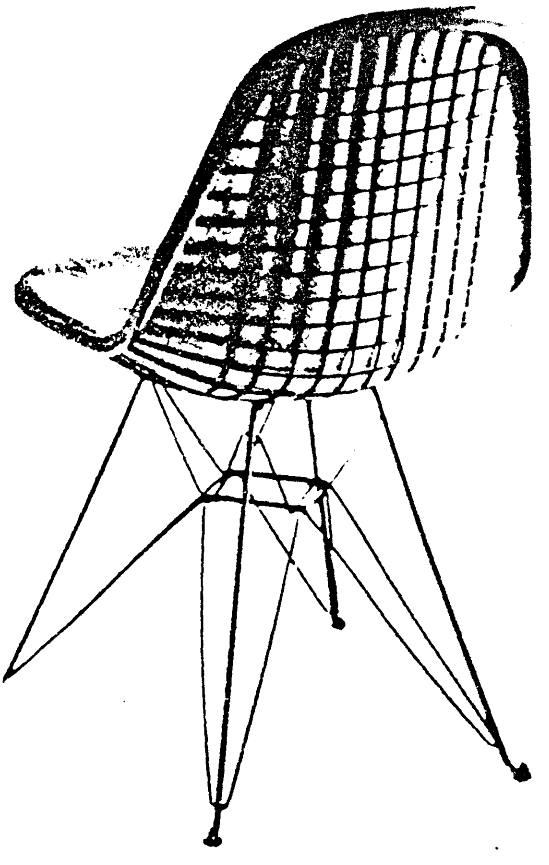
Pl. 49. Multi-Legged Chair, Charles Eames, 1944. In: Drexler, Charles Eames, p. 23.



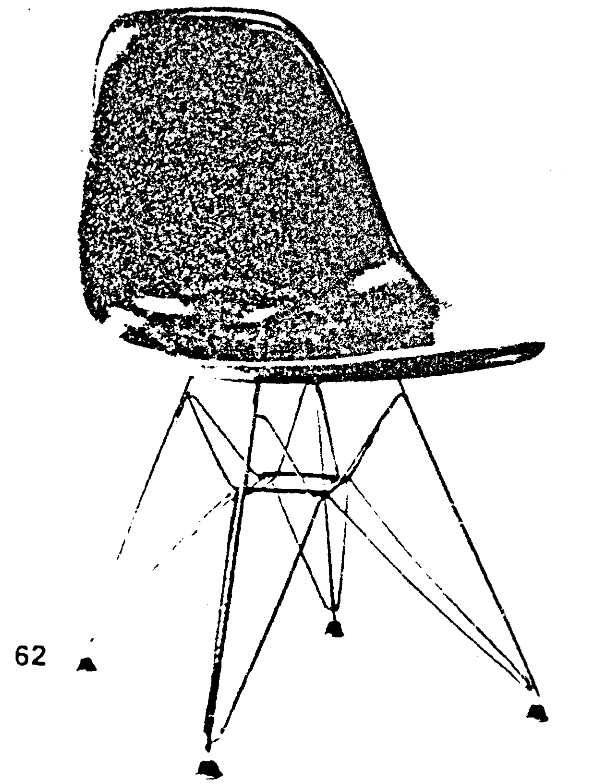
Pl. 50. Shell Chair for Low-Cost Furniture Competition, Charles Eames, 1948. In: Drexler, Charles Eames, p. 34, no. 58.

materials. The stamped metal shell was substituted by a new material: molded polyester. The base, though, was of metal rod, constructed somewhat like a cat's cradle. But the combination of solid shape and material of the shell and the delicate, transparent base of metal rod created a discrepancy. In an attempt to solve this problem, Eames designed a chair with a formed metal wire seat shell. The repetition of the interlaced wire gave the chair structurally and visually the desired unity. In 1951, Herman Miller produced two versions of Eames' wire chairs (pl. 51 and pl. 52). In both designs, Eames had kept the metal base. One of the pieces showed the wire shell partially covered with fabric to achieve more sitting comfort; the other only revealed the formed wire on the back side of the shell. The front of the shell was padded and covered with leather stretched over the edges of the wire shell.

The other prominent furniture producer, Knoll International, was founded by Hans Knoll in 1938. He started to produce Eero Saarinen's design in 1943. After extended expansion of the firm, now Knoll Associates, Inc., also took on the production of Breuer "classics" of the 1920s and 1930s and offered opportunities to designers who were able to create new and original designs.



Pl. 51. Side Chair, wire, padded, Charles Eames, 1951. In: Drexler, Charles Eames, p. 34, no. 58.



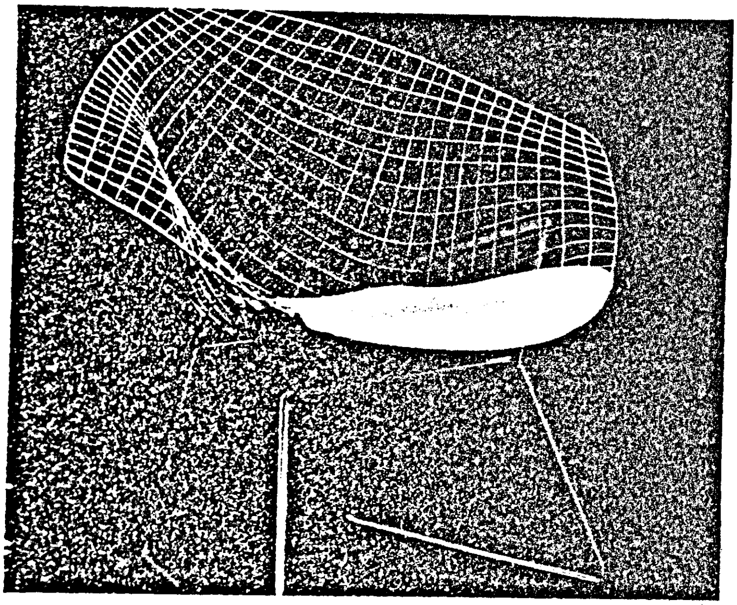
Pl. 52. Side Chair, Charles Eames, 1950. In: Drexler, _Charles Eames_, p. 36, no. 62.

Harry Bertoria, Italian born sculptor and painter, came to the United States in 1937 and after teaching at the Cranbrook Art Acadamy until 1943, began to design furniture for Knoll International.

His 1952 design picks up on Eames' formed metal rod as material for a lounge chair (pl. 53). The seat shell of the chair consists of chrome or plastic-plated steel rod, which is spot welded at the intersections. The shell is formed into a bucket-like seat out of an uneven triangular shape. Its three corners are used as arms and back, respectively, bent outward. The supporting substructure, made of thicker metal rods, stands on glide runners, formed out of one piece. A construction of two lateral bows is holding the shell. The shell is equipped with a seat cushion or entirely covered with padding and a cotton fabric or flexible artificial leather.[45] Bertoria's wire chair design shows his sculptural approach to the design problem:

> In the sculpture I am concerned primarily with space, form, and the characteristics of metal. In the chairs many functional problems have to be established first . . . but when you get right down to it, the chairs are studies in space, form, and metal too."[46]

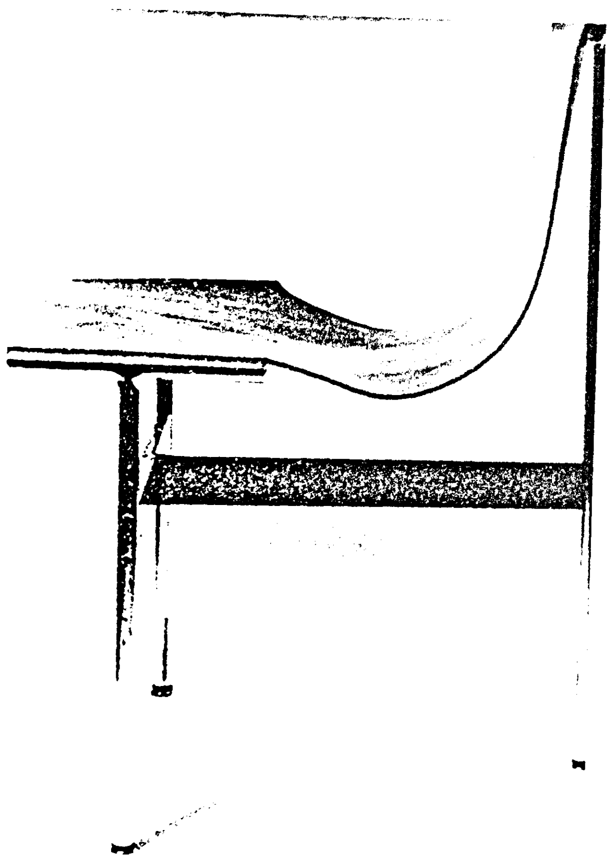
In executing his chair design, Bertoria, or rather Knoll International, took advantage of new technology



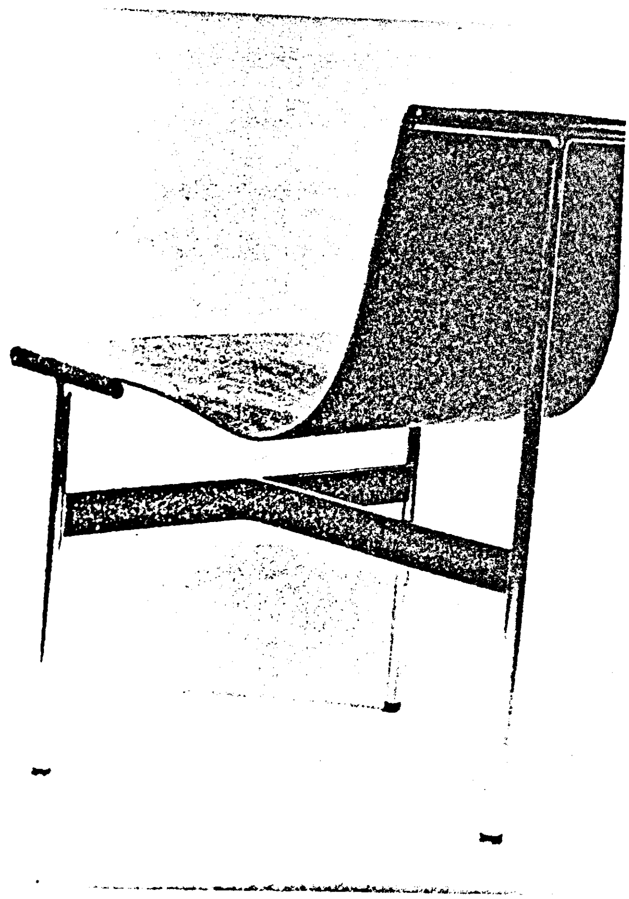
Pl. 53. Wire Chair, Harry Bertoria, 1950. In: Garner, Twentieth-Century Furniture, p. 149.

and materials, such as industrial electrical spot welding and the use of plastic for coating the metal rods, adapted from the aircraft manufacturing industry.[47]

A team of designers, William Katavolos, Ross Litell and Douglas Kelly, all of whom worked with Erwine and Estelle Laverne for Laverne International, created a series of chairs in the early 1950s. In 1953, Laverne International began the manufacture of the so-called T-Chair (pl. 54 and pl. 55). The goal of the designers was to create an elegant chair of clear, simple lines of construction. They described their approach to the design as an attempt to achieve "unity of form" in "similarity in differences and differences in the similarities."[48] The design of the chair meets these goals. It consists of four T-shapes made of steel and a T-shaped piece of leather for the seat and back. The sides of the T-shaped leather piece are stretched over two lateral chrome-plated T-rods by means of a semi-tubular metal section as attachment. The vertical part of the T-shaped leather piece curves up to the chrome-plated T-rod in the back, which for sitting comfort is slightly bent forward. In order to give the structure the necessary stability, a horizontal black laquered T-shaped metal bar is screwed to the verticals of the front legs and the rear leg. The



Pl. 54. T Chair, William Katavolos, Ross Litell, and Douglas Kelly, 1950. In: Meadmore, The Modern Chair, p. 119.

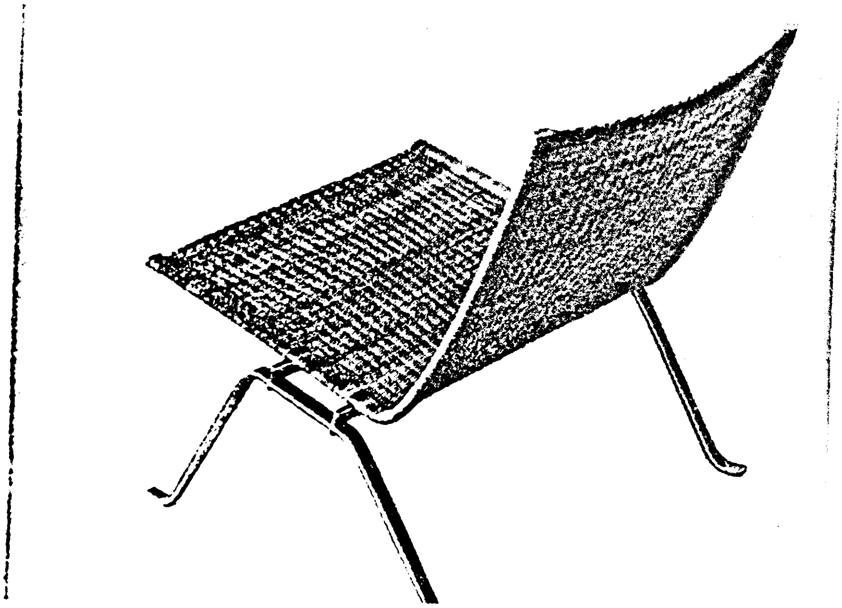


Pl. 55. T Chair, Katavolos, Litell, Kelly, 1950. In: Meadmore, The Modern Chair, p. 121.

proportions of the chair are well-balanced, and the repetition of the principal T-shape in every element of the chair give it a static unity that conveys solidity in spite of its transparency. The construction of the T-chair relies mostly on the strength of the T-shaped metal rods, which would not be possible to achieve in wood since the wooden joints at the intersection of the vertical and the horizontal rod would not be able to withstand the thrust of the sitter.

Danish designers, like Poul Kjaerholm, Arne Jakobsen, and Jorn Utzon, created an alternative to the popular Teak Style in post-war Denmark. Their designs basically followed the principles of the International Style characterized by their formal simplicity, visual solidity and harmony of the materials.

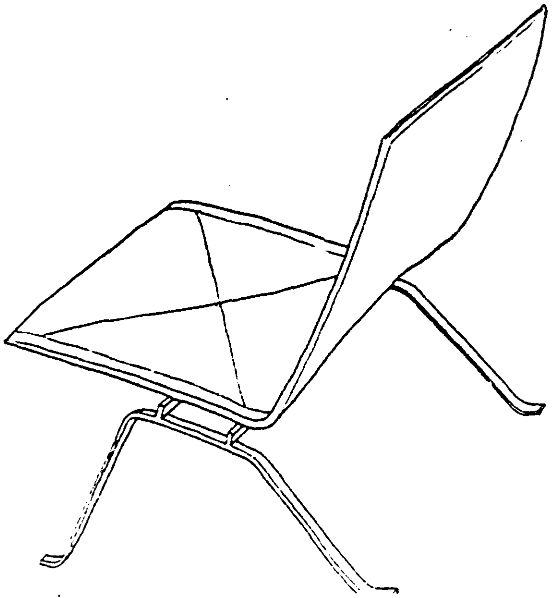
Poul Kjaerholm's chair of 1956 (pl. 56) is reminiscent in its simple, clear lines and sparingly used materials of Mies' Barcelona. Kjaerholm's design won the Grand Prix at the eleventh Triennial in Milan in 1957. It was subsequently referred to as the Triennial Chair. This Triennial Chair is made of a base of chrome-plated flat section steel. The front and back legs on each side are formed in a capped pyramidal line, the horizontal section attached with locking



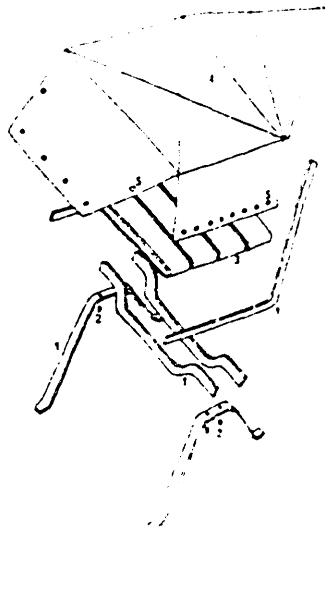
Pl. 56. Triennial Chair, Poul Kjaerholm, 1956. In: Mang, History of Modern Furniture, p. 157, no. 336.

screws to the seat supporting stiffening bars. The seat and back consist of two lateral angled steel bars and are covered either with wicker, woven around the lateral bars or with a leather cover over the reinforcing rubber straps of the seat (pl. 57 and pl. 58). This chair design was manufactured by Kold Christensen A. S. in 1960. In his 1956 chair design, Kjaerholm used the slanted flat section steel bars of the legs and the angle bars of the seat and back to achieve some resilience in order to enhance the sitting comfort. The construction of the chair relies chiefly on the four locking screws connecting the steel bars of the base and the seat.

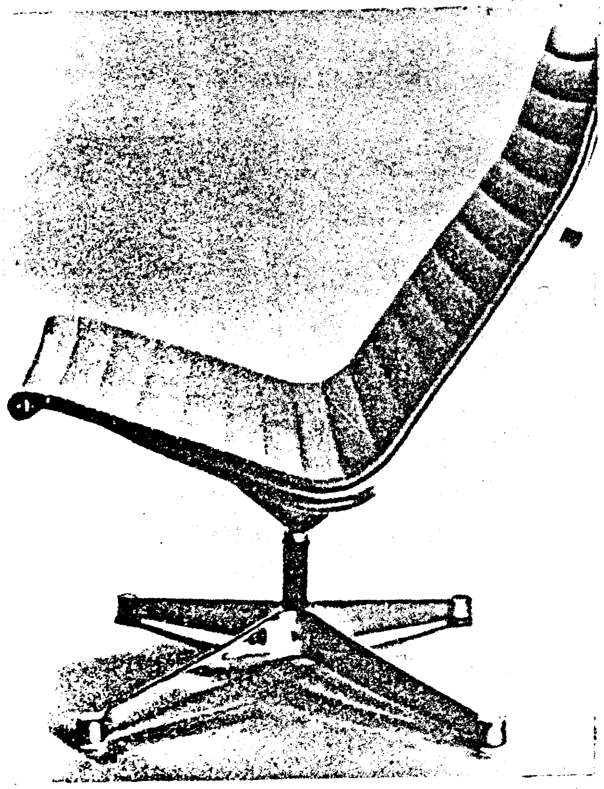
In 1958, Charles Eames began to develop the so-called Aluminium Group with a lounge chair (pl. 59), a side chair, and a recliner swivel lounge chair. The frames of these chairs were constructed of die-cast aluminium. The seat and the back rest were made from Naugahyde and vinyl foam padding. The structure of the chair frames is quite complicated (pl. 60). It consists of a four-pronged base of flat bars terminated by upright cylinders. A black stem of steel connects the base with the die-cast antler element, which in turn supports the lateral seat rails. The seat frame is made of two die-cast rib-like lateral bars forming the seat rails and



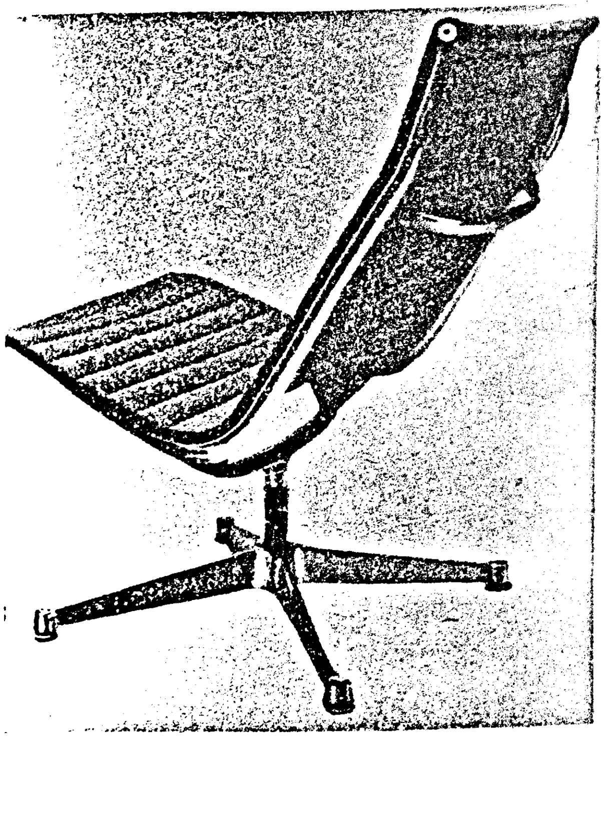
Pl. 57. Triennial Chair, drawing, Frey, The Modern Chair: 1850 to Today, pp. 106-107.



Pl. 58. Triennial Chair, drawing, Frey, The Modern Chair: 1850 to Today, pp. 106-107.



Pl. 59. Aluminium Group, lounge chairs, Charles Eames, 1958. In: Drexler, Charles Eames, pp. 42-43.



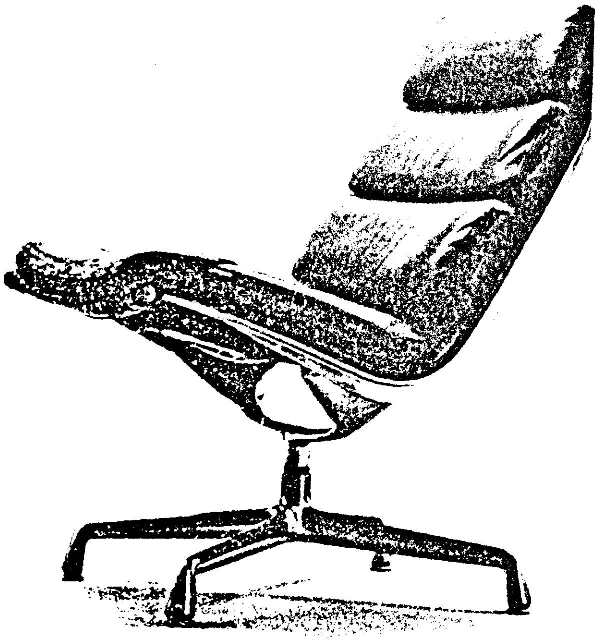
Pl. 60. Aluminium Group, lounge chairs, Charles Eames, 1958. In: Drexler, Charles Eames, pp. 42-43.

back posts. The front rail of the seat and the top rail of the back rest are aluminium rods attached to the side rails with a cylinder on either side. The padding and cover of the seat is slung around these rods. A curved antler-shaped stiffening bar stabilizes the two back posts the way a cross rail would.

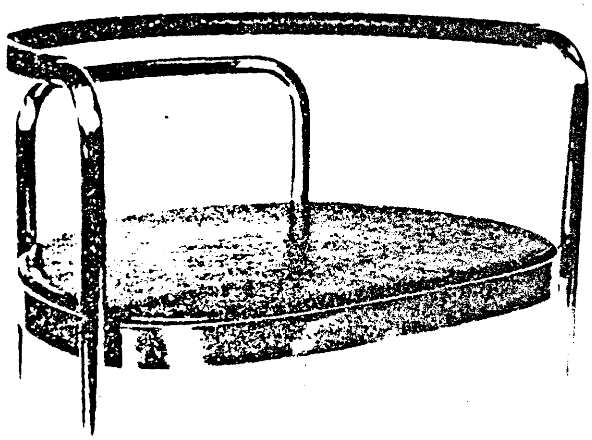
The recliner-swivel lounge chair has the same frame construction with the addition of a mechanical device for tilting and turning in place of the aluminium stem between base and antler elements.

Eames continued to create variations of the same design until 1969. In his so-called Soft Pad Group (pl. 61), he changed the form of the four-pronged base, making its lines smoothly curved. In some designs, he omitted the intermediate stem. He also substituted the relatively thin vinyl padding with soft leather cushions. In using die-cast aluminium elements for the frame construction, Eames' chairs are very light weight, despite their size and solid, rather massive appearance.

In 1962, Poul Kjaerholm designed his Armchair 12 (pl. 62). In this chair, he refers back to Thonet's bent wood forms, while at the same time relying on the properties of tublar steel. The Armchair 12 is constructed of two bent steel tubes. One U-shaped tube



Pl. 61. Soft Pad Group, lounge chair, Charles Eames, 1969. In: Drexler, Charles Eames, p. 47.

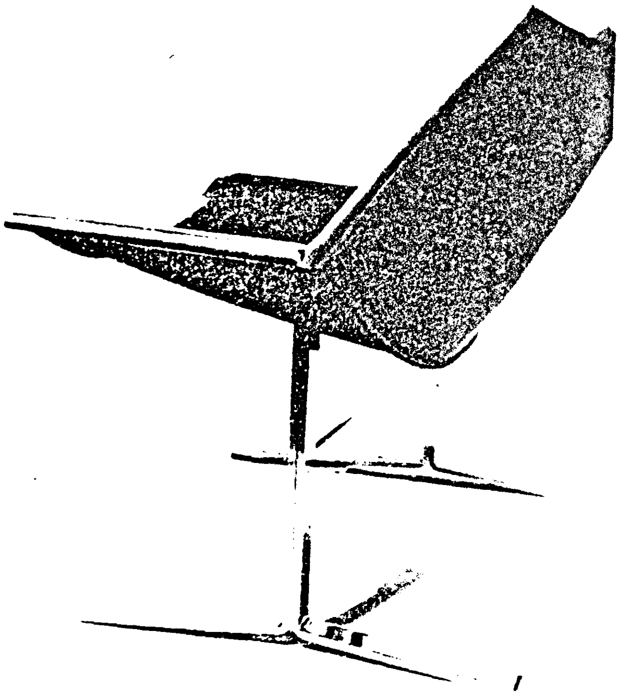


Pl. 62. Armchair 12, Poul Kjaerholm, 1962. In: Meadmore, The Modern Chair, p. 138.

in the back forms the rear legs and extends beyond the height of the seat as a back rung. The other tube is used for the front legs and is bent backwards in a narrow ninety degree angle, encircling the chair, creating the arm rests and back in a smooth curve. The seat is made of a flat-section steel bar as a seat frame, in which a flat upholstered seat pad is resting. The legs of the chair are welded to the seat frame. These welds are the only means by which the chair is held together, and subsequently, they have to withstand the weight of the sitter as well as the lateral pressures put on the back rail and arms. Kjaerholm's Armchair 12 shows elegant proportioning of the various curvilinear elements in a very simple construction. The curved, smooth lines of the design balance the cold appearance of the exposed steel structure.

Clement Meadmore, born in Australia, was originally a sculptor, but after 1966, he primarily designed furniture. He moved to New York in 1973 and subsequently became a United States citizen.

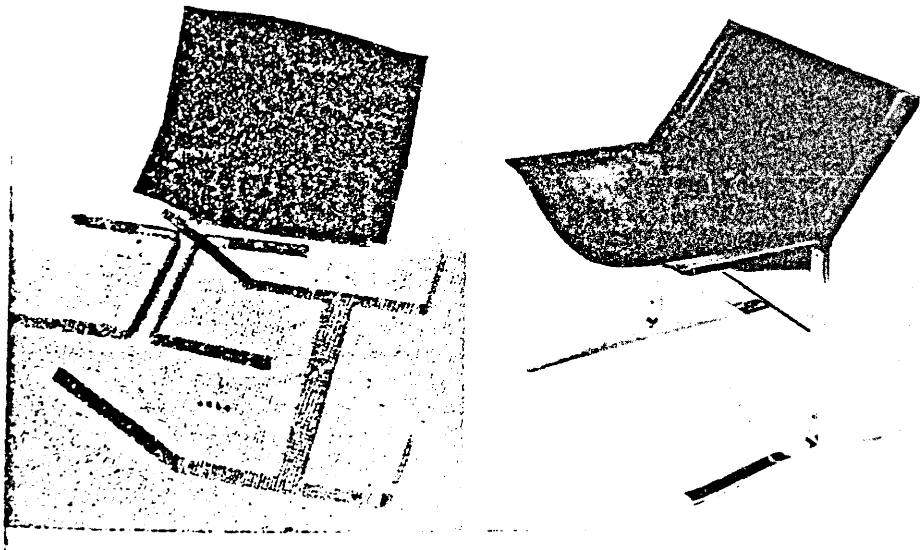
Meadmore's Sling chair (pl. 63) of 1963 was an attempt to arrive at a chair design which, with the use of the sling principle, met the anatomical requirements of the sitter.[49] The construction of the Sling chair



Pl. 63. Sling Chair, Clement Meadmore, 1963. In: Meadmore, The Modern Chair, p. 147.

consists of three chrome-plated flat-section steel elements (pl. 64). Two flat-section steel bars are bent to form two runners, uprights and angled back posts. The two bars are connected by a flat section steel horizontal brace, welded to each of the uprights to form one piece. Two U-shaped front elements are screwed to the uprights, creating the front section of the runners and the lateral seat rails. Two leather slings, sewn around the lateral seat rails and back posts, are seamed together along the seat-back meeting line. Since the leather sling hangs loosely between the lateral bars, it fits the anatomical proportions of the sitter without making any further padding or upholstery necessary. Due to the slight curvature of the flat-section bars of the runners, as well as the projecting flat-section bars of the seat rails and back posts, the chair gains its resilience. The horizontal stretcher, or brace, and the four screws in the uprights give the construction the required stability, so that no cross rails or braces are needed between the seat rails or back posts. Meadmore's familiarity with the properties of the materials and their carefully considered combination in his Sling chair give the chair a structural and visual integrity.

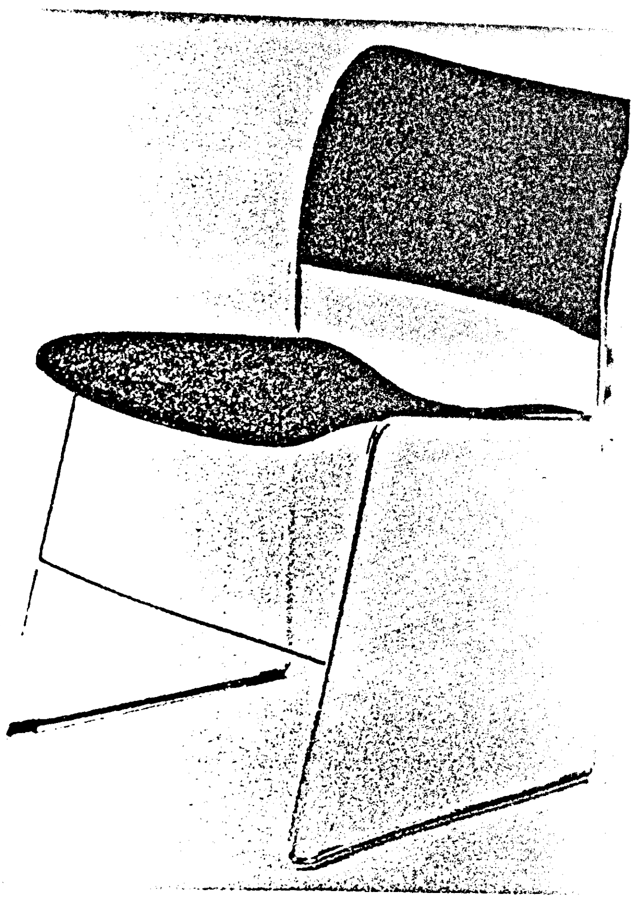
The American designer David Rowland began working on a design for a stacking chair in 1956. After extensive



Pl. 64. Sling Chair, dissembled, In: Meadmore, The Modern Chair, p. 149.

studies on materials, technology and experimental designs, the GF 40/4 (pl. 65) stacking chair was produced in 1964 by General Fireproofing USA. Rowland's design goal was to create a stacking chair with the closest possible nesting, as well as the most sitting comfort, lightness, and movability, structural strength, and fire resistance.

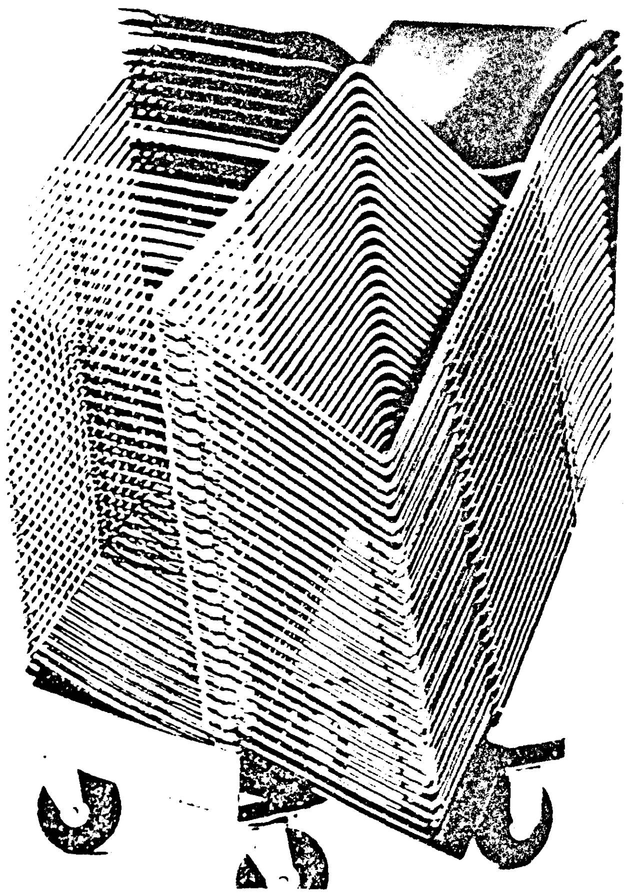
The frame of the GF 40/4 is constructed of thin steel rod (seven-sixteenths of an inch in diameter[50]). The lateral steel rods form the seat rails, forward slated front supports, glide runners at a small outward leading angle, and rear legs extended to form the slightly backwards-curving back posts. The two front supports are connected with a front stretcher; the seat rails and the back posts are joined by a rear seat rail for stiffening purposes. An unobstrusive flange is welded to the rear supports, so a row of chairs can be interlocked. In his GF 40/4, Rowland used silverbrazed welds for all joints to achieve a smooth surface that makes finishing work hardly necessary. The entire frame construction of the chair is chrome-plated. The seat and back panel of the GF 40/4 are formed of steel sheet (three-sixteenths of an inch thick at the rolled edges[51]). The steel sheets are vinyl-coated to give the seat and



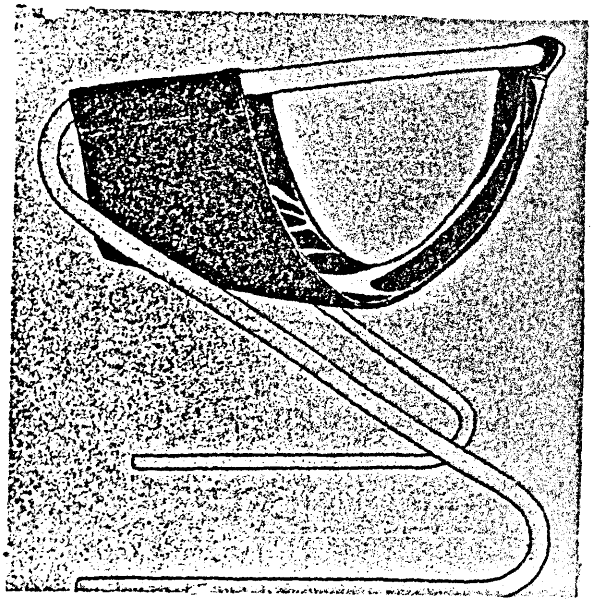
Pl. 65. GF 40/4 stacking chair, David Rowland, 1956-1964. In: Meadmore, The Modern Chair, p. 159.

back a soft, warm surface that is pleasant to the touch. This finish also makes it possible to produce the chair in a wide variety of colors. In order to keep the stacking distance between chairs at a minimum, both the seat and back panel are welded inside and flush with lateral seat rails and back posts (pl. 66). The construction of Rowland's GF 40/4 is somewhat resilient to provide the design with the desired sitting comfort, particularly needed in a chair that is often used in auditoriums and conference halls for mass-seating. On the other hand, it also offers the stability required for rigorous wear. The chrome-plated thin steel rod of the frame is characterized by high tensile strength and flexibility. The thin vinyl coating on the seat and back is highly wear resistant. Rowland combined in his design the modern materials and technology that make the GF 40/4 ideal for mass-seating as well as economical storage.

In 1965, Stylianos Gianakos and Andrew Morrison designed a very simple tubular steel chair which was manufactured by Zografos, New York (pl. 67). The chair consists of only one formed steel tube which is chrome-plated. It is a cantilever design. The runners of the chair lead backwards and curve up, at a forty-five degree angle into a diagonal which turns back in another



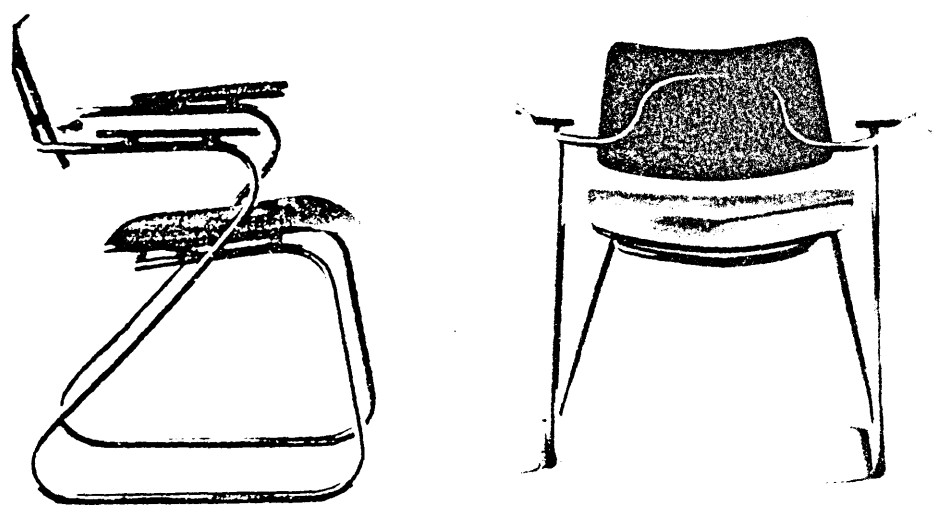
Pl. 66. GF 40/4, stacked. In: Meadmore, The Modern Chair, p. 161.



Pl. 67. Tubular steel chair, 1965, Stylianos Gianakos and Andrew Morrison. In: Frey, <u>The Modern Chair: 1850 to Today</u>, p. 137.

forty-five degree curve, repeating the horizontal line of the runners in the arm and back rest. The seat and back of the chair are made up out of a T-shaped leather piece, the ends of which are sewn around the tubing of the arms and back, hanging loosely down to create a sitting surface. The design of Gianakos and Morrison relies on the strength and resilience of the bent steel tubing as well as elasticity of the leather sling. The principle of Gianakos' and Morrison's construction design was copied in a number of chair designs of the early 1970s.

In 1966, the Austrian designer Egon Rainer developed a tubular steel cantilever chair (pl. 68). The frame of the chair, following the principle of Gianakos' and Morrisons' tubular cantilever chair of 1965, is formed out of one continuing piece of steel tubing. In Rainer's design, the molded plywood seat panel rests on a U-shaped tube, which curves down under the front edge of the seat leading into outward slanted front supports. Without interruption of lines, the supports are bent backwards to become glide runners which lead into an upward, forward diagonal, curving back to form the horizontal support for the wooden arm rests. The tubing continues in a flat, upside-down U-shape behind the back

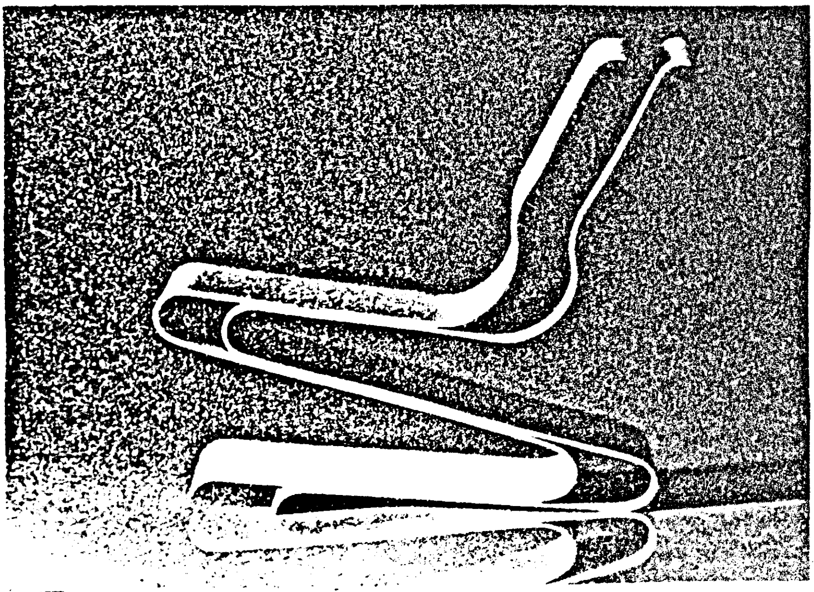


Pl. 68. Tubular steel cantilever chair, 1966, Egon Rainer. In: Hatje, New Furniture 11, p. 14, no. 20-21.

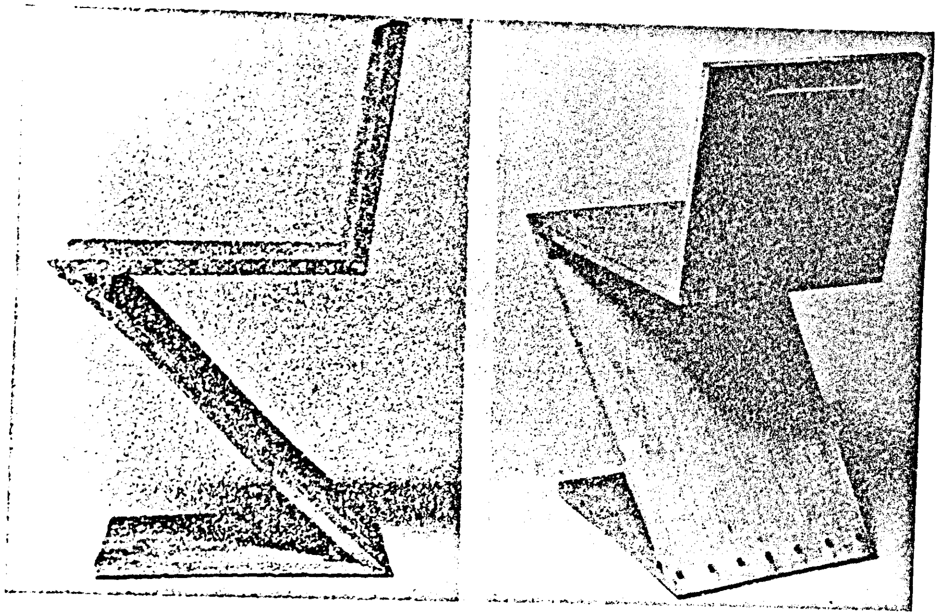
panel. The continuous line of the tubing makes it possible to avoid all but one weld. The molded plywood panels of the seat, the back rest, and the arm rests are screwed to the steel tube. Rainer's design allows a great flexibility of the seat. The resilience of the back is limited due to the forward movement of the diagonal.

During the same year, Rainer designed a stackable easy chair of much higher resilience. The chair is made out of formed processed spring steel (pl. 69). The steel sheet is cut into a long strip of the width of the chair and bent in a narrow zig-zag, much like Gerrit Rietveld's 1934 wooden Zig-Zag chair (pl. 70). The seat curves up to the slanted back. The small curve at the edge of the base is repeated at the top of the back rest. The chair is stackable, but it is not as efficient in its economy of space as Rowland's GF 40/4 described earlier. The resilience of Rainer's spring steel chair is its most outstanding quality, achieved through the use of processed spring steel and applied in a design entirely true to that material. The lines of the chair are clean and simple, but the sitting comfort is limited.

The cantilever system in chair design continued to be popular and was used in many variations. In 1968,



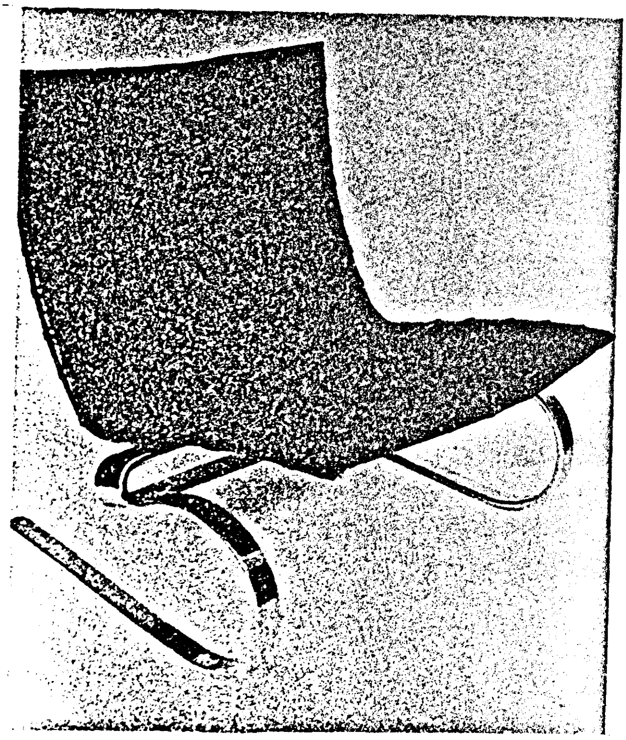
Pl. 69. Spring steel cantilever chair, 1966, Egon Rainer. In: Hatje, New Furniture 11, p. 31, no. 91.



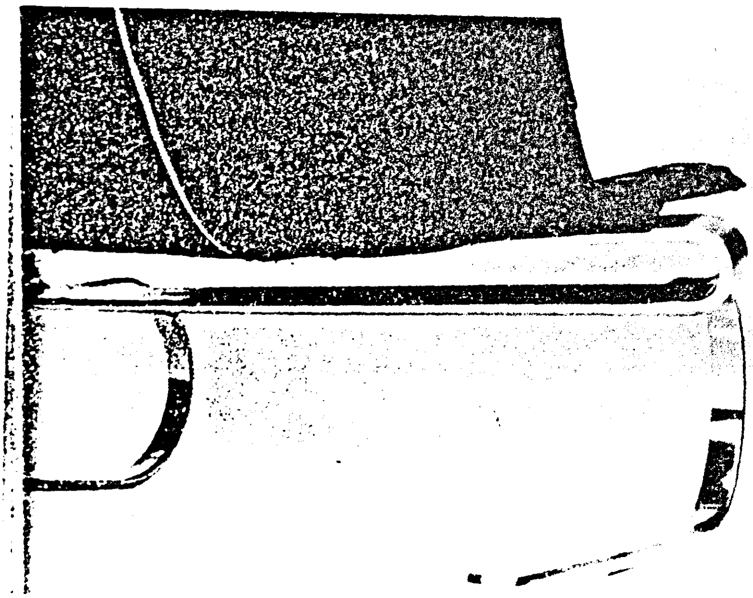
Pl. 70. Zig-Zag Chair, Gerriet Rietveld, 1934. In: Meadmore, The Modern Chair, p. 95.

Poul Kjaerholm designed his Chair 20 (pl. 71). It is a cantilever design, the seat construction of which seems strongly influenced by his Triennial chair (pl. 56) of 1956 previously described. The shape of the cantilevers of the Chair 20 is slightly reminiscent of Mies' MR chair (pl. 29), their application similar to Mies' Tugendhat chair (pl. 38). The base of the Chair 20 (pl. 72) consists of two spring-like cantilevers of flat-section steel bars that smoothly curve back and upwards. They are welded to a connecting yoke which repeats the curve of the cantilevers in small proportion. The ends of the yoke are attached to the side rails of the seat with four screws each. The spring-like curve of the yoke pulls the lateral steel bars that form the seat rail and back supports apart, against the tension of the leather straps which are slung around the seat frame and zipped in the back of the back rest and underneath the seat. As in the Triennial chair, Kjaerholm uses the materials true to their properties and so creates the most aesthetic and functional effect possible, with great simplicity in line as well as economy of material.

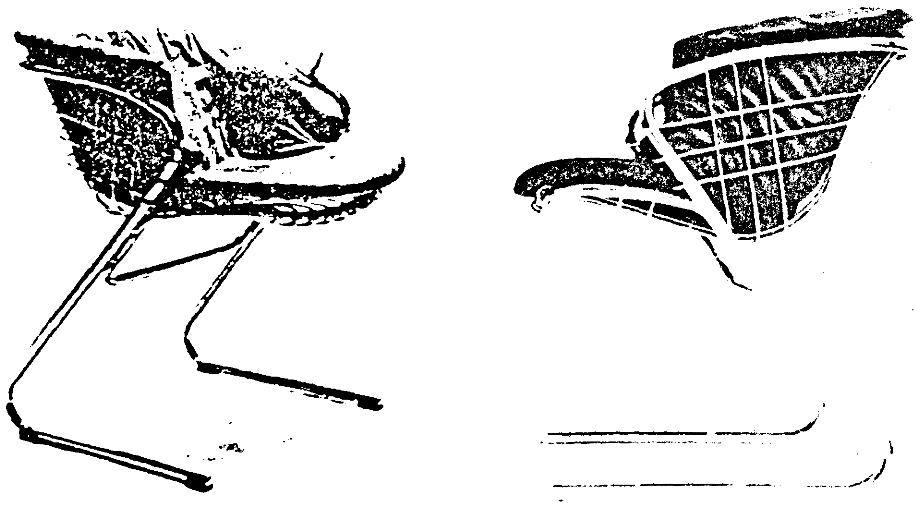
The 1970 cantilever chair design Zeta (pl. 73) by the Italian designer Gastone Rinaldi, seems to draw on Gianakos' and Morrison's 1965 tubular steel chair (pl. 67).



Pl. 71. Chair 20, Poul Kjaerholm, 1968. In: Meadmore, The Modern Chair, p. 95.



Pl. 72. Chair 20, detail. In: Meadmore, The Modern Chair, p. 169.

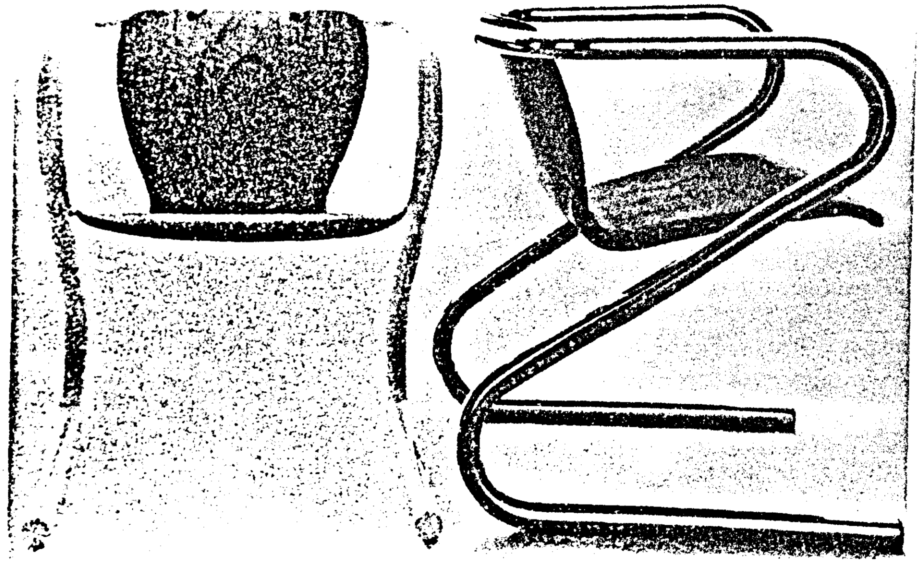


Pl. 73. Zeta, easy chair, Gastone Rinaldi, 1970. In: Hatje, New Furniture 11, p. 15, no. 26-27.

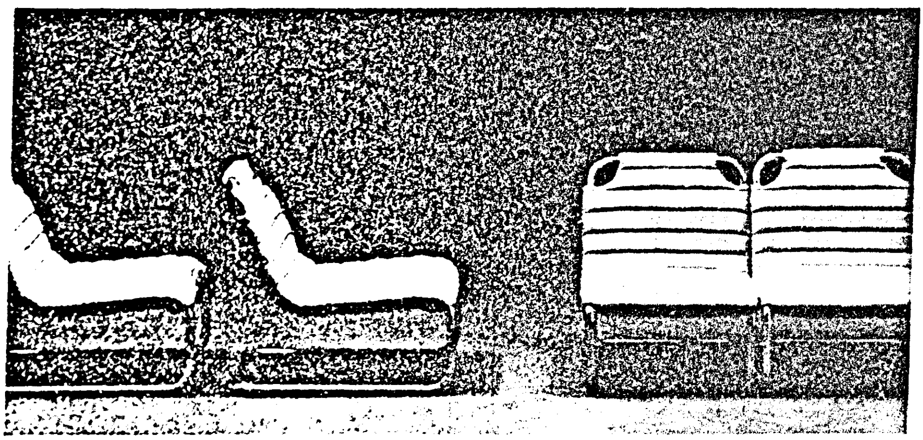
The Zeta is made of a chrome-plated tubular steel frame. One tube forms the backwards leading runners and continues at a forty-five degree angle in a forward diagonal which in turn is curved back to become arm rest and back. The seat and back of the chair is constructed out of thin chrome-plated steel rods in a basket-like fashion. In the rear and on the sides, the steel rods are welded to the back and arm rests. The frame of the chair is strengthened by a continuous steel tube which is set between the lateral diagonal tubes. It functions as a stretcher or stiffening element and extends forward in an obtuse angle, forming the front and side rails of the seat. The basket-like seat is furnished with a padded, fitted leather-covered cushion, which is detachable. The S-like shape of the Zeta provides the chair with the desired flexibility, while the seat rail/ stretcher works as a stabilizer. The combination of chrome-plated metal tubing and chrome-plated, interlaced steel rod, gives the design a harmonious appearance. The dark seat and back cushioning visually enhances the structure, as well as conveying the impression of solidity and comfort.

In 1972, Philip Salomon and Hugh Hamilton, two Canadian designers, adopted the S-shaped cantilever principle in their Chair 7001 (pl. 74). In comparison, the tubing of Salomon's and Hamilton's chrome-plated or lacquered chair frame is of nearly twice the diameter as the tubing of Rinaldi's Zeta (pl. 73). The glide runners of the 7001 extend further beyond the imagined vertical plane of the back rest and therefore, maintains the resilience of the chair, despite the thickness of the tubing by means of leverage. The horizontal curvature of the tubing of the arms and back is parallel to the runners, rather than in a slight angle to them, as in Rinaldi's Zeta (pl. 73). The seat and back of the 7001 are either of beech, metal, or upholstery, with a leather cover. In the metal version, a thin metal sheet is stamped in a double-horseshoe form and bent at a ninety degree angle at the seat/back meeting line. It is attached to the diagonal tubes and the tube in the back. Salomon's and Hamilton's chair, although of the same design principle as the Zeta, lacks the elegance of proportion, as well as the harmony of materials presented in the Zeta.

Giorgio Decursu, an Italian designer, developed the Cetra (pl. 75) in 1971. In this design, he refers



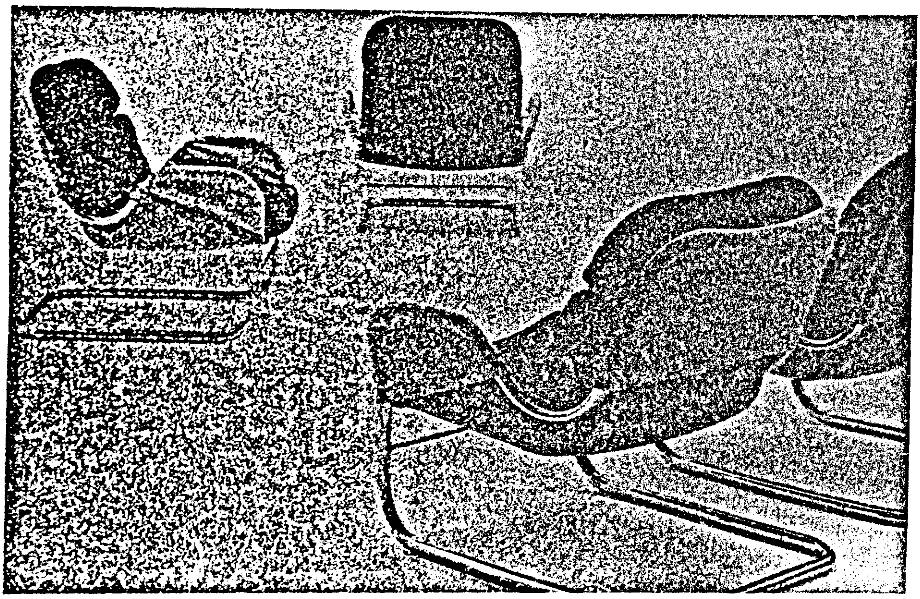
Pl. 74. Chair 7001, Philip Salomon and Hugh Hamilton, 1972. In: Hatje, New Furniture 11, p. 14, no. 18-19.



Pl. 75. Cetra, easy chair, Giorgio Decursu, 1971. In: Hatje, New Furniture 11, p. 34, no. 101.

back to the early classics of Mies van der Rohe. The frame of the Cetra is made of chrome-plated continuous steel tubing. The runners and terminating floor element extend beyond the vertical line of the backrest. The front verticals, which are similar to Breuer's lounge chair (pl. 33), are in harmony with the depth of the seat and the slightly tilted back rest. The seat and back of the Cetra consist of a continuous, detachable upholstery covered with leather or fabric. The resilience of the chair is increased by the fact that the seat has more depth than Breuer's chair and, therefore, greater leverage. The horizontal lines of the design clearly dominate the rather short verticals and subsequently give it the characteristic appearance.

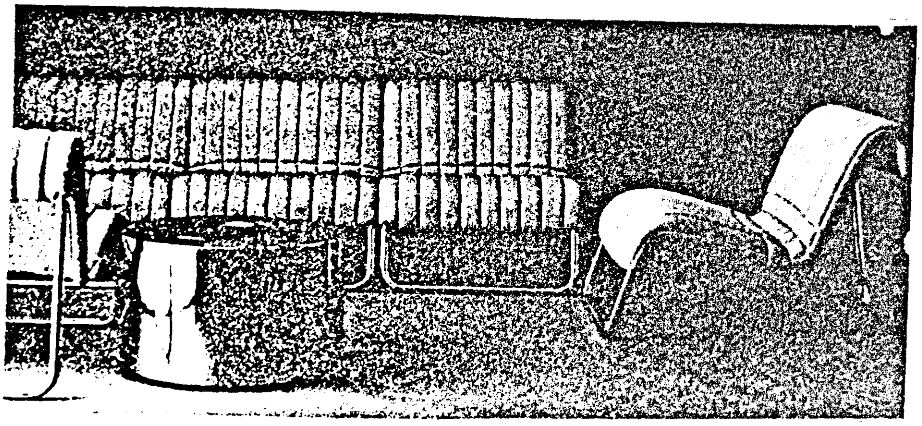
During the same year, the Finnish designer Esko Pajamies designed his easy chair Juju (pl. 76). The Juju also is a variation on the cantilever principle. The chair consists of a continuous tubular steel frame, which is available with a chrome-plated or lacquer finished surface. The base of the chair is formed very much like Decursu's Cetra (pl. 75). The vertical front supports are connected with a stiffening rod. The vertical supports extend beyond the height of the seat, curving backwards at the level of the arm rests into an irregular



Pl. 76. Juju Chair, Esko Pajamies. 1971.
In: Hatje, New Furniture 11, p. 34, no. 102.

S-shape, leading up into the tilted lateral supports of the back and the terminating top rail. The loose cushions of the seat and back rest on detachable, fitted fabric slings, which are stretched over the arm rests and the top rail. The resilience of the chair is achieved through the cantilever principle and the continuous tubing. The Juju though, lacks the sophisticated simplicity of the Certa because the flow of line of its frame is interrupted by the fabric slings, and the thick cushions are not in total harmony with the chrome-plated frame. Instead they appear to awkwardly weigh it down and seem to be rather an arbitrary concession to sitting comfort.

The Italian designers Jonathan De Pas, Donato D'Urbino and Paolo Lomazzi colaborated on a design for an easy chair and created the Duecavalli (pl. 77) in 1970. The chair shows a new support structure with runners parallel in the front and the rear of the chair rather than lateral. The frame of the Duecavalli consists of a continuous chrome-plated steel tube. The lateral supports of the seat and back are bent in an irregular S-line slanting outwards to the front and the back runners. The seat and the back are suspended between them in mid-air. The canvas seat, following the flow of

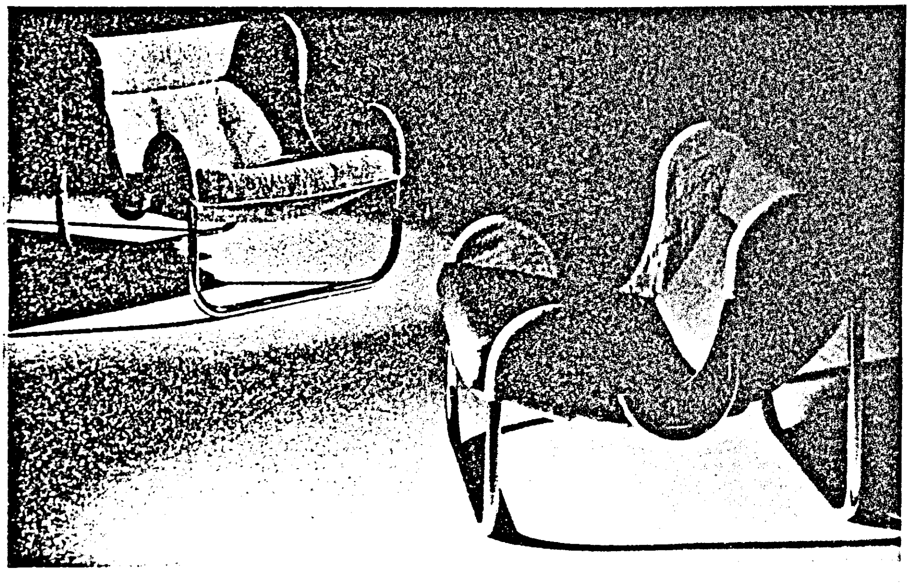


Pl. 77. Duecavalli, easy chair, Jonathan De Pas, Donato D'Urbino and Paolo Lomazzi, 1970. In: Hatje, New Furniture 11, p. 35, no. 103.

the S-line, is attached to the tubing by rubber rings, the upholstery can be taken off. The tilted seat and back surfaces, as well as the limited resilience of the frame, provide the desired sitting comfort.

A variation of the same structural principle can be seen in the frame of Esko Pajamies' easy chair Laiskiainen (pl. 78) of 1971. Like the Duecavalli (pl. 77), the Laiskiainen is supported by a front and rear runner. The double S-curve of the lateral section of the frame, though, reminds one more of Pajamies' Juju (pl. 76) of the same year. As the seat of the Juju, the seat of the Laiskiainen consists of detachable fabric slings, which are stretched over the uprising curves of the lateral S-shaped tubes, defining semi-circles. In order to give the chair more sitting comfort, Pajamies added loose cushions, one fitted to the seat, one to support the lower back of the sitter. Since the uprising front and back supports are kept vertical, the frame of the Laiskiainen does not rely on resilience for sitting comfort but rather on the elasticity of the fabric slings and loose cushions. The large S-curves of the chair give it a slight resemblance to a wing chair.

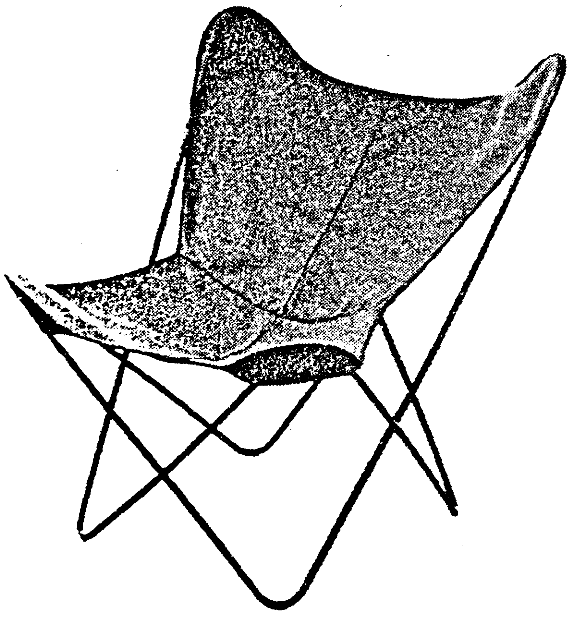
The principle of fitted fabric slings as chair seat and back, such as Pajamies used in both his Juju



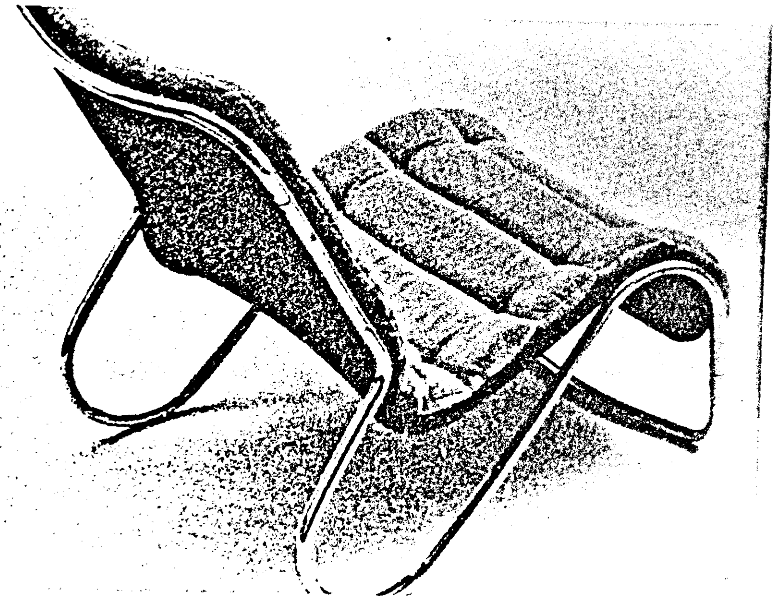
Pl. 78. Laiskiainen, easy chair, Esko Pajamies, 1971. In: Hatje, New Furniture 11, p. 35, no. 104.

(pl. 76) and his Laiskianen (pl. 78), reverts back to the A. A. Chair (pl. 79), produced by Knoll International in 1950, designed by Hardoy, Bonet, and Kurchan in 1938. The production model consisted of plastic-coated steel rod. The canvas was hung over the four corners of the steel rod frame, forming seat and back of the chair. Subsequently, Pajamies' 1971 chairs are not entirely innovative designs, but rather employ known principles, such as tubular cantilever construction and sling seats, and combine them in a new manner.

The German designer Juergen Lange created his easy chair 1011 in 1972 (pl. 80). The chrome-plated continuous tubular frame of the chair shows a new combination of curves. In the front, the 1011 rests on a runner. The lateral supports of the seat describe S-lines, with the rear curves functioning as rear supports of the seat and the back rest. The tubing leads to the tilted lateral back supports and the top rail. The seat of the chair consists of a second frame with lateral tubes screwed between the supports of the back and continuing at an obtuse angle across the rear sections of the S-curve, to be attached along the front supports of the seat. A piece of canvas is stretched over the secondary frame, creating the actual surface



Pl. 79. A. A. Chair, Antonio Bonet, Juan Kurchan and Ferrari Hardoy, 1938. In: Eckstein, Der Stuhl, p. 121, no. 151.

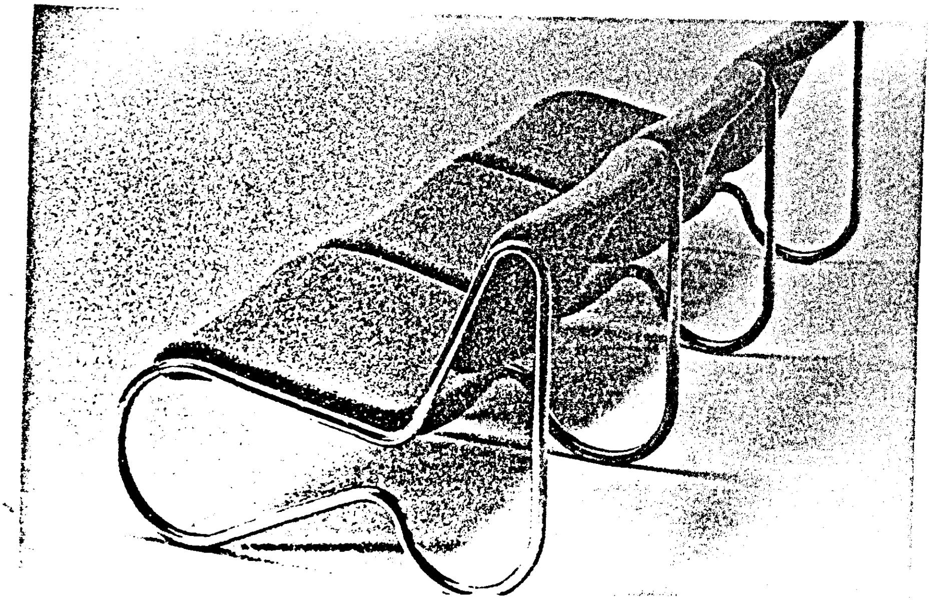


Pl. 80. Chair 1011, Juergen Lange, 1972.
In: Hatje, New Furniture 11, p. 36, no. 108.

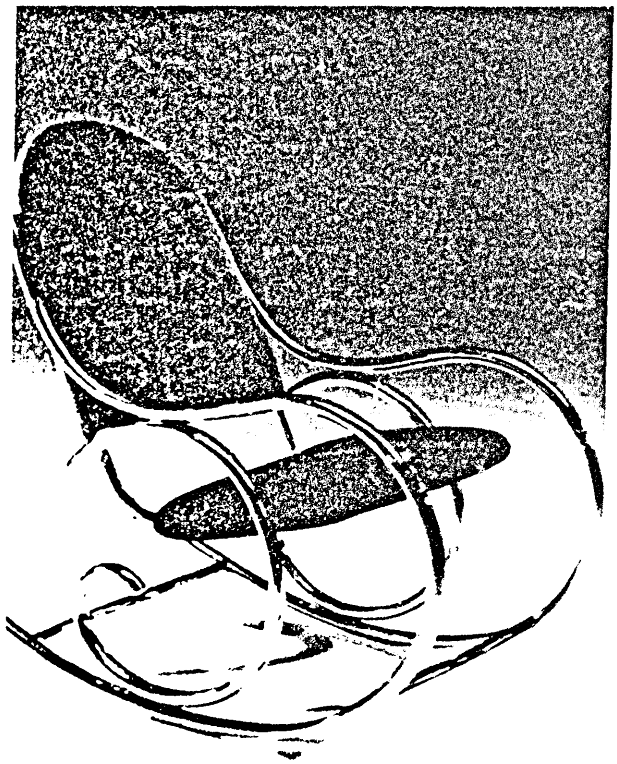
of the seat and back rest. The desired sitting comfort is achieved by a polyester foam upholstery covered with fabric or leather. The resilience of the chair is the result of the long S-shape of the base and the combination of a front runner and the gliding curve of the rear supports. Similar chair frame constructions were used by Arne Jakobsen in 1971 (pl. 81).

In comparison to the number of cantilever chairs and chairs with suspended seats, both resting firmly on the ground, the number of rocking chair designs succeeding the famous Thonet bent-wood rockers is very small. To some extent, they were superseded by chairs furnished with reclining and swivel mechanisms or they were recreations of old designs in new materials.

Renato Zevi's Z-3 (pl. 82) rocker of 1970 clearly draws on the Thonet bent-wood construction (pl. 9), including the form of ornamental elements. The Z-3 is detachable and consists of a chrome-plated tubular steel frame. The rockers, connected by a stiffening tube in the back and in the front, lead in a generous curve up to the slightly concave line of the arm rests, which extend up to hold the secondary back and seat frame. A scroll-like piece of tubing functions as support of the arm rests on either side, forming a connection to



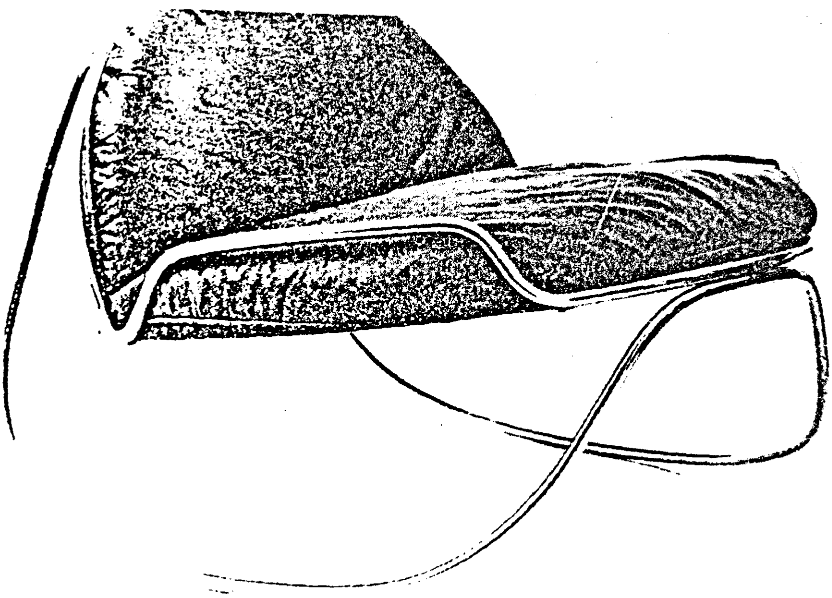
Pl. 81. Easy chair range, Arne Jacobsen, 1971. In: Hatje, New Furniture 11, p. 37, no. 111.



Pl. 82. Z-3 Rocker, Renato Zevi, 1970. In: Hatje, New Furniture 11, p. 36, no. 109.

the rockers. The back rest and the seat of the rocking chair is formed of a secondary frame. The back rest is terminated by an upside-down U-shape, which continues along the sides of the back rest and curves in a ninety degree angle to form the side rails of the seat. The back and seat upholstery of polyurethane foam is supported by elastic straps and covered with leather, imitation leather or nylon. The frame construction of the Z-3 could just as well have been done in bentwood or laminated plywood, since it does not rely on the properties of tubular steel.

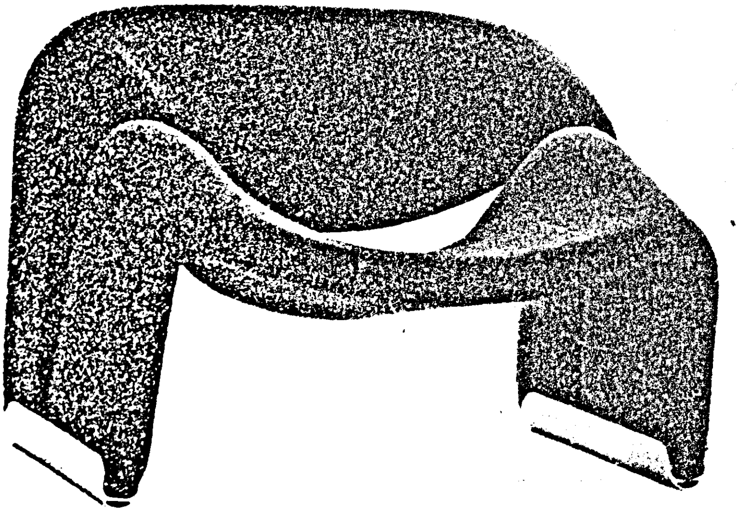
The rocking chair Onadlunga (pl. 83), created by the Italian designers Giuliano Pozzi and Gastone Rinaldi in 1970, represented a new construction principle. The frame of the Ongalunga consisted of chrome-plated tubular steel. One continuous tube is bent in a waving manner into four large irregular U-shapes. It forms the curved side runners and the front and rear supports for the seat and back, which are constructed as a secondary frame. This secondary frame describes a semi-circle enclosing the back of the chair. The continuous tubing leads at a forty-five degree angle into the side rails of the seat, which hold the leather-covered polyurethane foam cushions in place. The two frame components are



Pl. 83. Ondalunga, easy chair, Giuliano Pozzi and Gastone Rinaldi, 1970. In: Hatje, New Furniture 11, p. 36, no. 107.

connected in the front and rear, leaving the seat suspended. The construction only relies on the strength of the joining points and the tensile strength and resilience of the tubing. The designs of the Ondalunga shows Pozzi's and Rinaldi's understanding of and familiarity with the materials used.

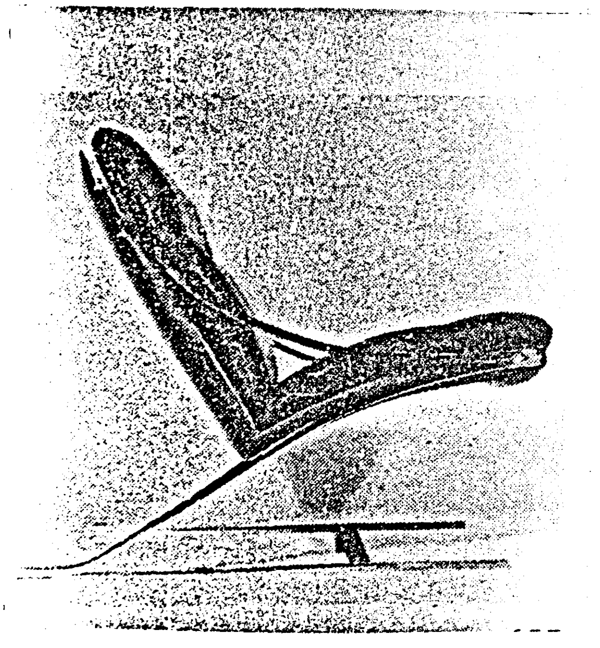
In 1972, the French designer Pierre Paulin created the 598 Easy Chair (pl. 84). The 598 Easy Chair is composed of a two-piece metal chassis, which is held together by extruded aluminium foot glides, the only metal elements visible. The metal structure of the chair is entirely surrounded with polyurethane foam, covered with elastic fabric. The two elements of the chair, one forming the lateral supports and the seat, the other forming the lateral supports and the back rest, are bent multi-directionally in continuous curves, leaving an opening between the surfaces of the seat and the back. Since the seat and back elements of the chair are only connected by the foot glides, the seat and back are independently resilient and allow a great amount of flexibility. The suspended seat and the smooth curves of the design give the 597 Easy Chair a light, elegant appearance, combined with comfort and stability of



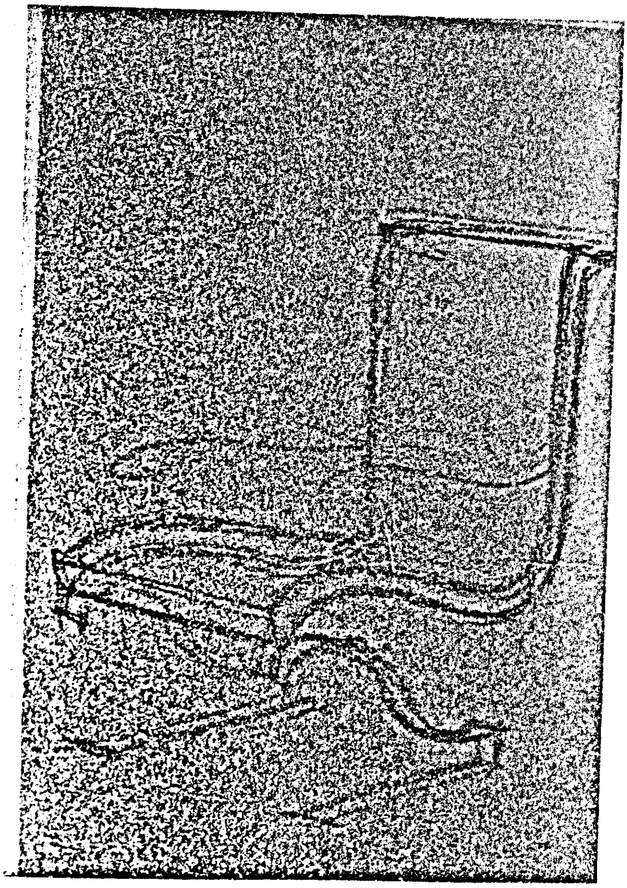
Pl. 84. 598 Easy Chair, Pierre Paulin, 1972.
In: Hatje, New Furniture 11, p. 42, no. 132.

form, due to the resilience and tensile strength of the metal chassis.

Another easy chair of a quite different design approach is represented in Paul Tuttle's chair of 1973 (pl. 85), created for the Swiss manufacturer Straessle Soehne and Company. The chair's bar stock steel frame is constructed in cantilever form, reminiscent of a 1934 sketch by Mies van der Rohe for a reverse Z-frame (pl. 86). In his easy chair, Tuttle uses a frame with an H-shaped base of floor bars, which projects beyond the back of the chair. The seat of the chair is mounted on the front section of the slightly curved diagonally forward leading U-shaped steel bar. The ends of this steel bar are bolted to the ends of the lateral floor bars in the back. To hold the back rest of the chair in position, a continuous, oval-shaped bar, which is bent in a concave line, encircles the front edge of the seat where it is attached to the up-rising U-bar and the top of the back rest. The seat and the back rest, in a ninety degree angle to each other, are slanted backward to allow the sitter a lounging position and to shift the weight back, behind the center of the frame. This weight shift prevents the overstressing and subsequent breakage or tilting forward of the chair, yet it still offers a great amount



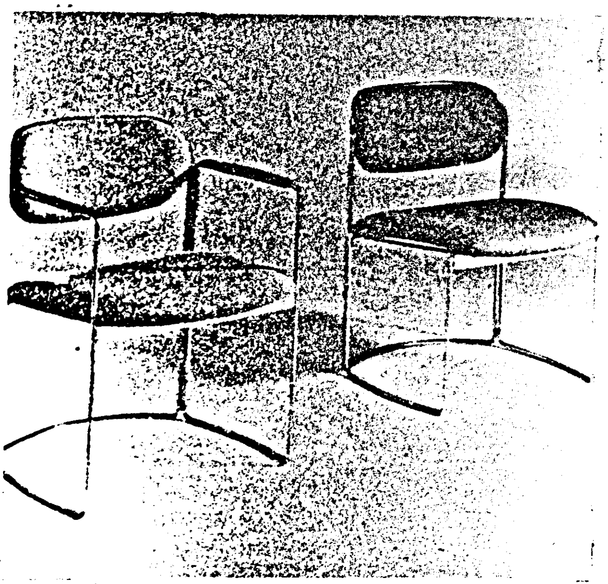
Pl. 85. Leather easy chair, Paul Tuttle, 1973. In: <u>Architectural Record</u> Mid-October 1973, p. 140.



Pl. 86. Sketch, Z-Frame, Mies van der Rohe, 1973. In: Glaeser, Ludwig Mies van der Rohe, p. 71, no. 92.

of resilience. For additional sitting comfort, Tuttle's easy chair is furnished with soft seat and back leather cushions. The amount of resilience of the Z-frame chair can only be achieved by the use of bar stock steel of the highest quality and through extensive familiarity with the laws of statics and the physical properties and limits of the material. The 1973 leather easy chair was distributed by Thonet Industries, Inc.

In 1977, G. F. Business Equipment, Inc. introduced Earl Koepke's Fine Line seating series (pl. 87). The frame of the chairs of this series is constructed of a very small diameter chrome-plated metal rod. The frame of the armchair consists of three basically rectangular shaped continuous metal rods, the horizontal sections of which are slightly curved to give the chair better footing. The two side elements, forming the front legs and arm rests, are attached with flanges to the higher back element at the rear vertical rods. The front verticals of the side elements are connected by a metal bar, functioning as a seat rail. The rear edge of the padded seat rests on a metal bar connecting the verticals of the back elements, which also encircles the horizontally-curved back panel. The Fine Line armchair is of a very light and transparent appearance

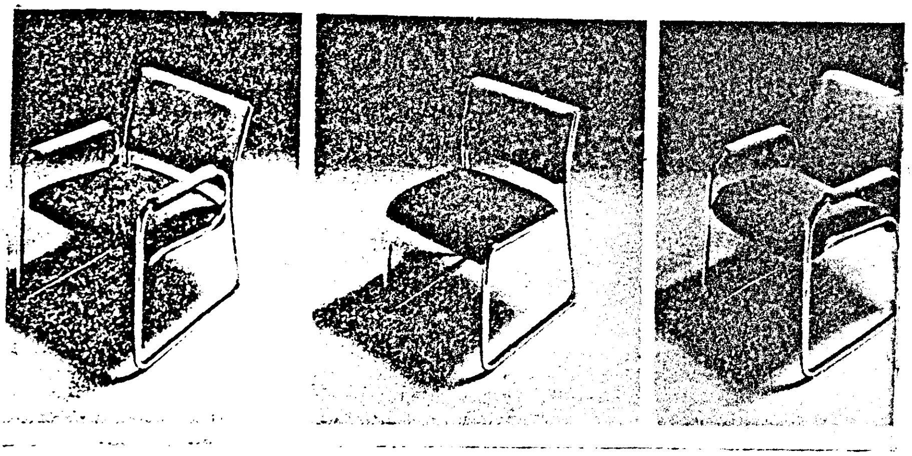


Pl. 87. Fine Line, chair series, Earl Koepke, 1977. In: Progressive Architecture, September 1977, p. D10.

and its frame enhances the impression that the seat and the back panel are suspended in mid-air, an effect only possible through the use of high tensile-strength steel rod for the frame construction.

Charles Gibilterra, in connection with Vecta Contract, had worked on a new construction principle for tubular steel chair frames since 1971, applying methods used in airplane wings. These construction principles made it possible to grant multi-directional flexibility of a frame structure. In 1972, Gibilterra introduced his first chair design, based on airframe principles. He continued to develop a series of seven chairs for Vecta Contract, the most recent an executive chair in 1978.

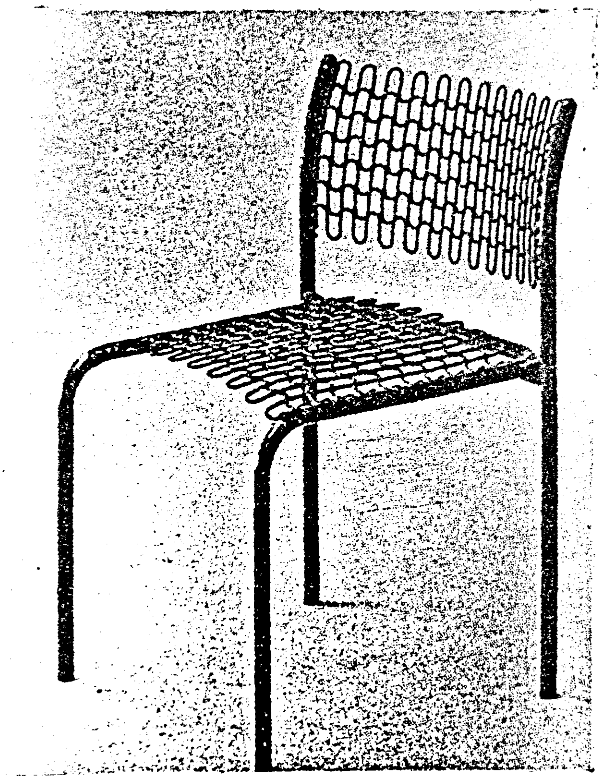
The frame of Gibilterra's Executive chair of his "Gibilterra Series" (pl. 88) consists of two continuous metal tubes, bent in an overlapping trapezoidal line, nearly describing a stylized figure six. The seat made of steel rod and Pirelli webbing,[52] is attached to the lower horizontal in a cantilever fashion. Its front and rear edges are curved downwards. The back rest, constructed like the seat, is curved in a convex curve to support the lumbar region. It is attached to the downward extension of the arm rest, thus nearly touching the rear



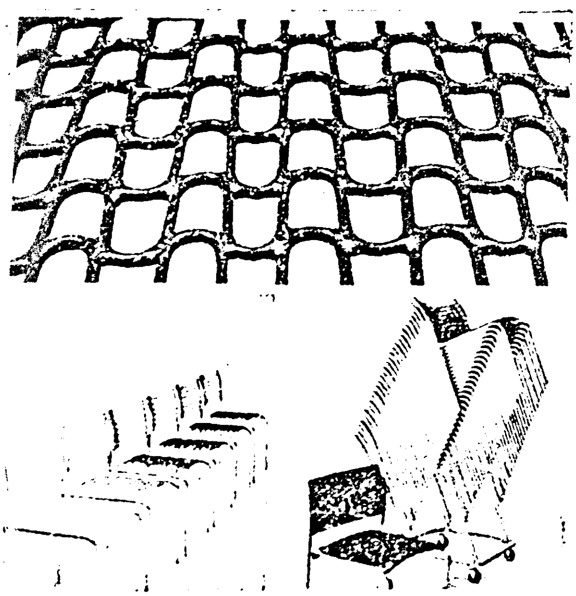
Pl. 88. Gibilterra Series, Executive Chair, Charles Gibilterra, 1978. In: Progressive Architecture, May 1978, p. 15.

edge of the seat. Both the seat and back are fixed to the side frames with so-called floating head bolts,[53] which allow a lateral flexibility of the seat and back panel independently from each other. As a result of the airframe construction of the "Gibilterra Series", all of its chairs offer resilience as well as lateral flexibility. These qualities render the chair's frame structure immune to the strains of vertical or lateral impact or thrust and give it great sitting comfort. The multi-directional flexibility of the "Gibilterra" necessitates the use of tough, high tensile-strength metal tubing and metal bolting.

Since the 1950s, the designer David Rowland had been toying with the idea for the Sof-Tech (pl. 89) stackable chair. Finally, the chair was introduced by Thonet Industries at the NEOCON in 1979. Rowland's aim with this design was to create an ergonomic chair design for mass-seating. He constructed his Sof-Tech chair by employing a bent U-shaped frame, forming the front supports, side rails, and back rail, connected by triangular flanges to two vertical steel tubes, which function as supports for the back rest. The seat and back rest of the chair consist of "Soflex" (pl. 90), a patented webbing of sinus springs with a plastic coating, which



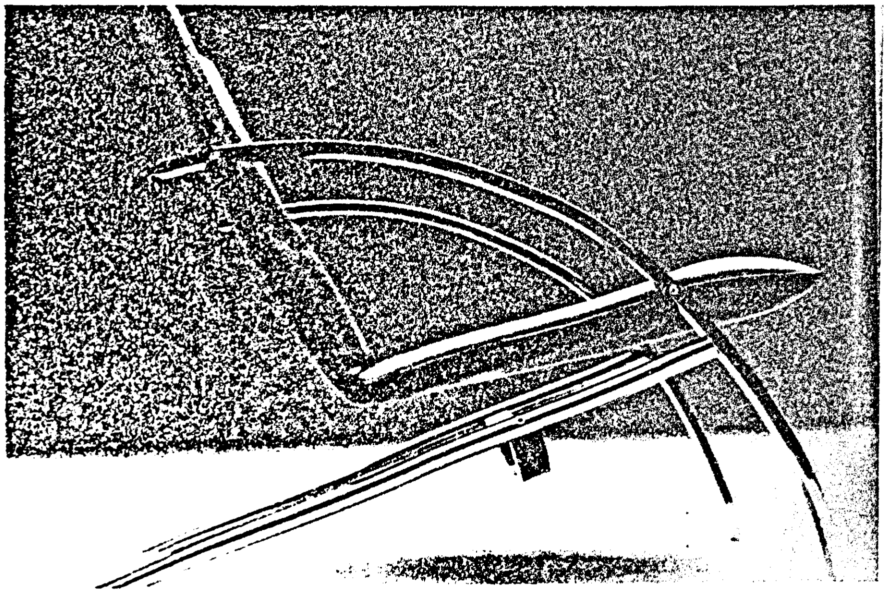
Pl. 89. Sof-Tech, stacking chair, David Rowland, 1979. In: Interior Design, August 1979, p. 167.



Pl. 90. Sof-Tech, stacking chair, David Rowland, 1979. In: Interior Design, August 1979, p. 167.

makes welding unnecessary and weatherproofs the metal webbing. The "Soflex" offers multi-directional flexibility, which in combination with the lack of a front rail or a cross and top rail, allows the seat and back rest to adjust to the sitter's movements. The chair frame is kept flexible, since Rowland omitted any stretchers, a fact which lets the front legs compensate for uneven floors. The Sof-Tech is also produced with zipped slip covers for the seat and the back rest, and a wide variety of frame finishes in chrome or polyester powder-coated. The chair is light-weight and of actual transparent appearance. In the case of the Sof-Tech chair, Rowland's fascination with the metal sinus springs led to the development of the design. This development, according to David Rowland, will have a strong impact on chair design.

The 1980 Pacifica Awards Competition with the motto: "Designed and manufactured in the West" awarded Paul Tuttle's Arco chair (pl. 91) the first prize for contract furniture seating. The Arco chair consists of an unusual chrome-plated steel frame of two oblique steel tubes, connected by a curved steel bar below the seat. The steel tubes are welded to two lateral angular-section steel elements, which rise up to the back rest



Pl. 91. Arco Chair, Paul Tuttle, 1980.
In: Designers West, March 1980, p. 32.

in a quarter circle. They form the front supports and hold the continuous seat and back rest with four bolts suspended between them. The leather covered seat and back rest of the chair and its smooth, high-polish frame give the design an interesting reciprocal visual as well as tactile effect. The problem of statics is solved in the proportioning of the intersection of curves and angles of the frame construction, as well as by Tuttle's familiarity with the material's strength in relation to its sectional dimensions. The jury's comment, published in Designers West reads:

> Clean, sweeping lines, good integration of materials and interesting contrast of soft and hard surfaces. There is no sacrifice of function in order to achieve this appealing sculptured chair.[54]

Summary of Characteristic Features of Metal Chair Design

In examining a selection of metal chair design created since the Bauhaus period through 1980, it becomes evident that the development of metal chairs was influenced by a number of factors, such as the impact of the new architecture, the trend toward functionalism as a primary design goal, the increasing awareness of the social necessity for mass-produced and thus inexpensive chairs, and particularly the progress of the iron and steel technology.

The construction of metal chairs differed increasingly from the traditional construction methods of wooden chairs. These wooden chairs generally consisted of a seat with seat rails, supported by front legs and back legs which extended into back posts with cross and top rails. The legs had to be stabilized by stretchers to prevent them from collapsing under thrust. The high tensile strength and resilience of metal bars, rods, or tubes allowed cantilever construction and thus, the omission of front or back legs, and suspended seats. With the progress in steel technology, metal chair frames could be built of continuous tubing, necessitating only one weld. The process of mandrel bending eliminated solid steel cores in tight curves of cold drawn, seamless steel tubes. The increased resilience and tensile strength made it possible to reduce the structural elements of chairs to the absolute essential. This reduction to simplified, impeccable lines complied with the demands of the new architecture of the International Style, stressing functionalism and advocating designs which lend themselves to industrial mass-production. The optical and physical lightness and transparency of the chairs was regarded as being symbolic of modern technology. Their clean lines and mostly rectangular or square plans did not interfere with, but rather enhanced the cubic shapes of the architecture and the continuous spaces of the interiors. Besides these aesthetic criteria, the new metal chairs also met the demand for mobility and portability, allowing easy changes in their placement and, if stackable, necessitating only little storage space.

But the new metal chairs were not only of simple and self-contained designs and in accord with the principles of the new, modern aesthetics, they also were more resistant to the wear and tear of public seating and were nearly maintenance free. The carrying glide runners of some of the designs proved to be easier on flooring as well. In addition to the aim of functionalism, a new goal was introduced to chair design, the goal of developing chairs according to orthopedic criteria. While Breuer and Mies had still worked on mastering the new material, trying to take advantage of all the possibilities it offered in the context of form and construction, the post-war generation of designers also included the aspect of ergonomics in their studies of innovative chair designs. Subsequently, frame construction gained multi-directional flexibility and was furnished with highly intricate adjustment mechanisms. Ergonomic design became a primary concern particularly in office chair design and in seating for the transportation industry. A great number of the technological features of chair design were based on or closely related to airplane construction, revealing the designers' never-ceasing interest in the structural improvement of chairs, making use of every technological advance that was applicable to chair design.

CHAPTER II

PLASTIC CHAIRS

The Development of Modern Plastics and their Technology

Although plastic materials are generally thought of as materials of post-World War II modern industry, their development actually started in the second half of the nineteenth century. While the progress in the development of plastics was relatively slow in the beginning, it has become more and more rapid during the last fifty years.

The first man-made plastic material was exhibited at the International Exhibition in London in 1862. The material was discovered by Alexander Parks and consisted of a mixture of cotton waste, nitric and sulfuric acids, castor oil, camphor and coloring matter. The result was a compound which could be molded. Unfortunately, though, the so-called Parkesine did not lend itself to being produced industrially. In 1868, the American, John Westly Hyatt, was able to solve Parks' problem by substituting the castor oil with camphor, and so developed a compound called Celluloid. Celluloid had excellent molding qualities, but its flammability was a great disadvantage. Since 1872, chemists, such as Adolf Bayer and Arthur Smith, experimented with phenol and various aldephydes, in order to find an alternative to Celluloid. They were able to develop phenolic resins, which, with the inexpensive fabrication of formaldehyde, were eventually mass-produced after Smith took out a patient for phenolic resin in 1899. In 1904, James Swinsburne's Fireproof Celluloid Syndicate in London began to produce and sell phenolic resin.

But only after the Belgian chemist Leo H. Bakeland had developed Bakelite in 1908 could plastic material be successfully used in industrial production. Bakelite was also made from phenol and formaldehyde, though in a different process which allowed the control of the two ingredients. Bakelite was a gummy compound which could be molded into any shape and would set through heat and compression.[1] With Bakelite, the future plastic industry was laid.

It was the discovery of the formation of big polymer molecules, composed of a number of smaller ones, that made the production of man-made plastic materials possible. Subsequently, the progress made in the development of the various organic high-polymers, each one with a peculiar set of properties, was breathtaking. One reason for the rapid development in Germany, for example, was the extreme shortage of rubber during World War I, when a substitute material was urgently needed for military purposes.

In 1934, the American chemist W. H. Carothers made Nylon. By that time, chemistry had improved in its understanding of polymerization mechanisms, and the development of polymers by adding monomers to each other could be realized more scientifically and no longer chiefly relied on chance.

Acrylic was first made in 1936; Polyvinyl Acetate was developed during the same year. In 1938, Polystyrene was invented, and in the same year, Otto Bayer produced Perlon-U, which has similar properties as Nylon and the various other Polyamides. During the 1940s, a number of chemical and technological processes were developed which led to the invention of Polyester and Polyethylene in 1942, Silicones and Fluorocarbons in 1943, Epoxy in 1947, and ABS (Acrylonitrile-Butadiene-Styrene) in 1948.

To gain even more control over the chemical reactions during the forming of polymers and to be able to determine the properties of the resulting materials, new methods of catalysation were developed in the 1950s, by Prof. Karl Ziegler and Prof. Giulio Natta. The result of their research was high-density polymers, which could be produced under less pressure but showed more rigidity and a higher softening point. With a more and more thorough understanding of the polymer molecules, the possibilities of plastic materials have become nearly unlimited.

The various industries quite rapidly have been taking advantage of the newly developed compounds; at first as inexpensive substitutes for traditional materials, then using them true to their peculiar properties and characteristics. During the process of putting plastics to use in mass-production, a number of different manufacturing methods for plastic objects were developed according to the varying behavior of softened or liquified plastics.

The first consideration in the manufacturing technology was whether the plastic to be used was a thermosetting plastic or a thermoplastic. Apparently, most plastics used in the production of furniture in general, and chairs in particular, are thermoplastics. This means that at normal temperatures, the long, interlaced molecules remain in a stable position. When the plastic is heated, the molecular structure becomes flexible, and the molecules start moving around. The plastic becomes fluid at its peculiar softening point. When the plastic has cooled off again, the original molecular structure is re-established. Some thermoplastics have a property called "plastic memory", referring to the quality to return to their original form after heating. The various plastics for the respective products are chosen by matching their peculiar characteristics and the requirements of the design. Molding qualities, heat resistance, moisture resistance, dimensional stability, effect of sunlight, burning rate, clarity and color, machining qualities, mold shrinkage, toxicity, and resistance to chemicals and stains are some of the properties to be taken into consideration, previous to their application in a certain design.

The plastics most frequently used in the production of chair designs are as follows: Polyester, often reinforced with fiberglass; Polyethylene; Acrylic; ABS; Nylon; Polystyrene; and Polyporpylene. Except for Polyester, which is a thermosetting plastic, all of the above are thermoplastics of excellent molding quality with a heat resistance ranging from 140° Fahrenheit to 400° Fahrenheit.

Polyester, developed in 1942, is a thermosetting plastic. It is usually reinforced with fiberglass, since polyester is not resistant enough to bending or strong impact, although it is hard and rigid. Commonly, polyester comes in forms of liquids, dry powders, or premixed molding compounds. Its heat resistance is 250° Fahrenheit and its dimensional stability is excellent, though it does warp in thin sections. Its machining and molding qualities are good to very good, and it is non-toxic. Polyester is resistant to most acids. Its burning rate is slow to self-extinguishing, if a flame retardant is added. Polyester was one of the first resins used in chair design, but not until 1950 was the industrial production economically possible.[2]

Polyethylene was invented during the same year as Polyester. It is a thermoplastic which, in its high-density form , has a heat resistance of up to 250° Fahrenheit. The high-density polyethylene used in chair manufacturing is rigid and burns only very slowly. Its clarity ranges from transparent to opaque; its machining qualities are only fair, whereas its molding qualities are excellent, although a slight mold shrinkage has to be considered. It is resistant to alkalis, but is slowly affected by acids. Polyethylene is non-toxic.[3]

Acrylic, often used as a substitute for glass due to its glass-like clarity, was developed in 1936. It lends itself excellently to machining and molding and has little mold shrinkage. Its heat resistance ranges from 140° Fahrenheit to 210° Fahrenheit, and some forms of acrylic are fire retardant. It is a material of high tensile strength and therefore is often used as reinforcing material for polyester. Acrylic, if colored, retains color very well, even under the effect of sunlight. It is resistant to breakage, but it is not scratch-proof. Acrylic is non-toxic and resistant to most household chemicals.[4]

ABS, standing for Acrylonitrile-Butadiene-Styrene, is a thermoplastic, developed in 1948. Its heat resistance varies between 140° Fahrenheit and 250° Fahrenheit, and it is resistant to most chemicals. It is translucent to opaque and may yellow slightly under the effect of sunlight. Its machining qualities are excellent. ABS has very little mold shrinkage. It withstands high impact and has excellent tensile strength and flexual strength, both important for furniture production.[5]

Nylon was invented in 1938. It is one of the thermoplastic polyamides with a heat resistance of 175° Fahrenheit to 400° Fahrenheit. It is tough and resilient and has high tensile and impact strength. It has excellent machining and molding qualities and only little mold shrinkage. Nylon is resistant to almost all chemicals, but it is easily scratched. It can be transparent, translucent or opaque. Its burning rate is slow to self-extinguishing, and it is non-toxic.[6]

Polypropylene is a thermoplastic, developed in 1954 by Giulio Natta. Its heat resistance ranges between 250° Fahrenheit and 335° Fahrenheit, and its burning rate is slow. It has excellent molding and machining qualities, although the mold shrinkage is up to 2 percent per inch. It is resistant to most chemicals and has high tensile strength and impact strength, as well as resilience. Polypropylene is the lightest commercial plastic and was the first suitable for injection molding since its toughness makes reinforcement with fillers or other plastics unnecessary.[7]

Vinyls come in a number of variations and all of them are thermoplastics. Polyvinyl chloride (PVC), developed in 1927, Polyvinyl acetate, made in 1936, and Polyvinylidene chloride, invented in 1939, are all rigid and have a heat resistance of up to 210° Fahrenheit. Their burning rate is slow to self-extinguishing and they are non-toxic. The three types of vinyl, mentioned above, have excellent molding and machining qualities, and only slight mold shrinkage has to be considered. They are resistant to most household chemicals, only attacked by strong acids.

The flexible types of vinyl are frequently used for coating of panels, upholstery, and metal surfaces. Those vinyls can be clear, transparent, translucent, or opaque.[8]

Polystyrene is a thermoplastic, developed in 1938. Its heat resistance ranges between 140° Fahrenheit to 250° Fahrenheit, depending on the variety. Styrene acrylonitrile for instance can be heat resistant. Most polystyrene varieties are brittle. Only Styrene Butadiene has good to excellent machining and molding qualities, though with a slight mold shrinkage, and is highly impact resistant. Polystyrenes are non-toxic and resistant to most household chemicals. They can be optically clear, transparent, translucent, and opaque in a full range of colors.[9]

All of the plastics, dealt with in chair manufacture can be, and often are, mixed with a variety of chemicals in order to achieve certain additional properties, colors, or textures. They can be mixed with various fillers like cotton, sisal, shell flour, soybean meal, and many more organic fillers. They can also be mixed with inorganic fillers and reinforcements, such as glass fibers, yarns, and minerals in order to achieve better impact strength or textures. They may also be blended with chemical stabilizers, resulting in higher resistance to heat, oxidation and ultra-violet light. Colorants are added for visual purposed in form of dyes and organic and inorganic pigments. These colorants may, depending on the type, also function as stabilizers. Consideration has to be given to any chemical changes induced by stabilizers or colorants, as for example a change in the original color of the resin through a filler, or a variation in the curing time of the resin caused by certain pigments, which has to be allowed for in the lower or higher concentration of the added curing catalyst. Colorants and fillers can also influence the transmission of light, if the indexes of light refraction of the filler and resin differ. Depending on the type of filler and colorant and the amount added to the resin, the cost of the plastic can be reduced dramatically, since most fillers, particularly, are very inexpensive compared to the cost of the resin. Thus more of the plastic compound can be produced with less resin content.

Plastic foams are actually expanded plastics, and their properties subsequently depend upon the properties of the original plastic. Plastic foams most frequently used in chair upholstery are Polyurethane, Polystyrene, and Polyether. Plastic foams are produced by adding a chemical compound which is being gasified when heated, and so, at the moment of plastification of the resin, inflates the resin cells. Some of these gas producing compounds, such as AZDN, also function as initiators for polymerization.

Depending upon the type of plastic used for a chair design, the resin compound has to be processed and formed by various machines, according to the desired shape of the end product.

Mixing is generally the first step in the production line. This process is done with either an "open roll mill" or an "internal mixer". The first consists of two rolls, rotating toward each other, which are heated or cooled from the inside. The rolls differ in rotating speed as well as temperature, to prevent the sheet of compound from separating. The compound is kept at flow temperature to ensure even mixing and evenly rolling itself around one of the rolls. By virtue of the shearing action of the rolls, the compound is eventually satisfactorily mixed and proceeds to further processing.

The internal mixer represents an alternative method, predominantly used for polymers which, if mixed in the open roll mill, could suffer under the high temperature. The internal mixer consists of a closed chamber in which rotating blades knead the compound. Both machines can perform in a continuous action, being fed with the necessary components while the evenly mixed resin is put out.

Extrusion of polymers is usually done with extruders, consisting of an "Archimedean screw, rotating inside a heated barrel",[10] feeding into various molds or through a die, such as a hole, a rectangular slit, or a wide narrow slit. The form of the die determines the shape of the extruded polymer. The extruder can produce rods, tubes, pipes, bars, sheets, and film. It can also feed into split molds, in which a stream of compressed air blows the polymer to the walls and forms a container.

Vacuum forming and blow molding are two related processes in which a softened piece of plastic is forced into the interior surface of a mold under the application of air pressure or by forming a vacuum. The pressure is held until the plastic has cooled off and stiffened over the shapes of the mold.

Injection molding was done by heating the granulated plastic in a cylinder through which the material is forced by a plunger and made fluid enough to be injected into a cold mold. After cooling, the material is ejected. Another variation of injection molding has been developed to increase the efficiency of production. In it, granulated material is forced through a cylinder by a reciprocating screw. By virtue of external heaters, and the shearing action, the material melts while being moved forward. When the desired amount has collected in front of the screw, the screw stops rotating and pushes the material into the mold.

Compression molding is generally used for thermosetting polymers, such as unsaturated polyesters. In this process, granulated polymers or pellets of a polymer are placed between the die and the punch and are heated to a fluid consistency by heaters and pressure. The fluid compound fills the individual molds and the connecting cross-links between them. The cross-links are needed to facilitate the removal of the molded material without endangering distortion of the molded parts. If compression molding is used for shaping thermoplastics, the mold has to cool off prior to removal of the molded material.

In the production of plastic seat shells or entire plastic chairs, the material has to satisfy a number of criteria. Aside from the visual appearance, it has to be resilient, impact resistant, and resistant to light and household chemicals. The material has to have a satisfactory tensile strength or it has to be reinforced with certain fillers and other components. Its molding and machining qualities have to be known in order to facilitate inexpensive production without much or any involvement of handwork.

In the beginning, plastic chair production was problematic, because quite a number of facts were yet unknown. Some chair designs executed in plastic turned out to be more expensive due to the high amount of machining it took to manufacture them. On the other hand, plastics were often used as inexpensive substitutes for wood, metal, or glass which resulted in low appreciation of plastics. Only after designers, as well as manufacturers, had gained enough knowledge about the characteristics of plastics and the required technology was it possible to be true to the new material and to do it justice.

The Socio-Historical and Architectural Background of Plastic Chair Design

In order to understand the socio-historic background of the "plastic age", it seems necessary to remember the political and economic situation since 1945. Although, a number of plastics were developed since 1860, the manufacturing of plastic products was limited until the middle of the twentieth century. Nevertheless, plastics slowly entered almost every aspect of every day life. During World War I, plastics and synthetic rubbers were used as substitutes for natural rubber. During the period of World War II, most industries were forced to leave the major part of raw materials, such as metals and petroleum, to the manufacturers of military equipment. Thus the production rate of peace-time products stagnated. On the other hand, though, various materials as well as technologies were further developed since needed in the war effort.

Under the presidency of Harry S. Truman, 1945-1953, the United States became the military as well as the economic leader in the world. Reconstruction was in its beginning phases all over Europe, and with the start of the Cold War in 1947, the United States became the protecting power of the free Western World, granting military and economic support in the 1947 Truman Doctrine and the Marshall Plan.

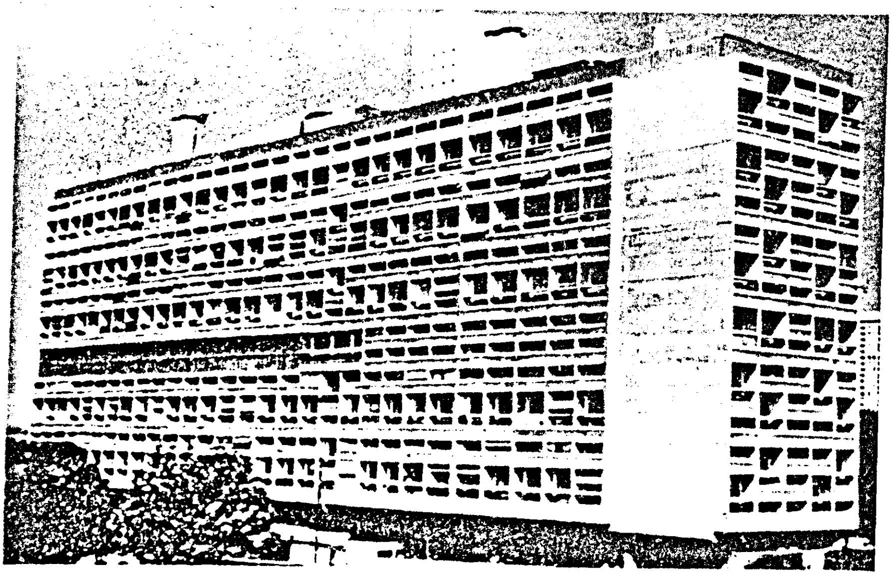
The termination of World War II had resulted in a diminished demand for military equipment and subsequently in the lay-off of workers in the supplying industries. Another result was the sudden availability of petroleum and various other, formerly rationed, products. It was now that the technological processes made during the war could be taken advantage of by all industries readjusting to peace-time production.

With the re-establishment of a peace-time economy in the United States, family-life and the "American Dream" celebrated a come-back, and a wave of modernity and science rapidly conquered day-to-day life. Plastic products became one of the symbols of the scientific era, the age of air-travel for the masses and space-exploration programs.

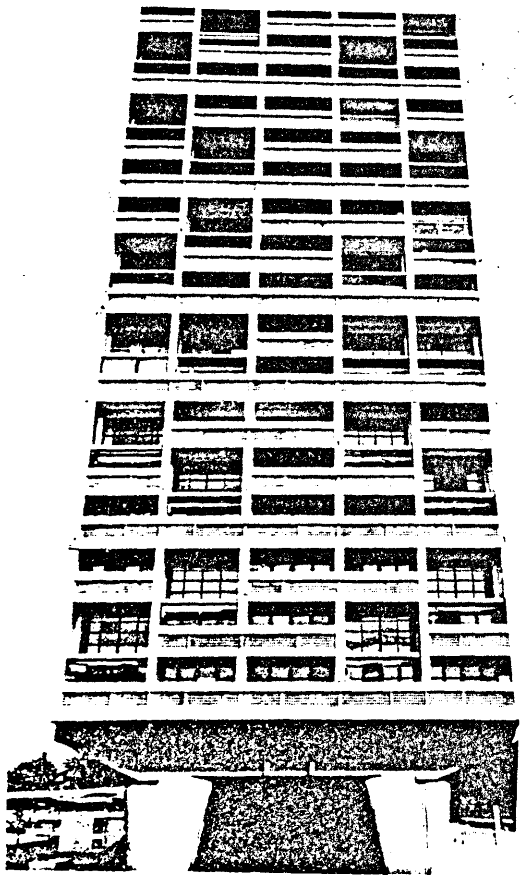
Europe impelled the building of mass-housing and the construction of its industries, aided by United States credits and raw materials. The economic boom, due to the Korean War, accelerated the world economy after 1950 and led to the quite rapid recovery of the world production and international trade. The industries in general, and the building industry in particular, flourished, using new materials and technologies, as well as new building concepts.

Le Corbusier introduced beton brut in his Unite d'Habitation in Marceille of 1947-1952 (pl. 92 and pl. 93), also showing some deviation from the smooth, angular International Style, still widely prevalent. While maintaining its functional elements, the building was impressive in its somewhat exaggerated proportions, its broken-up wall surfaces, and its elevated body. With it, Le Corbusier not only set a trend for the well thought-through lay-out of spaces for communal and private purposes in mass-housing, but also for the use of raw concrete as a new material.

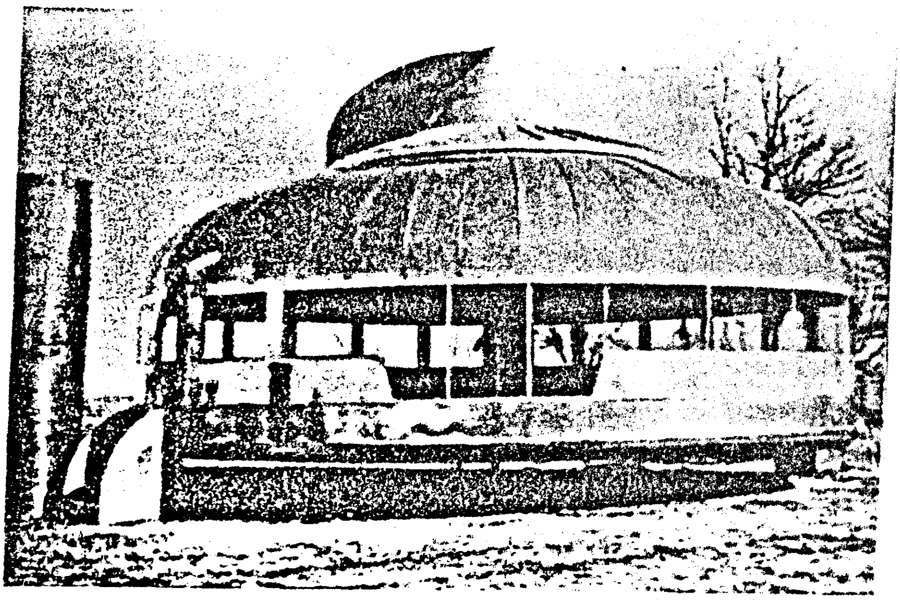
While cubical forms were generally maintained, in government mass-housing, other buildings began to employ curved planes and obtuse angles in the uprising exterior walls. Buckminster Fuller's 1946 Wichita House in Kansas (pl. 94), Frank Lloyd Wright's Guggenheim Museum in New York of 1946-1959 (pl. 95), and Le Corbusier's Ronchamp Chapel of 1950-1955 (pl. 96)



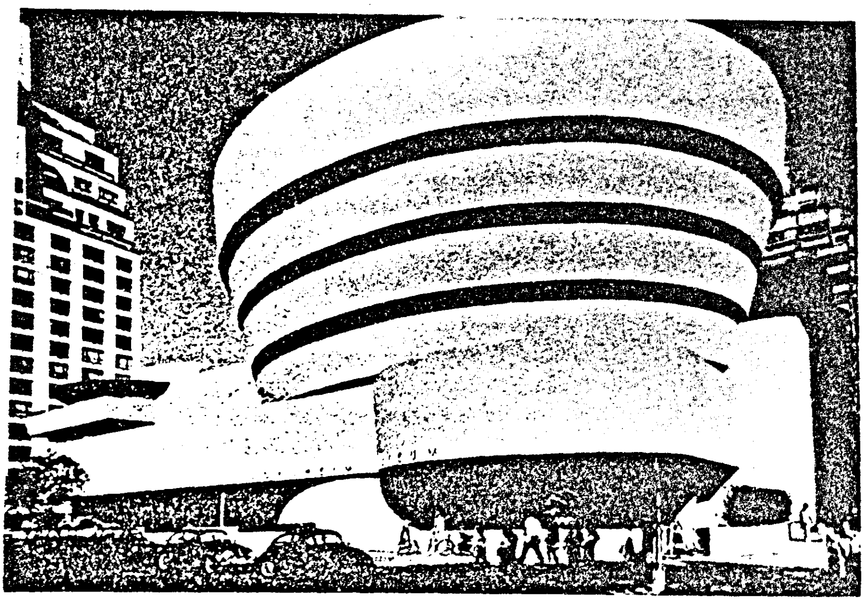
Pl. 92. Unite d'Habitation, Marseille, 1947-1952, Le Corbusier. In: Jencks, Le Corbusier, p. 141, no. 79a.



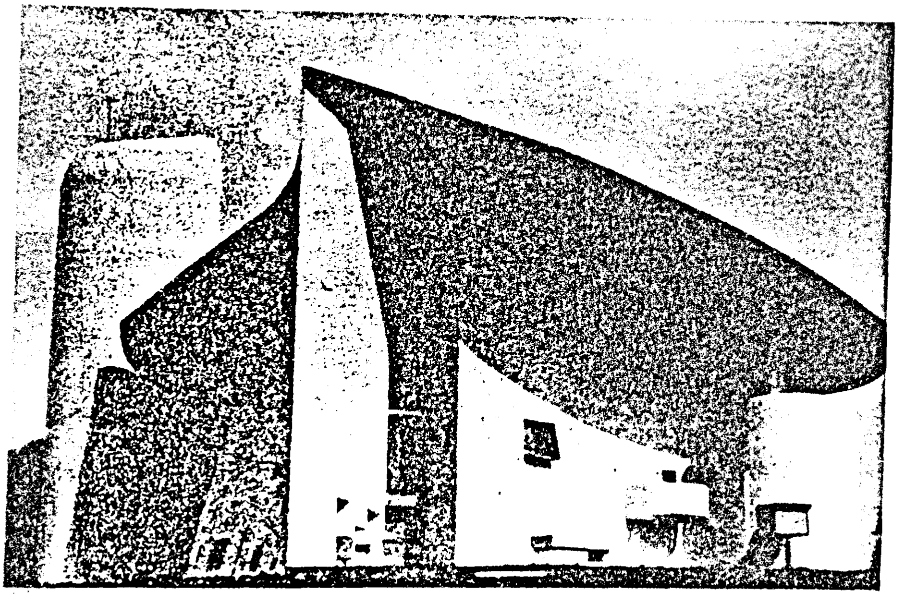
Pl. 93. Unite d'Habitation. In: Jencks, Le Corbusier, p. 141, no. 81a.



Pl. 94. Wichita House, Kansas, 1946, Buckminster Fuller. In: Heyer, Architects on Architecture, p. 383.



Pl. 95. Guggenheim Museum, New York, 1946-1959, Frank Lloyd Wright. In: Jencks, <u>Modern Movements in Architecture</u>, p. 136.



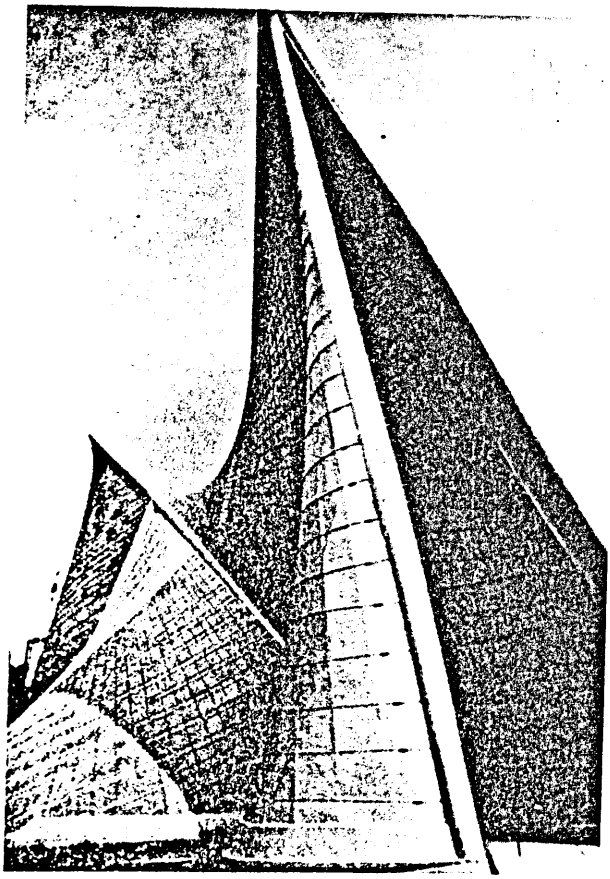
Pl. 96. Ronchamp Chapel, 1959-1955, Le Corbusier. In: Jencks, Modern Movements in Architecture, p. 155.

and his Philips Pavillion in Brussels of 1958 (pl. 97) were the first actual built evidence of a new three-dimensional architecture. As Gropius stated in Architects on Architecture:

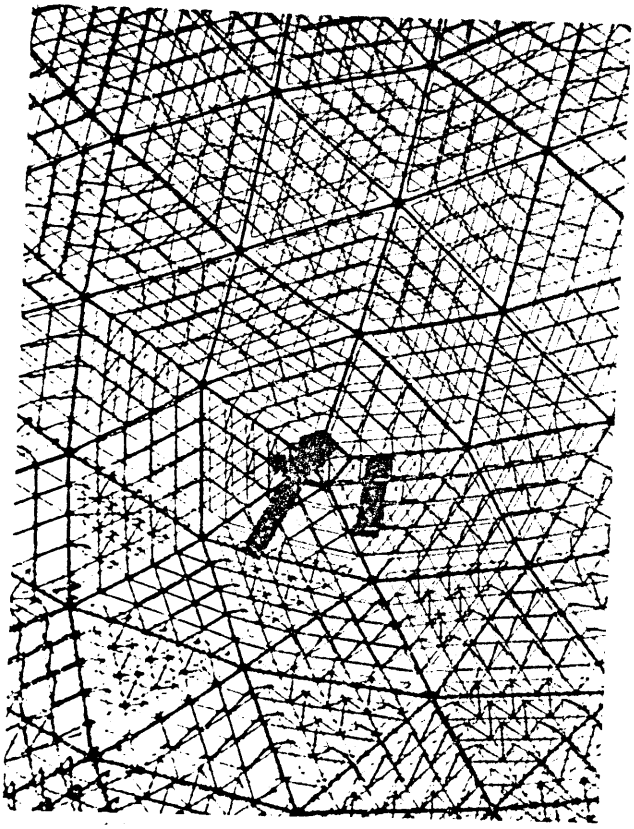
> If one compares the typical architecture of the 1920s with that of today, the most significant development lies in the increasing accentuation of three-dimensional plasticity. Structural boniness, curved shells, recessed and protruding building parts offer a rich play of light and shadow absent from the surfaces of the curtain wall, which, for so long, has become the one-sided trademark of modern architecture.[11]

The three-dimensionality of post-war architecture was achieved by new building techniques which were closely connected with machine-made building materials and pre-fabricated building elements. The structural approach to architecture changed from post and beam constructions to continuous structures, made possible through the development of the space-frame (pl. 98) and pre-stressed concrete. But these new tendencies, evident in some of the monumental public buildings, were not as readily employed in the mass-housing projects in Europe or the average residence in the United States.

The almost total destruction of the European cities during World War II resulted in a strong involvement of government agencies in the construction of mass-housing. First and foremost, the housing



Pl. 97. Philips Pavillion, Brussels, 1958, Le Corbusier. In: Jencks, Le Corbusier, p. 164, no. 96.

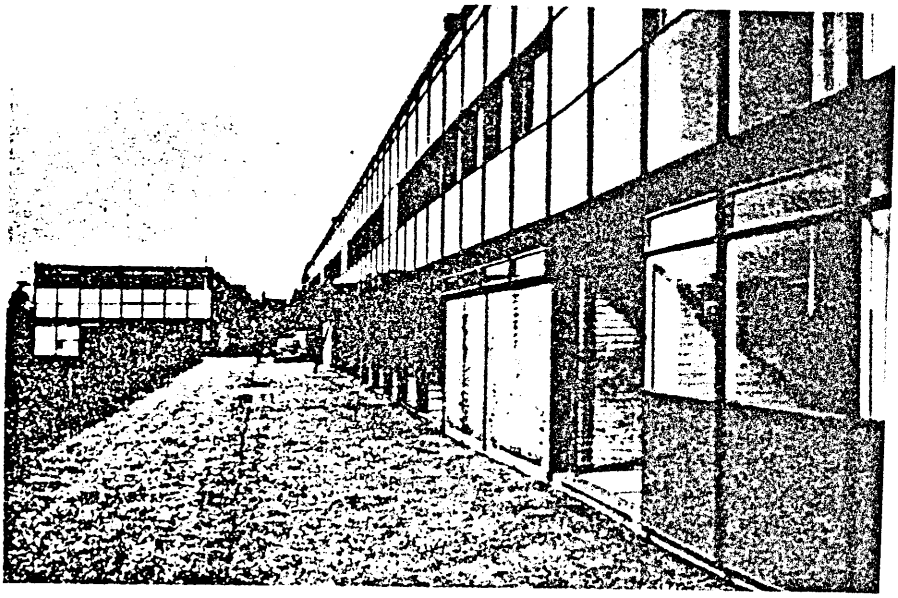


Pl. 98. Ford Rotunda, Detroit Michigan, 1953, Buckminster Fuller. In: Heyer, Architects on Architecture, p. 383.

developments had to be built as quickly as possible. Since London, for example, had lost one-third of its housing, satellite "New Towns" and "Garden Cities" were designed and built by employing industrialized building, supported by the London City Council (LCC). Duncan Sandys, Minister of the Conservative Party, explained:

> We desire as much as anyone to maintain diversity of design and scope for the individual talents of architects. But first things must come first. The houses must go up and nothing must stand in the way.[12]

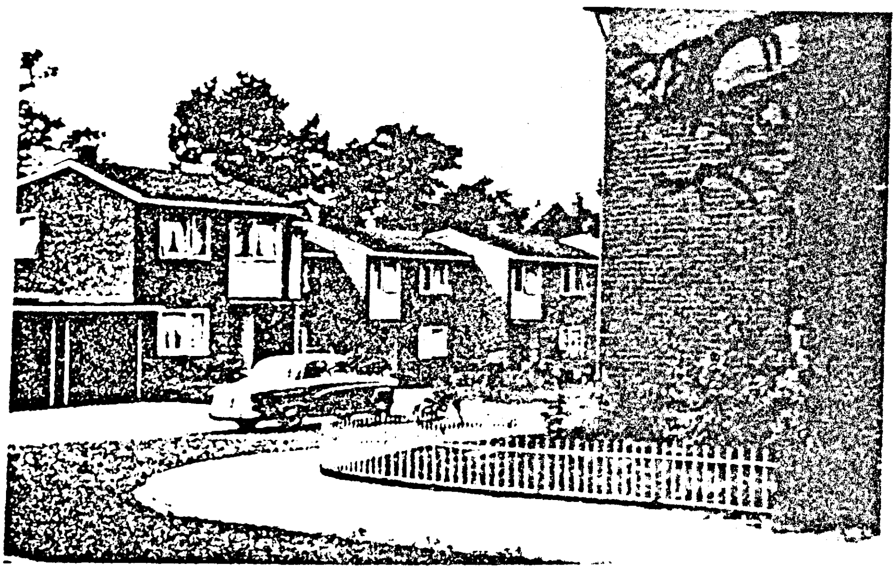
The result of this attitude was a vernacular architecture, built with repetitive design elements which were meant to create flexibility and indeterminacy in a standardized architecture. It often could be somewhat related to a pared-down International Style or Le Corbusier's Purism, and it was justifiable because of tight budgets and because it was considered modern. But the conflict between the need for inexpensive, fast, industrialized building, and innovative design also resulted in what was called the "New Brutalism", "definitely in the academic tradition of calculated 'movement'."[13] This new style was applied in the building of the Hunstanton School, Hunstanton, England, by Alison and Peter Smithson, in 1949-1954 (pl. 99).



Pl. 99. Hunstanton School, Hunstanton, England, 1949-1954, Alison and Peter Smithson. In: Jencks, Modern Movements in Architecutre, p. 251.

The post-war economy of the United States recovered quickly, and soon building was flourishing on the residential, as well as in the governmental and corporative sectors. The monumental architecture of the latter two was on one hand still holding on to a Miesian style of steel and glass structures with mirror-like curtain walls; on the other hand, it allowed innovative construction methods and new creative shapes of a "three-dimensional" architecture. Residential housing continued in a steady growth, attempting to satisfy the great demand. Some designs were influenced by Frank Lloyd Wright; some were built in the style of the Bauhaus or Mies van der Rohe. The open space plan and angular lines were very prevalent elements.

To accomodate people left without homes through the destruction of the war, quickly constructed housing projects, such as Roehampton (pl. 100), the Unite d'Habitation (pl. 92 and pl. 93), and many more were needed in Europe. The development of housing in America was rather dictated by the constant transition of people moving from one side of the country to the other. More housing became necessary at a great number of colleges and universities and in the vicinity of the newly



Pl. 100. Roehampton Housing Development Alton East, Roehampton, England, 1953-1956, LCC Architects. In: Jencks, Modern Movements in Architects. p. 245.

developing industrial areas. Satellite cities began to spread around major metropolitan centers of the country, and a general movement to the suburbs set in, together with a massive development of a vernacular architecture which increased to a point of mass-production and repetition of identical residential buildings with identical facades and floor plans. Pseudo Victorian, Pseudo Colonial, Pseudo Prarie-Style, and International Style were represented in the rows of residences along the grid-pattern of streets in the new suburbs. They were followed by large shopping centers and apartment complexes of the same vernacular styles in the late 1950s. The shopping centers became necessary to accommodate regional shopping as well as social gathering places for suburbanites: " . . . it is becoming apparent that the necessary 'social glue' is largely being provided by the regional shopping mall."[14]

The attempt of city-dwellers to get out of the city and closer to nature was only one factor leading to suburban sprawl. Other reasons for the growth of satellite communities were the exorbitant land prices in the cities, which made it impossible for families to own their own home, the increased mobility, facilitated through a network of highways and the relatively economical use of cars and gas, and eventually the establishment of various commercial and industrial developments throughout and around the residential suburban areas. All of these factors also led to the earlier mentioned mass-production of family dwellings and, as William Cowburn stated in an article in the Journal of the Architectural Association:

> People want a standardized article which they can "own", "embrace", and "understand", . . . (they) can "embrace" the car, the fridge, and the detached bungalow, not the insignificant unit in a block of flats![15]

In 1950, Mies articulated his philosophy of architecture as "the real battleground of the spirit"[16] and the conviction that " . . . architecture depends on facts, but its real field of activity is in the realm of significance . . . and has nothing to do with the invention of forms."[17] But in 1958, Hundertwasser declared in his "Verschimmelungs Manifest" (Mould Manifesto Against Rationalism in Architecture):

> The material uninhabitability of the slums is preferable to the moral uninhabitability of functional, utilitarian architecture. In the so-called slums only man's body can perish, but in the architecture ostensilby planned for man his soul perishes. Hence the principle of the slums, i.e. wildly proliferating architecure, must be improved and taken as our point of departure, not functional architecture.[18]

By 1960, Reinhard Gieselmann and Oswald Mathias Ungers' work Toward a New Architecture presented possible solution to Mies' and Hundertwasser's controversy, explaining architectural design by stating, "Form is the expression of spiritual content."[19]

The ambivalent attitude of owning a mass-produced article, which by the freedom of choice from a wide variety of products gained kind of pseudo-individualism, was applied to nearly all objects. The cost of hand-made or custom-made products, including furniture, had become so high that it was not affordable but for the very well-to-do. Subsequently, almost all production processes were industrialized to a point at which no handwork was needed anymore. The consumer-market was born, and it was often the consumer who dictated alteration of design and fast-changing fashion trends, after the mid-1960s.

Since the launching of the first spaceship in 1957, the influence of science on every-day articles became remarkably evident in their designs, as well as in their materials. Modernity was expressed in streamline, and plastic as a modern material became a symbol of the ingenuity of mankind, a triumph of science. As Thelma R. Newman said in her book Plastics as an Art Form:

"Historical evidence points to the emergence of a changed aesthetic when a new medium is introduced."[20] Plastic was in many cases a superior material to what had been used previously. It was functional and practical; since nearly maintenance free, it was available in a large variety of colors and was more hygienic than wood, leather, or fabric. It was often nearly indestructable, scratch and stain resistant, and light-weight. But foremost, in time, it became much less expensive than other materials with similar qualities. Therefore, it encouraged the new consumer-society to speed up the turn-over of every-day objects. "Newness" became a status symbol, frequently with the result of innovation for its own sake, and not necessarily for the sake of improvement. Gillo Dorfles stated:

> The success of much so-called "industrial" design has been largely through its acceptance as symbol --as conveying the image of functional modernity rather than its actuality. One might trace this from the "Bauhaus-International" style to ergonomic tableware, streamlined typewriters, and the "contemporary" chair. Acceptance is related more to symbolic "status" than to any rationale of increased efficiency via improved design.[21]

Selected Plastic Chairs Important to the Development of Plastic Chair Design

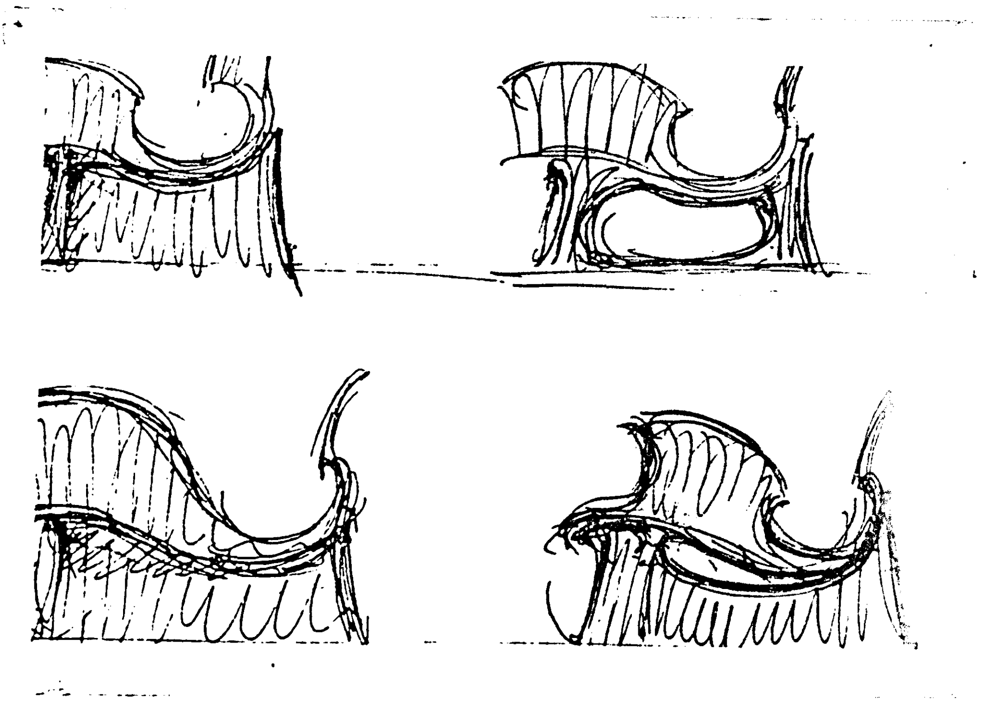
In relation to chair design, plastics brought on a number of new possibilities. Not only could plastic be used in upholstery, replacing leather and fabrics, as well as various traditional padding materials, but it was also used for coating metals.

With increasing familiarity with the new material, designers began to realize its suitability to the relatively new trend in chair design, namely ergonomic design. Plastics hardly imposed any limit on the realization of a desired shape of a seat bowl. The number of studies done on anatomically correct, or at least improved seating, increased.

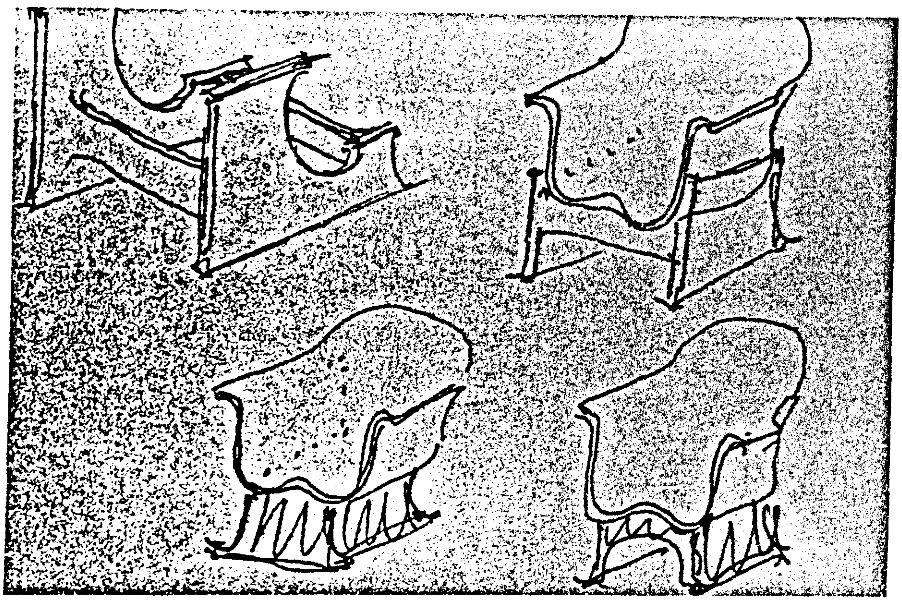
Subsequently, not only the general trend toward three-dimensionality, already apparent in architecture, but also ergonomic considerations were responsible for the innovative, sculptural chair designs, executed since the late 1940s. With that, the traditional approach to chair design was left behind. The new technological possibilities and ergonomic factors became mandatory elements. The problematic of the feasability of industrial mass-production though required a close collaboration of designers and industry. "American designs seemed to assert that the designer in close day-to-day alliance with the latest technology could always do better than one who restricted himself to occasional collaboration with it."[22]

The plastic industry, though, was not yet able to produce plastics with sufficient tensile strength inexpensively enough until 1954, and appropriate molding methods were only in the process of being developed. Consequently, a great number of chair designs still relied on metal supports, which led many designers to various, more or less satisfactory solutions. But with the improvement of materials as well as technology, the possibilities of the new plastic materials were certainly inspiring to a great number of designers. The concept of flowing forms, nearly unlimited by the traditional laws of construction wood and metals imposed on the practicability of a design, seized the minds of designers all over the world.

It seems possible that Mies van der Rohe's sketches of the early 1940s (pl. 101 and pl. 102) were inspired by the new materials. They may have been influenced by the idea of "Organic Design" and his experiments in the construction of an innovative ergonomic design for a car seat on one hand, and very possibly



Pl. 101. Sketches of conchoidal seat shells, 1946, Mies van der Rohe. In: Glaeser, Ludwig Mies van der Rohe, p. 84, no. 245.

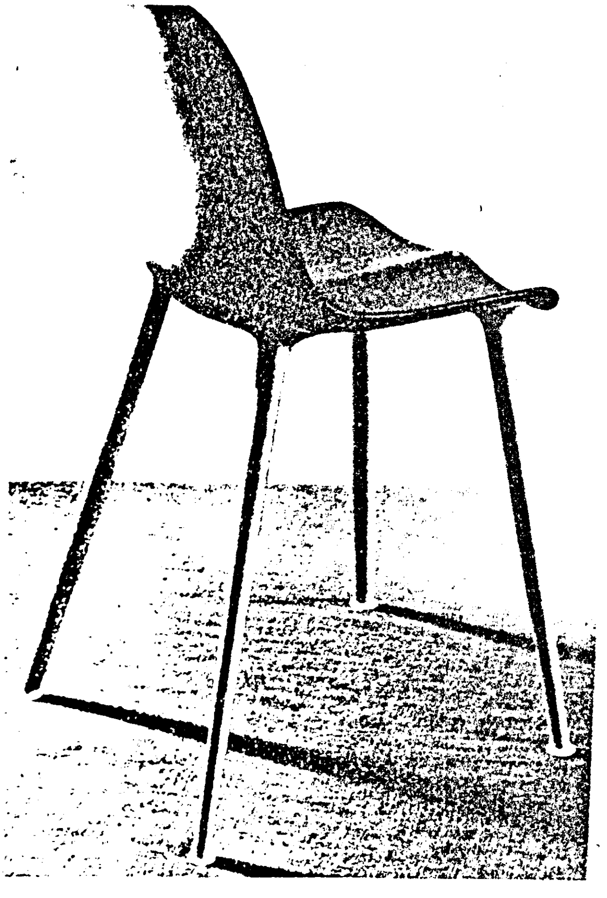


Pl. 102. Sketches of conchoidal seat shells, Mies van der Rohe, 1946. In: Glaeser, Ludwig Mies van der Rohe, p. 84, no. 126.

by the invitation to participate in a competition conducted by the publishers of Modern Plastics of 1936[23] on the other. The three-dimensionality of the sketches and the baroque flow of lines suggests a new medium, since previously Mies' drawings showed mostly elevations and only few, very linear perspectives.[24] Mies' sketches show gradual variations of the seat shell, as well as the supporting structure of the shells. The seat shells are developed from the basic shape of a tractor seat into conchoidal forms, rising the sides and the back to become armchairs. Mies' sketches seem related to Eames' and Saarinen's entry of the Organic Design competition in 1941 (pl. 103), which in that form was never produced.

Clive Latimer designed a chair made from aluminium and plastic for Heal and Sons Ltd., the model of which was published in 1947 (pl. 104). The seat of this chair was, like Mies' and Eames' designs, derived from the tractor seat. The seat shell sits on long, tapering, spike-like legs, which seem incongruous and do not harmonize with the molded shell. The remarkable element of Latimer's chair design is the attempt to shape the shell to meet anatomic criteria,

Pl. 103. Relaxation Chair for Organic Design Competition, drawing, 1940, Charles Eames and Eero Saarinen. In: Drexler, <u>Charles Eames</u>, p. 7, no. 5.

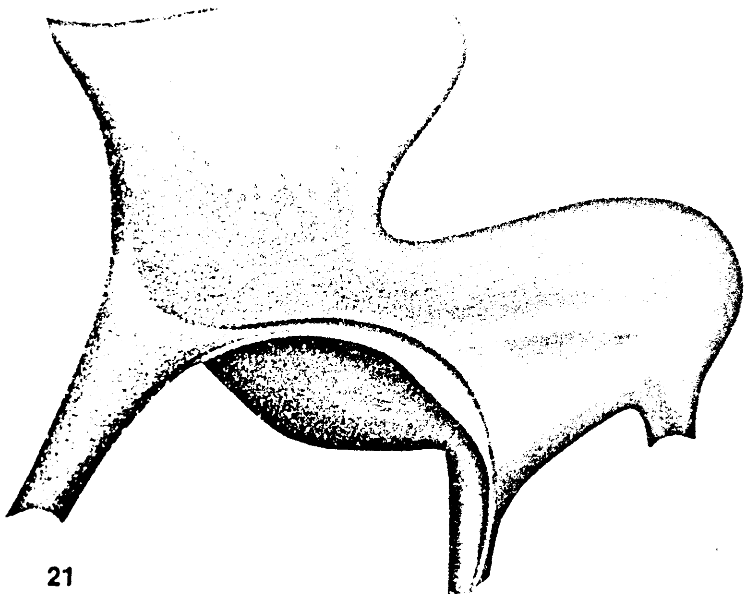


Pl. 104. Side Chair, model, Clive Latimer, 1947. In: Garner, Twentieth Century Furniture, p. 139.

which with the advancement of molding methods, as well as the progress in ergonomic studies, was later recognized as one of the unparalleled advantages of plastic materials.

In 1948, the Museum of Modern Art conducted a competition for Low-Cost-Furniture. One of the entries was Robert Lewis' and James Prestini's Lounge chair entirely made of molded plastic (pl. 105). Lewis' and Prestini's design takes advantage of the three-dimensional moldability of plastic. The chair is made out of one piece and the design is totally divorced from the traditional appearance of chairs of any other material. Its supports in the front and back are extensions of the sides, molded into curved sections, to secure footing and to prevent the supports from bending and caving in. Lewis' and Prestini's Lounge chair design was too expensive though, for mass-production and the fact that it was not upholstered made its gaining popularity with the consumer doubtful.

Charles Eames also participated in the International Competition for Low-Cost-Furniture of 1948 and submitted the design for a low armchair consisting of a set shell and a metal-rod substructured (pl. 50). The



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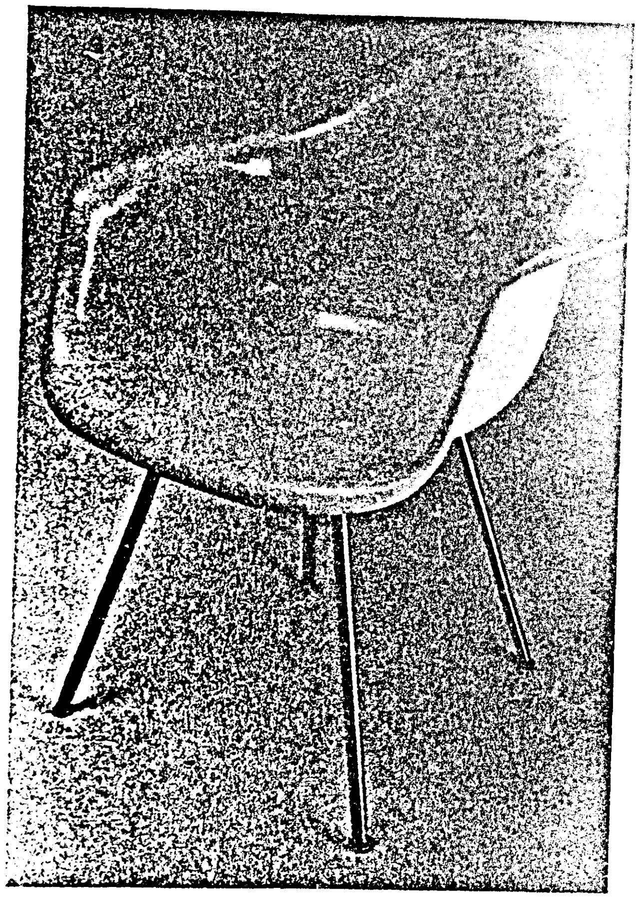
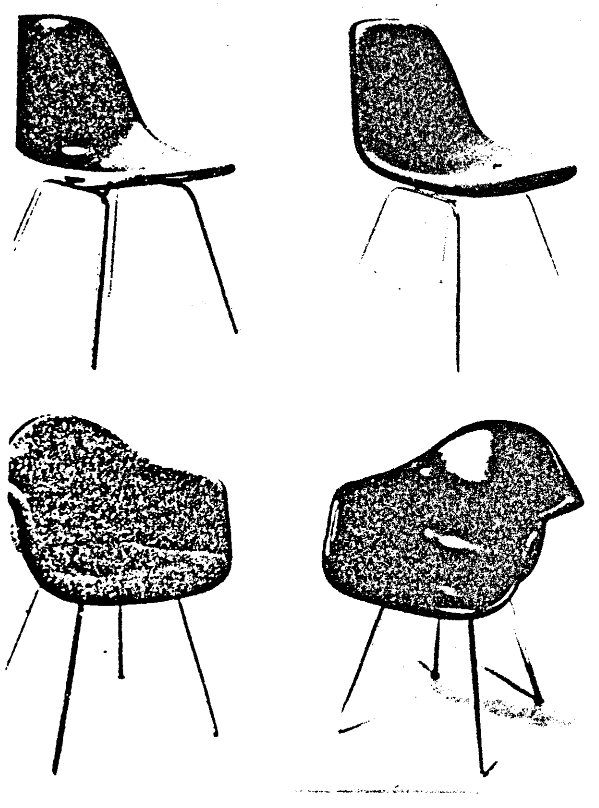
Pl. 105. Lounge Chair for Low Cost Furniture Competition, Robert Lewis and James Prestini, 1948. In: Drexler, Charles Eames, p. 15, no. 21.

seat shell was originally designed to be made of stamped metal sheet. But by 1950, when the design was manufactured, molded plastic had become economically more advantageous than stamped metal, and thus the Eames armchair was produced with a Fiberglass reinforced polyester shell, by the Herman Miller Furniture Company.[25] The design of the plastic shell of this chair was produced with various supports (pl. 106), all connected to it with the rubber shockmounts developed by Eames and already used on his LCM chair (pl. 44). Only in the case of the plastic shell could the rubber pad be chemically connected.[26] In comparison with a stamped metal sheet shell, the reinforced polyester shell offered a number of advantages, peculiar to the qualities of the material. Aside from being maintenance-free and colorful, scratch and stain resistant, and pleasant to the touch, it was more resilient and lighter than material.

Subsequently, Eames created a number of variations of essentially the same design between 1949 and 1963. Eames DAR chair (pl. 107) is produced as an armchair and as a side chair with a chrome-plated leg frame or a columnar base. It is manufactured with different finishes, padded and uncovered. The shell



Pl. 106. Armchair for Low Cost Furniture Competition, Charles Eames, designed 1948, produced 1950. In: Drexler, Charles Eames, p. 35, no. 60.



Pl. 107. DAR Chair Series, Charles Eames, 1949-1963. In: Drexler, Charles Eames. In: Meadmore, The Modern Chair, p. 110.

of both the armchair and the side chair obviously relate closely to Eames' and Saarinent's entry in the Organic Design in Home Furnishings Competition of 1940 (pl. 43) and Eames' entry for the Low-Cost-Furniture Competition (pl. 50), except for slight changes due to the difference of material, such as the rolled edges of the shells and an increased horizontal curve of the back of the side chair. The DAR side chair is also produced as a stacking chair since 1955.[27] All shells made from molded fiber-glass reinforced polyester.[28] With the inspiration of the possibilities offered by the new material, Eames was able to further his ambition to mold the seat shell to the anatomy of the human body. His DAR chair series was the first to go into semi-mass-production and proved itself in the test of time. It is still produced by the original manufacturer, the Herman Miller Furniture Company.

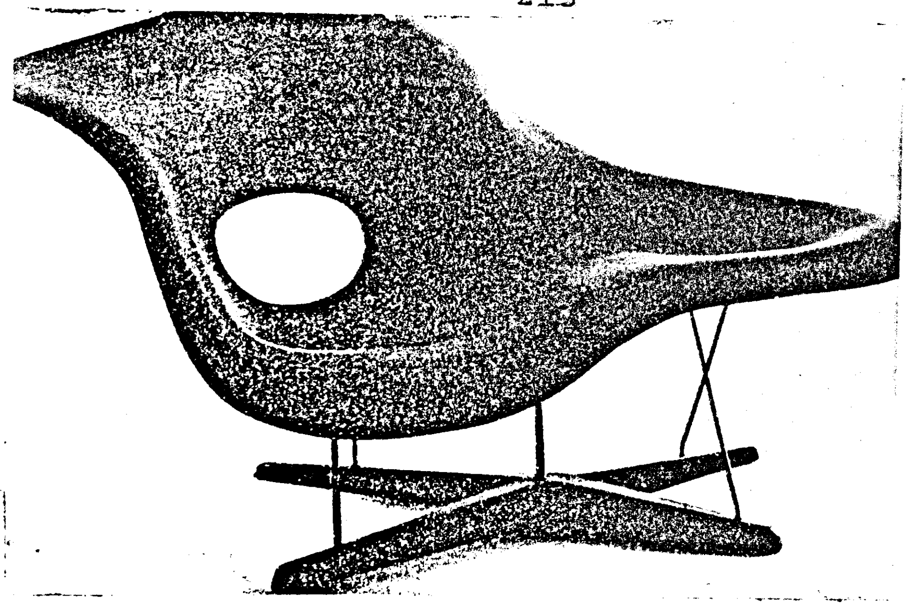
Eames' DDS chair (pl. 108) of about 1950, shows basically the same design as the DAR chair (pl. 107), except for the increased padding and upholstery made of foam rubber, adding to the sitting comfort.

Pl. 108. DSS Chair, series
Charles Eames, 1950. In:
Meadmore, The Modern Chair, p. 113.

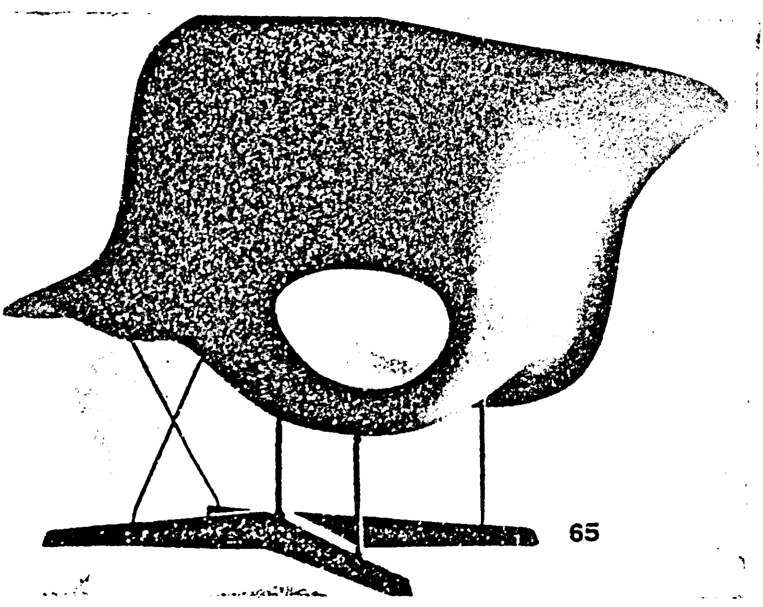
The plastic material Eames used for his chairs created an entirely new trend in chair design and construction in more than one way. As Meadmore quotes Peter Smithson's statement:

> Before Eames no chairs were many-coloured or really light in weight, or not fundamentally rectangular in plans. Eames chairs belong to the occupants not to the building.[29]

The Eames design, La Chaise, most effectively shows the qualities of the new material, though it never went into production. In 1948, when Eames began to experiment with molded plastic shells, he designed La Chaise (pl. 109 and pl. 110), a truly three-dimensional, sculptural piece. The entire design consists of two molded sheets of fiberglass reinforced polyester, enveloping a layer of hard foam rubber.[30] This so-called stress-skin shell is shaped according to the requirements of the reclining position of a human body, whereby the upper part of the body rests on a lower level than the legs. The shell varies in thickness to ensure adequate structural support where needed. The shape of the shell is totally asymmetrical and is more like an abstract sculpture than a chaise. All edges are curved outward, giving the piece a very smooth soft appearance. The shell of the chaise rests on a pedestal construction.



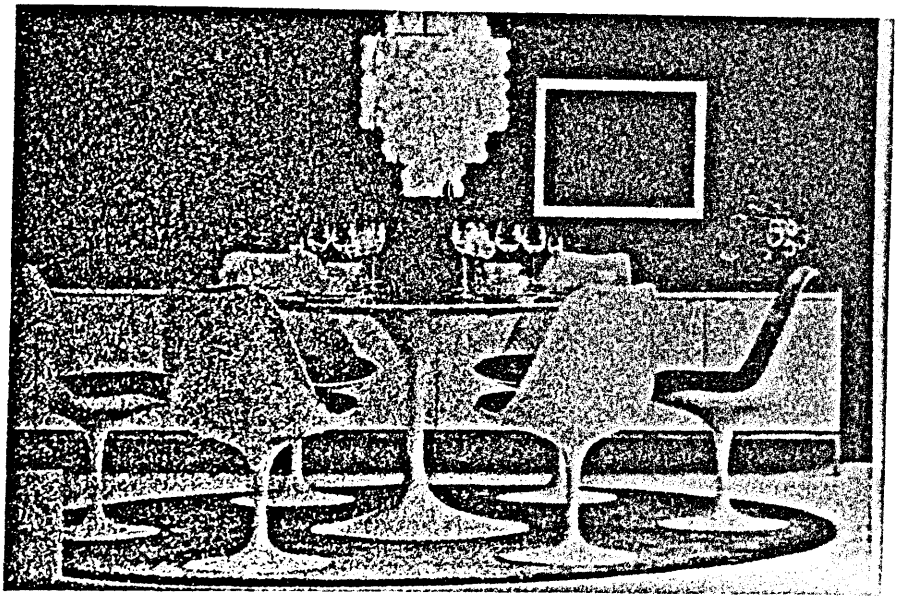
Pl. 109 and Pl. 110. La Chaise, Charles Eames, 1948. In: Drexler, Charles Eames, p. 37.



In continuation of the idea of a one-piece plastic chair, Eero Saarinen started to design his Tulip chair (pl. 111) in 1953. The result of his studies and experiments was manufactured by Knoll International in 1957. The Tulip chair consists of a fiberglass reinforced white polyester seat shell, which was pressure molded, and a pedestal base of cast aluminium coated with a white polyester film. The seat shell and coated pedestal form a visual unity. The flow of curves is uninterrupted and the uniform surface material as well as the single support enhance the self-contained appearance of the Tulip chair. Saarinen's idea of the pedestal support, appearing to be of one piece with the seat shell was the first serious attempt to unify the two structural components of a chair. Saarinen himself explained:

> As to the pedestal furniture, the under-carriage of chairs and tables in a typical interior makes an ugly, confusing, and unrestful world. I wanted to clear up the slum of legs.[31]

Aside from office swivel chairs, like the DAR and the DSS chairs by Eames, pedestal chairs had not been produced prior to 1957. As for pedestal chairs for residential use or lounge areas, the Tulip chair



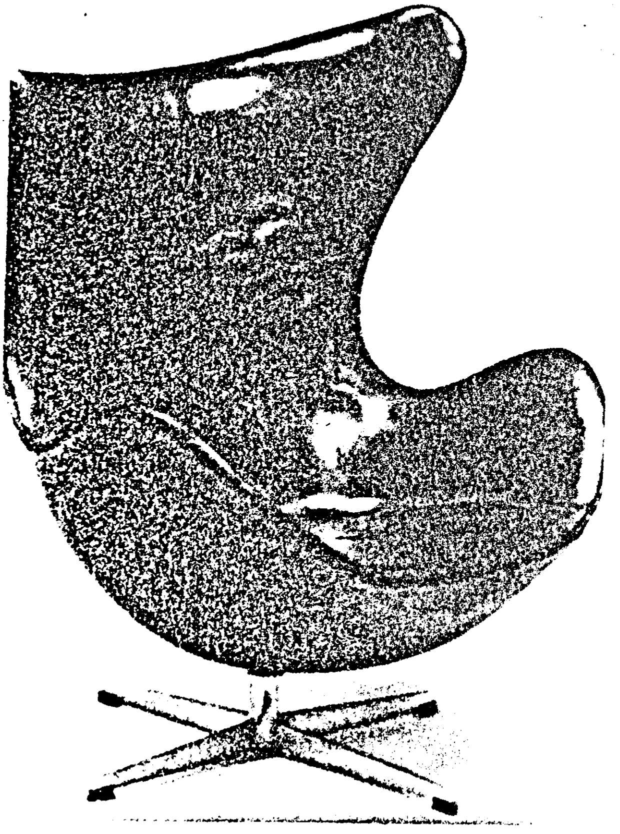
Pl. 111. Tulip Chair, Eero Saarinen, 1953. In: Mang, History of Modern Furniture, p. 153, no. 327.

was the first to be manufactured. Pedestal chairs in general had only become possible with the new mode of chair construction, using a seat shell of some kind, to the bottom of which the pedestal could be secured. In the case of Eames' DAR chairs (pl. 107), and his other chair designs, consisting of a seat shell and a carrying substructure, the pedestal was usually only one of the options offered along with an array of support structures of metal legs. Saarinen's Tulip chair decidedly set the trend in regard to the unity of materials, achieved by the polyester film coating of the aluminium pedestal. The flexibility of the shell and the ergonomic form of the shell, together with the fitted seat cushion, resulted in great sitting comfort.

The casting of plastic chair shells, though was still problematic to execute in a fully mechanized mass-production, that is in continuous process without any handwork. Until it was possible to produce a plastic resin that did not need any reinforcement, the manufacturing process remained at a stage of semi-mass-production. The fiberglass mats that were and still are used for reinforcement, have to be thoroughly saturated and coated with the desired resin, and the setting of the shell material was delayed by the necessity of variations in strength of certain areas of the shell. To achieve a gradual increase in strength equalling thickness, several layers of material had to be applied by hand, and the lamination process was terminated by the application of heat and pressure on the mold. Subsequently, the production cost of the first generation in plastic chairs remained high. As Ella Moody remarked in her book Modern Furniture: "Costs of materials and methods have been so high as to set these chairs apart--as works of art rather than pieces of furniture."[31]

The three-dimensional quality of the plastic shell designs was carried further in the chairs of the Danish designer Arne Jacobsen. Since the early 1950s Jacobsen had been experimenting with single-unit seat shells. In 1958, Fritz Hansen began to manufacture the results of Jacobsen's studies, namely, the Egg chair and the Swan chair.

The Egg chair (pl. 112) derives its name from its shape. The back of the three-dimensionally formed seat shell comes up in a high smooth curve, with the upper corners tapering out in a rounded, wing-chair-like manner. The arm rests of the chair are formed in continuation of the conchoidal lower part of the seat. The flow



Pl. 112. Egg Chair, Arne Jacobsen, 1958. In: Garner, Twentieth Century Furniture, p. 168.

of lines of the chair's silhouette is uninterrupted and smooth moderating the massive appearance of the chair. The seat shell, padded and covered with leather or fabric, rests on a cast aluminium four-pronged base with a built-in swivel mechanism.

The Swan chair (pl. 113), less massive than the Egg chair, shows a similar silhouette of meandering curves. Its back is not as high as the Egg, resulting in a broader, more horizontally resting appearance. The Swan, too, is padded and covered with leather or fabric and mounted on a four-pronged pedestal with a built-in swivel mechanism.

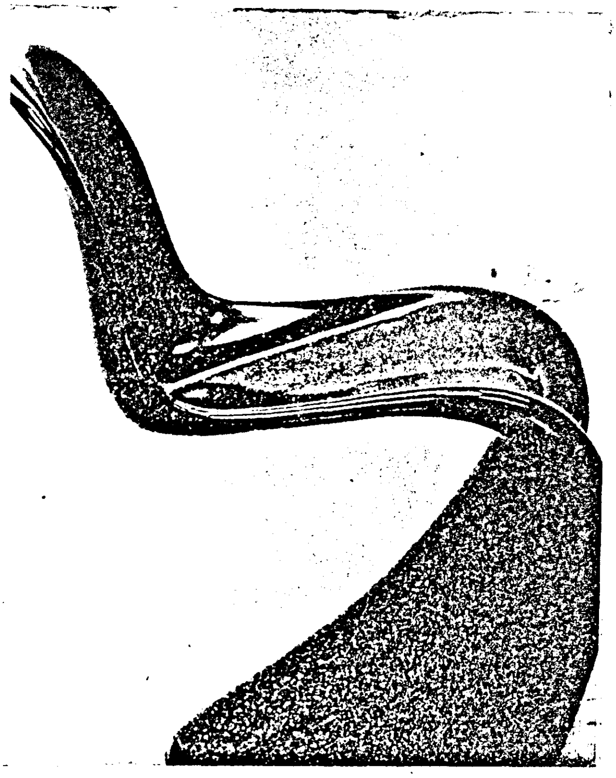
The seat shells of Jacobsen's Egg chair and Swan chair are made from fiberglass reinforced polyester, molded by high-pressure laminating, which involves some handwork and can only be executed in a semi-mass-production process. Hence, these chairs, like Saarinen's tulip chair (pl. 111), can only be manufactured at relatively high cost.

While Saarinen, in 1953, had to compromise on the idea of a one-piece chair, by supporting the plastic shell by a plastic coated aluminium base, the beginning of the 1960s brought the technology to the point, at which

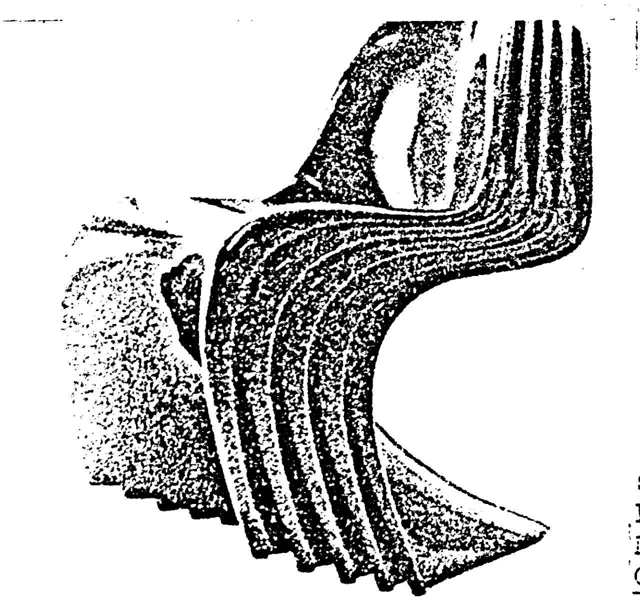
Pl. 113. Swan Chair, Arne Jacobsen, 1958. In: Garner, Twentieth Century Furniture, p. 169.

mass-production of molded fiberglass reinforced polyester was possible without any large extent of handwork.

In 1960, the Swiss designer, Verner Panton, created the first all-plastic chair. The Panton '276 S' stacking chair (pl. 114 and pl. 115) was put into production in 1967 by the Herman Miller Furniture Company. Panton's stacking chair is designed in a basic zig-zag shape, using the cantilever principle. The smoothly curved silhouette, the balance between the horizontally curved base, which extends backwards in a diagonal line, and the slanted surface of the seat, which continues at approximately a ninety degree angle into the three-dimensionally curved back of the seat give the chair an organic, self-contained appearance. The flowing lines of the chair and the simplicity of its silhouette are in harmony with the statics and structure required for the stability of the chair under the weight of a seated person. The resilient quality of the chair together with the properties of fiberglass reinforced polyester, such as being break-proof and weather-resistant, not only offer good sitting comfort, but also require only a minimum of maintenance. Panton's '276 S' stacking chair is



Pl. 114. 276 S, stacking chair, Verner Panton, 1960. In: Meadmore, The Modern Chair, p. 131.

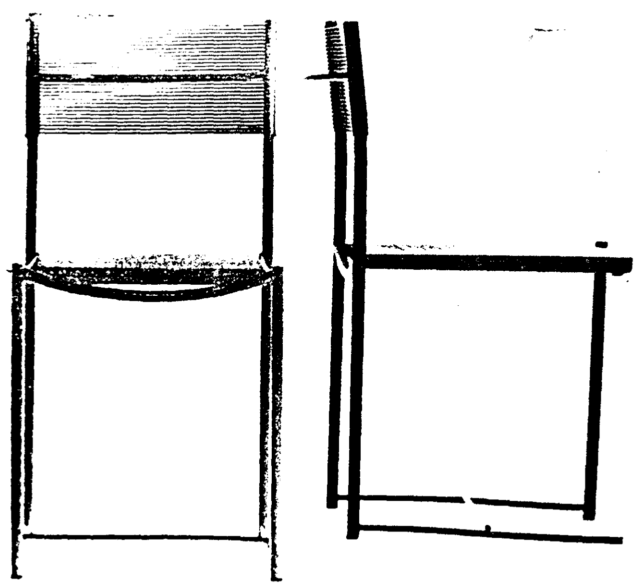


Pl. 115. 276 S, stacking chair, Verner Panton, 1960. In: Meadmore, The Modern Chair, p. 131.

manufactured in white, black, blue, and red, produced by the Herman Miller Furniture Company.

During the 1960s and 1970s chair design did not entirely divorce itself from the traditional modes of construction. As the materials were combined with each other, such as a metal frame with a plastic seat and back or a one-piece seat shell, so were the forms of the chairs a combination of old and new, traditional and avant-garde, even if they were all-plastic chairs.

The Italian designer, Giandomenico Belotti created his Spaghetti chair (pl. 116) in 1960 for a hotel in Italy.[33] In it, he joined a rather conventional frame of steel tubing with strands of polyvinyl chloride (PVC) as seat and back. The angular and highly functional frame of Belotti's Spaghetti chair consists of thin, angular-section steel tubing and is constructed much like traditional wooden chairs, with front legs, back legs extending into vertical back supports, and side rails, around which the PVC strands are stretched to form the seat and back, respectively. For reasons of stability, the front and back legs of the chair are connected by floor bars, which in turn are joined together by a stretcher. The front legs and back legs are each



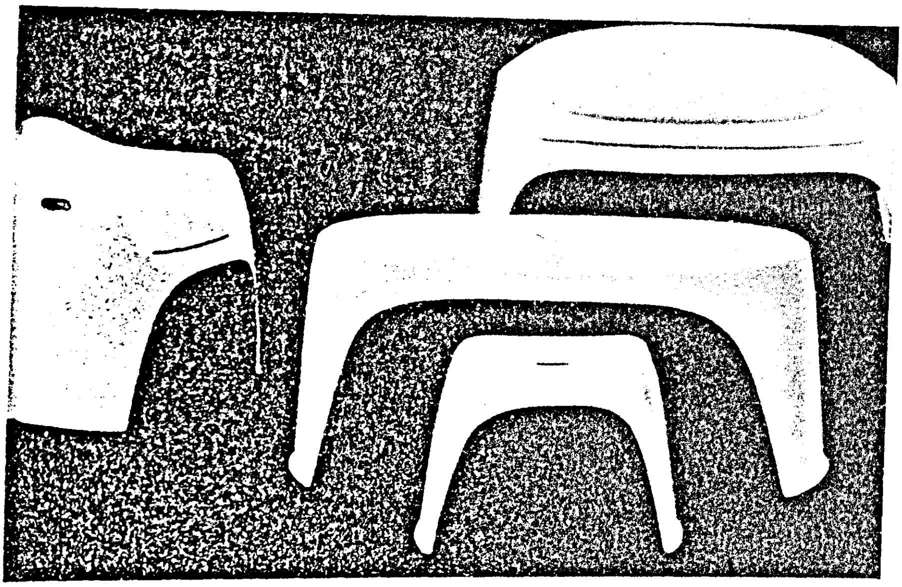
Pl. 116. Spaghetti Chair
Giandomenico Belotti, 1960.
In: Interior Design, April 1980, p. 12.

connected with a curved steel tube, which is repeated between the lateral back supports of the chair. The thin steel tubing of the frame forms a harmonious unity with the PVC strands of the seat and back, which would not have been possible without the high tensile strength of steel in small sections. The PVC, in turn, lends itself better than most materials to this specific design, since it can be elastic and still very tough. Belotti's design also relies on the plastic memory of PVC strands as well as the material's various other properties.

Belotti's Spaghetti chair is produced in chrome-plated steel with transparent vinyl strands and in enameled steel with vinyl strands of matching colors. Belotti's design unites the advantageous qualities of steel tubing and plastic. This is a modernized version of a traditional construction principle in a light weight chair of transparent, delicate appearance, not achievable in any other material.

Taking advantage of all the available new materials and using them in designs where they seemed most appropriate and functional, designers created all-plastic chairs as well as combination metal-plastic chairs and further developed both types at the same rate as technology progressed.

Walter Papst, a German designer, came out with the stackable seating series 401/4 (pl. 117), consisting of a chair, a bench, and a stool in 1961. The one-piece molded armchair, like the other pieces of the series, is made of white fiberglass reinforced polyester. The seat surface of the 401/4 is indented so that it forms a shell with arm and back supports in a continuous scoop. The outer surfaces of the arms continue down to the ground and are shaped in a slight horizontal curve, serving as supports for the chair. The silhouette of the chair shows uninterrupted, smooth curves; the all-over form is very self-contained and functional. Papst's chair can be used indoors and outdoors. If the latter is specified, the chair can be produced with little openings to allow water to drain from the seat indentation. The chair is available with and without upholstery pads, which are attached to the seat. Since polyester is a resin which is very moisture-resistant when acrylic-based and can be stabilized to prevent yellowing under the influence of sunlight, it lends itself well to outdoor furniture production. It also has the advantage of light-weight



Pl. 117. 401/4 stacking chair, Walter Papst, 1961. In: Hatje, New Furniture 11, p. 25, no. 65.

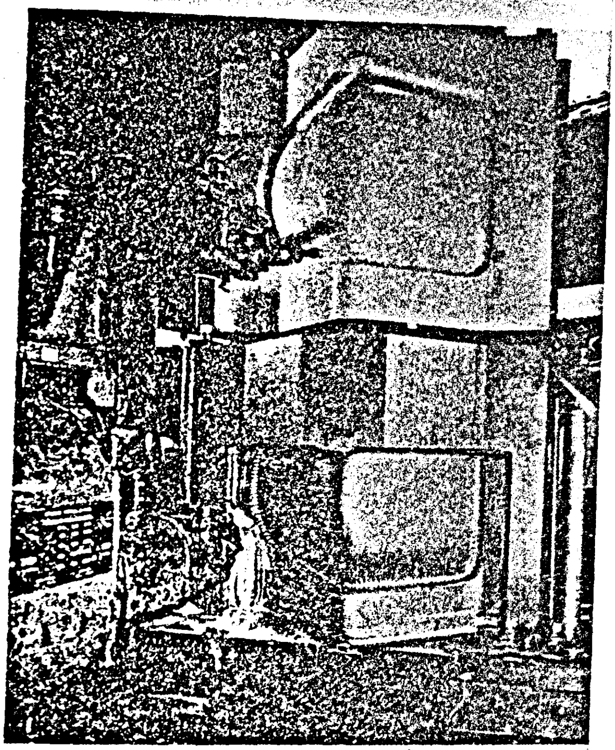
over any other non-plastic material that could be used for the design of the 401/4.

All the chairs described previously were manufactured from fiberglass reinforced polyester and had molding process. After the development of polypropylene by Professor Natta in 1954 and the necessary technological progress in injection molding, it became possible to increase the efficiency of the mass-manufacture of plastic shells and entire chairs which decreased the production cost immensely. The toughness, high tensile, and impact strength of polypropylene make it unncessary to reinforce it with fiberglass or any other reinforcement, and it can easily be used for injection molding, which does not involve any handwork.

In a joined effort with Hille of London, Ltd., the English designer, Robin Day, produced a polypropylene seat for a stackable office chair (pl. 118), using injection molding in 1963. The mold (pl. 119) for the Day chair was shipped to France several times a year, where the chair was made under licence[34] in order for the mold to fully amortize its cost. The seat shell of Day's chair is armless and consists of a slightly horizontally curved seat surface, which leads at an obtuse angle into the

Pl. 118. Side Chair, Robin Day, 1963. In: Moody, Modern Furniture, p. 118.

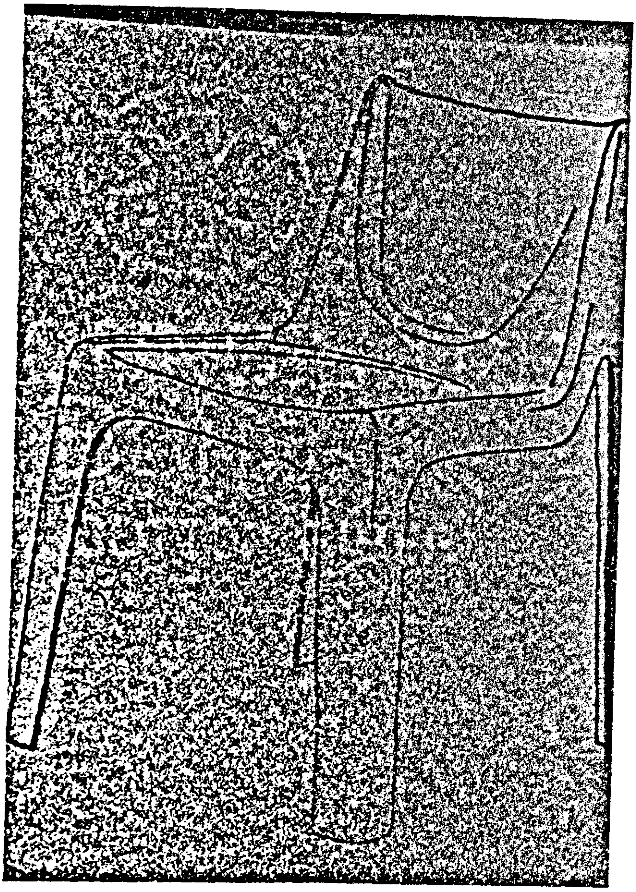
Polypropylene injection-moulding by Thermo-Plastics Ltd, Dunstable



Pl. 119. Injection Mold for side chair, Robin Day, 1963. In: Moody, Modern Furniture, p. 119.

strongly three-dimensionally curved back rest, tapering towards the top. The seat shell is supported by a four-legged steel tube construction. The Day chair design is an example of the close collaboration between the designer, the chemical technician, the mechanical engineer, and the producing company. Robin Day's chair was produced with various substructures and developed into an entire chair program. Although Day's chair was the first to be made of polypropylene, it was still used in combination with metal tubing for its substructure, and in that respect, his design principle can already be considered a traditional construction method, widely used since the first Eames' plastic shell chairs.

The Unica chair of 1964 (pl. 120) by French designer, Andre Vandenbeuck, is entirely made from plastic, yet in its appearance it converts back to the traditional four-legged chair form. The Unica is molded out of one sheet, the legs are vertical extensions of the seat corners and the stiles respectively and are of a horizontally curved section to ensure a secure stand and prevent them from buckling under pressure and thrust. The chair was produced in black, white, and red, by Straessle Soehn & Company in 1965. Due to the plastic

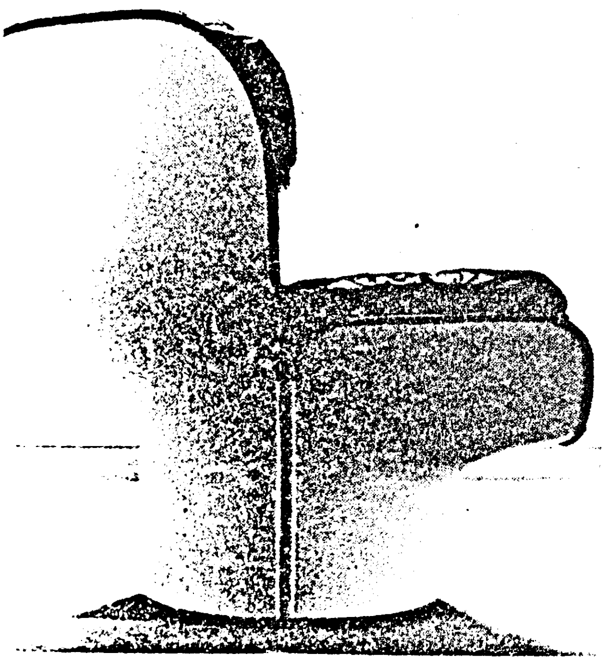


Pl. 120. Unica Chair, Andre Vandenbeuck, 1964. In: Frey, The Modern Chair: 1850 to Today, p. 131.

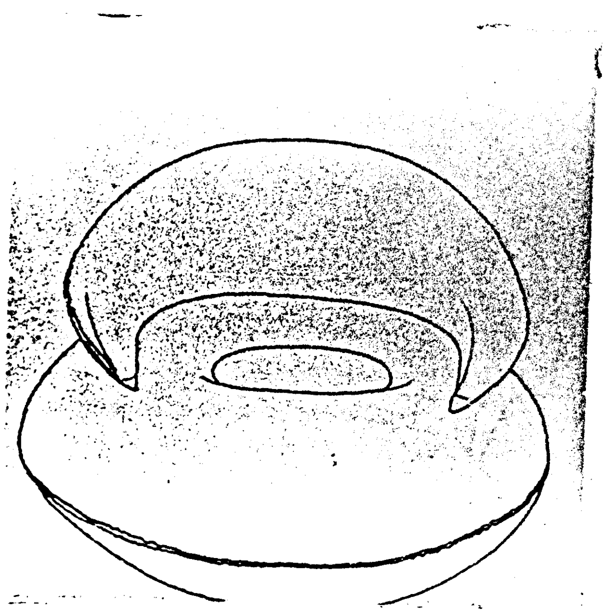
material used, it is light-weight and nearly maintenance free, qualities which can only be achieved in the use of plastic.

During the same year, the Italian, Joe C. Colombo, designed Elda 1005 (pl. 121), creating a new shape for a high-backed armchair. The Elda 1005 consists of a fiberglass reinforced polyester shell, which is generously padded with cushions for seat, back, and arms. The shell is constructed out of two parts with a vertical seam on each side. The back of the chair is three-dimensionally curved in a quarter sphere-like shape, continuing downwards in a half-column. The front section of the chair is formed somewhat like a spout, projecting forward and leading into another half-column to complete the base of the chair with the lower part of the back section. In his Elda 1005, Joe Colombo created a massive, yet dynamic shape, combined with the mobility offered by the light-weight plastic material.

The ultimate mobility, as well as lightness though, was achieved by the French designer, Bernard Quentin, in 1964, when he created the so-called Croissant armchair (pl. 122). This armchair was quite a revolutionary chair design, consisting of an elastic but tough,



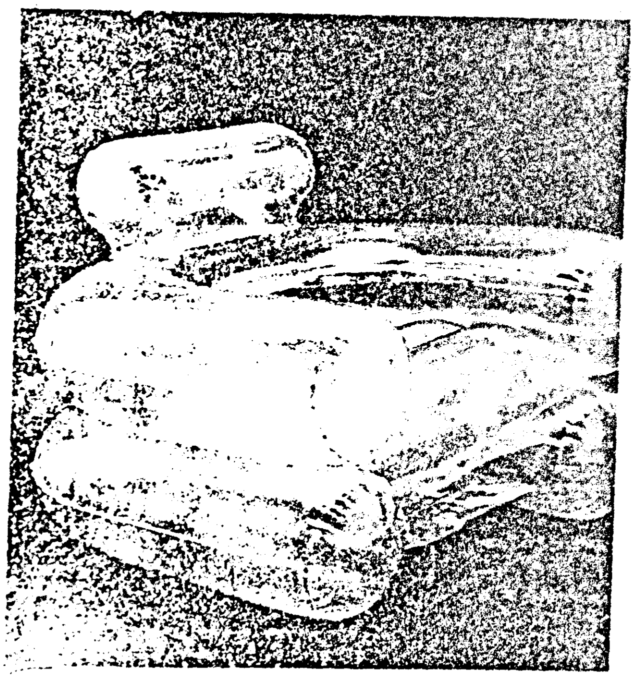
Pl. 121. Elda 1005, Joe Colombo, 1964. In: Garner, Twentieth Century Furniture, p. 199.



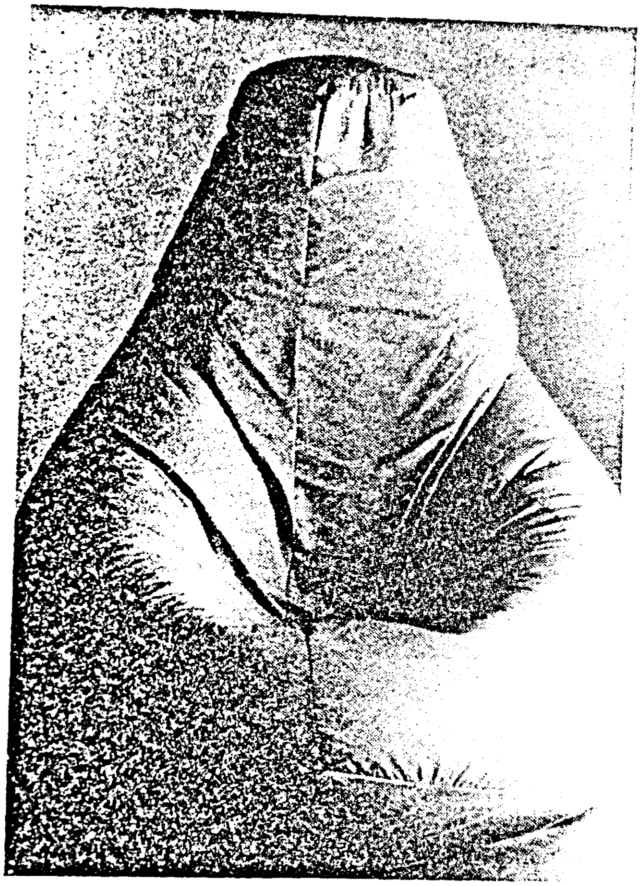
Pl. 122. Croissant, Bernard Quentin, 1964. In: Frey, The Modern Chair; 1850 to Today, p. 127.

thin neoprene-coated nylon sheet.[35] The nylon is welded together to form a kind of innertube-shaped base, the center of which is filled, giving the chair an indented seat. The back and arm rests of the chair are shaped by a crescent-like element, welded to the base. The entire armchair is inflatable or deflatable. The elastic nylon sheet adjusts to the displacement of air inside the chair when occupied. The elasticity of the material compensates the pressure put on the material and seams. The toughness of the nylon prevents the rupture of the seat and seams under impact. The Croissant was produced by Zodiac in 1966.[36] In the case of Quentin's Croissant armchair, it is nearly superfluous to mention that only a plastic material, such as nylon, with its high resilience and elasticity, and its high impact resistance lends itself to such a design, or rather that a design like the Croissant could hardly be conceived or executed without the inspiration of the material.

The design of inflatable chairs (pl. 123), and seating consisting of an elastic skin, filled with either foamed soft plastic (pl. 124) or styrofoam pieces, became quite popular in the 1960s and the early 1970s, representing a relaxed unaffected way of life, which



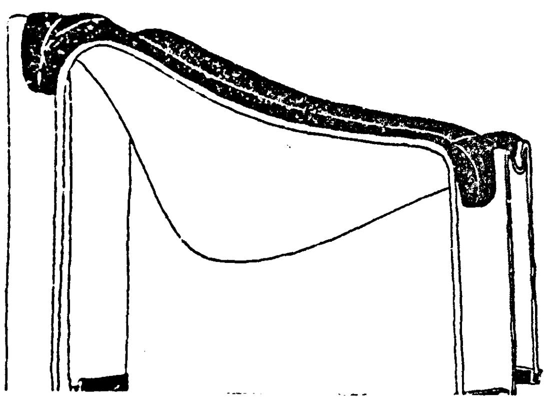
Pl. 123. Inflatable P.V.C. chair, Carla Scolari, Donato D'Urbino, Paolo Lomazzi and Jonathan DePas, 1967. Garner, Twentieth Century Furniture, p. 189.



Pl. 124. Sacco Chair, Gatti, Paolini, and Theodoro, 1968. In: Lucie-Smith, Furniture Concise History, p. 196, no. 178.

expressed itself not only in form and material, but also in the posture of the sitter. Mobility, ease, and unconstraint were a part of the Zeitgeist and the attitude toward life, particularly of the younger generation and plastics made it possible to express this life-style.

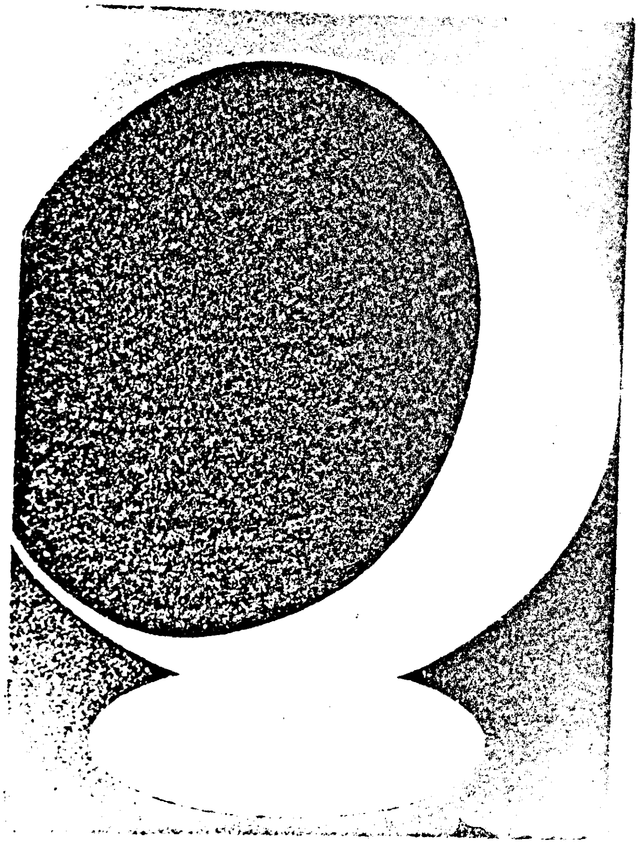
In 1965, Pierre Paulin, another French designer, developed a plastic lounge chair (pl. 125) manufactured by Artifort, Wagemans and van Tuinen BV in the Netherlands. This armchair consists of a one-piece fiberglass reinforced polyester shell with attached, fabric covered foam padding. The chair rests on four supports, which are the extended corners of the scooped-out seat. The arms and back of the chair are formed by the continuous up-sweeping surface of the seat. The seat and back of the chair are slanted in such a manner that the sitter automatically leans back in a lounging position. Paulin's armchair shows an uninterrupted flow of clear lines and gracefully curved sufaces. The fact that the seat indentation is elevated at the corners gives it a suspended, light appearance. The form of the chair and its light weight require a high-impact, high-tensile strength material to ensure stability.



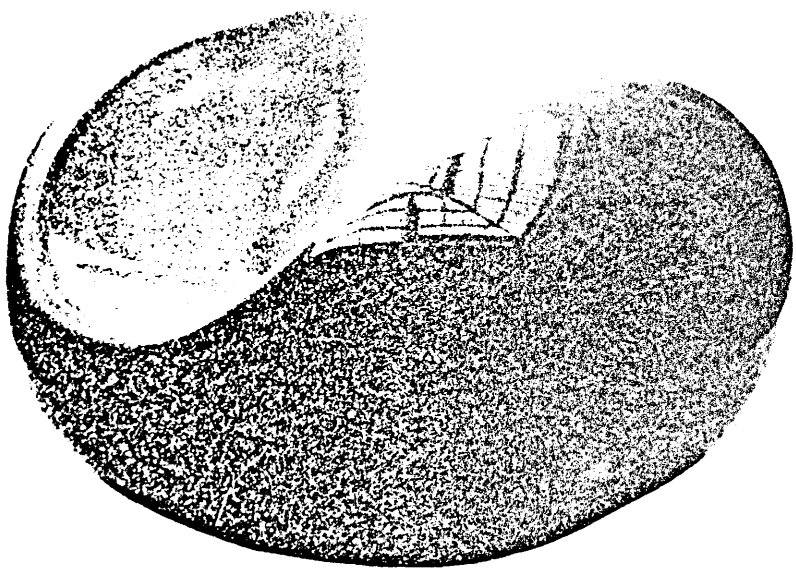
Pl. 125. Lounge Chair, Pierre Paulin, 1965. In: Frey, The Modern Chair; 1850 to Today, p. 134.

Another quite innovative design, which characterized the mid-1960s, was Eero Aarnio's Globe chair (pl. 126) manufactured by Asko Finnternational in 1966. The chair consists of a truncated sphere of white fiberglass reinforced polyester on a swivel mechanism, attached to a disc-shaped aluminium base. The interior of the sphere is fully padded with foam rubber and furnished with cushions for the seat and back for additional comfort. The Globe chair represents the modernist orientation of the mid-1960s, the spaceage era expressed in a slightly futuristic design, which is less function-oriented and austere. The rule of the Bauhaus and International Style periods, demanding strictly functional forms and economy of material, is evidently decreasing in its importance. The simplicity and clarity of line, though, remains since it is the slick, streamline designs that are engaged in space exploration. Smooth, glossy surfaces and transparent or white plastics gave the chair designs their fashionable look.

Eero Aarnio's Pastilli armchair of 1967 (pl. 127), manufactured by Asko in 1968, exhibits the futuristic trend of its time in the same playful manner as the inflatable chairs, and the Globe chair (pl. 126). The



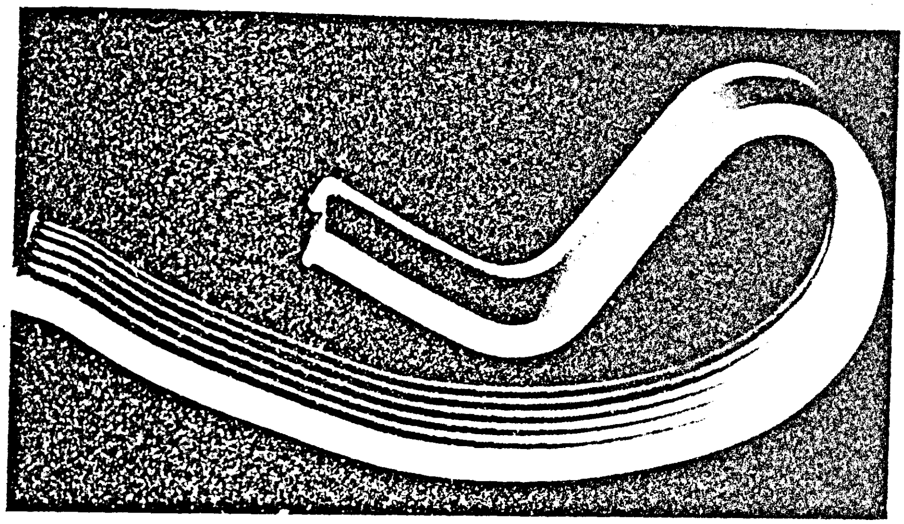
Pl. 126. Globe Chair, Eero Aarnio, 1966. In: Garner, Twentieth Century Furniture, p. 182.



Pl. 127. Pastilli Chair, Eero Aarnio, 1967.
In: Garner, Twentieth Century Furniture, p. 190.

influence of the contemporary Minimal and Pop Art becomes notable, though in a muted form, in some plastic chair designs. Aarnio's Pastilli consists of two fiberglass reinforced polyester sheets, molded in a half ovoid for the base and completed by the matching half, which is scooped out to form a seat, arm, and back surface. The two parts are welded together. The chair is produced in white, yellow, and pink with a high-gloss finish. It is light-weight and nearly maintenance-free due to its material. These qualities, along with the chair's floating shape, certainly demonstrate the inspirational force of plastic and the total departure from any of the traditional principles of chair design.

In 1969, Leonardo and Franca Stagi designed the Dondolo (pl. 128), a rocking chair out of ribbed, reinforced fiberglass. The shape of the chair is innovative and elegant describing a gradually curved, rising rocker section, which leads into the suspended, continuous back and seat of the chair. The Dondolo, even though more two-dimensional than most of the plastic chairs, seems like an abstract sculpture, rather than a rocking chair. The material used makes it light-weight and nearly maintenance-free. Unfortunately, its design

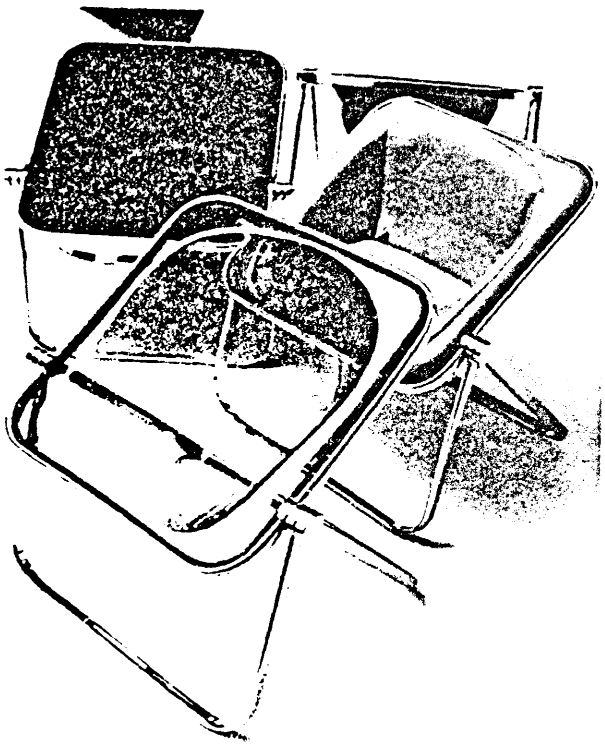


Pl. 128. Dondolo, rocking chair, Leonardo and Franka Stagi, 1969. In: Garner, Twentieth Century Furniture, p. 199.

is not without problems, since it is very difficult to sit down in or to get up out of. Hence it certainly is more playful and decorative a design than functional.

Aarnio's Globe (pl. 126) and his Pastilli (pl. 127), and Leonardo and Franca Stagi's Dondolo (pl. 128) were not based on practical, functional, or ergonomic studies. They rather represented the modernist trend of the late 1960s and a playful experimenting with design for the sake of form and fashion.

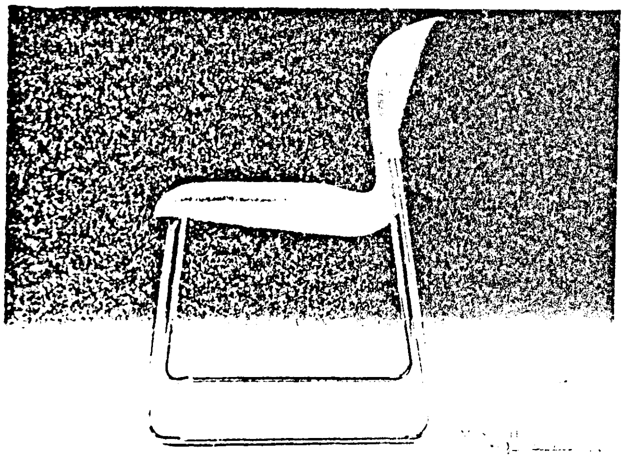
Different from these chairs is the folding chair Plona (pl. 129) of 1970 by the Italian designers, Giancarlo Piretti and Emilio Ambasz. The chair consists of a translucent ABS plastic shell, molded out of one sheet. The seat of the shell is based on the form of a tractor seat with its sides and back extending upwards and leveling out in the diagonal plane, out of which the seat was molded. The shell is set into a frame of polished aluminium, which in turn attaches to the two U-shaped elements of the folding construction, joined in a self-locking pivot. The support structure is made from oval-section aluminium tubing. The entire chair can be folded or stacked and conveniently stored. Piretti's Plona folding chair is set apart from the group of chairs



Pl. 129. Plona, folding chair, Giancarlo Piretti and Emilio Ambasz, 1970. In: Hatje, New Furniture 11, p. 33, no. 98.

dealt with before by its no nonsense approach to the design, combining practicality, functionalism, and the modern aesthetics of plastic and light-weight metal in a harmonious interplay.

Another example for such qualities is Gerd Lange's Nova stacking chair of 1970 (pl. 130). The armless seat shell is molded out of nylon or polypropylene into a shape that relates well to the anatomical demands of the human body. The smoothly curved lines of the shell, the rolled edges, and the three-dimensionally formed seat and back give the chair a light, functional, and elegant appearance. The shell is attached to a metal tubular substructure of cross-frame design. The ends of the lateral back supports are inserted in the edges of the back rest. These supports lead into gliders, rising up to form the front legs of the chair. The Nova chair is also produced with a number of other substructures, such as ganging frames, tandem riser mounts, and fixed pedestal bases.[37] The material used for the seat shell of the Nova makes the chair very advantageous for public spaces where wear and harsh treatment are to be expected. Since the color of the shell is integral to the resin, be it nylon or polypropylene, scratches and chips do not

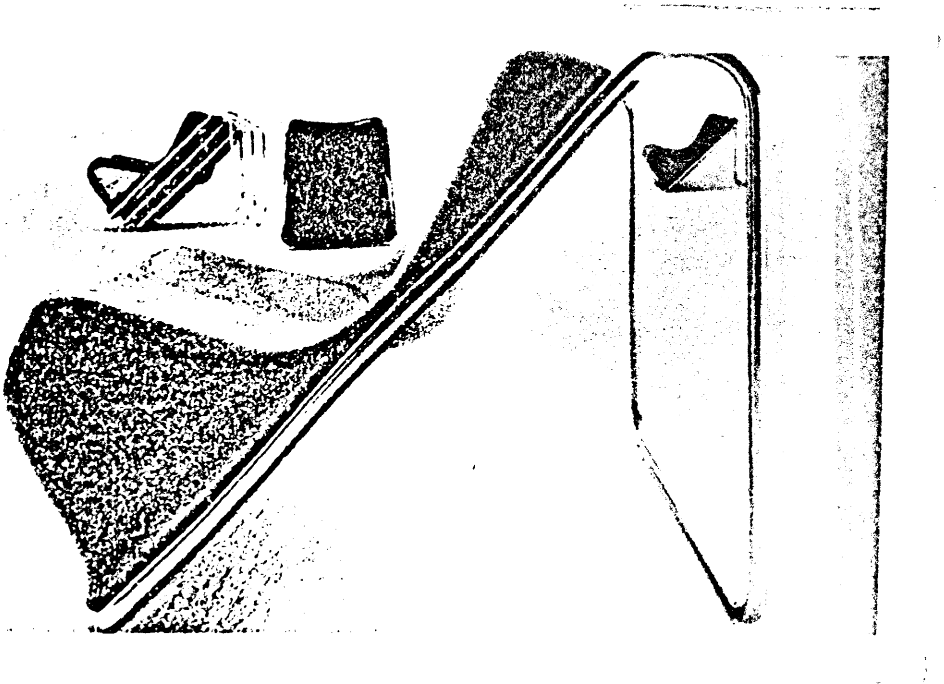


Pl. 130. Nova, stacking chair, Gerd Lange, 1970. In: Contract, August 1980, p. 2.

easily damage the chair's appearance. Another advantage of the Nova's material, aside from its wear resistance, is its suitability for injection molding, which allows a low-cost production.

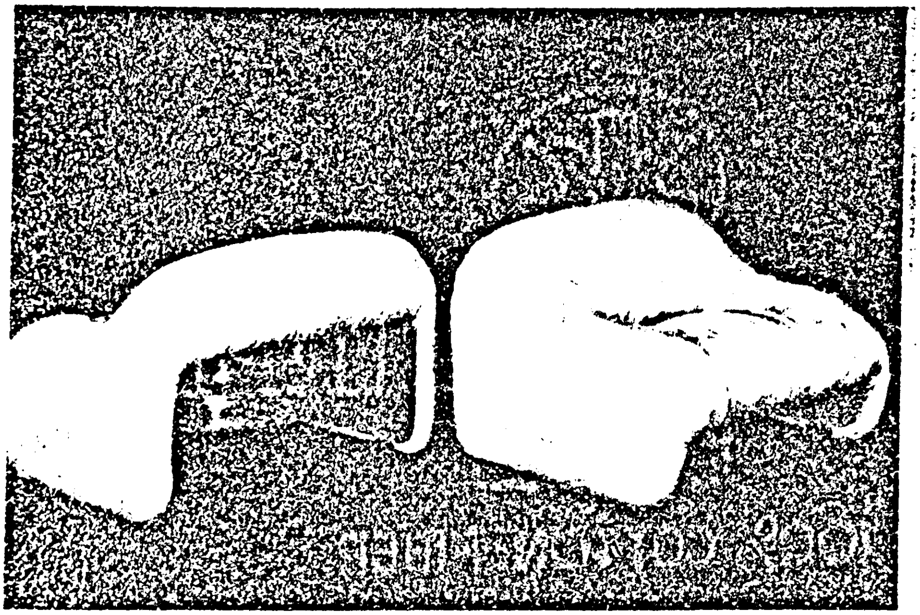
Alberto Rosselli designed the P/110 stacking easy chair in 1971 (pl. 131). The chair frame consists of a continuous metal tube formed into a rectangle. The long sides are bent to form a diagonal longer and a vertical shorter line. The edges of the seat shell of pressure molded plastic are fit into the diagonally up-rising part of the tubular frame. Across the top of the shell, the frame is connected by another metal tube to lock in the seat shell. The one-piece plastic shell is three-dimensionally molded in an irregular S-section. Rosselli's P/110 represents a new form of stacking easy chair, the frame of which remotely resembles the principle of the Duecavalli easy chair (pl. 77) of 1970 by De Pas, D'Urbino, and Lomazzi, described previously in the chapter on metal chairs. The P/110 is light-weight and meets the demand for mobility and wear resistance, thus lending itself well to contract furnishings.

Among the great number of foam rubber easy chairs introduced in the late 1960s and early 1970s, most designs relied primarily on shaped foam rubber



Pl. 131. P.110, stacking easy chair, Alberto Rosselli, 1971. In: Hatje, New Furniture 11, p. 33, no. 99.

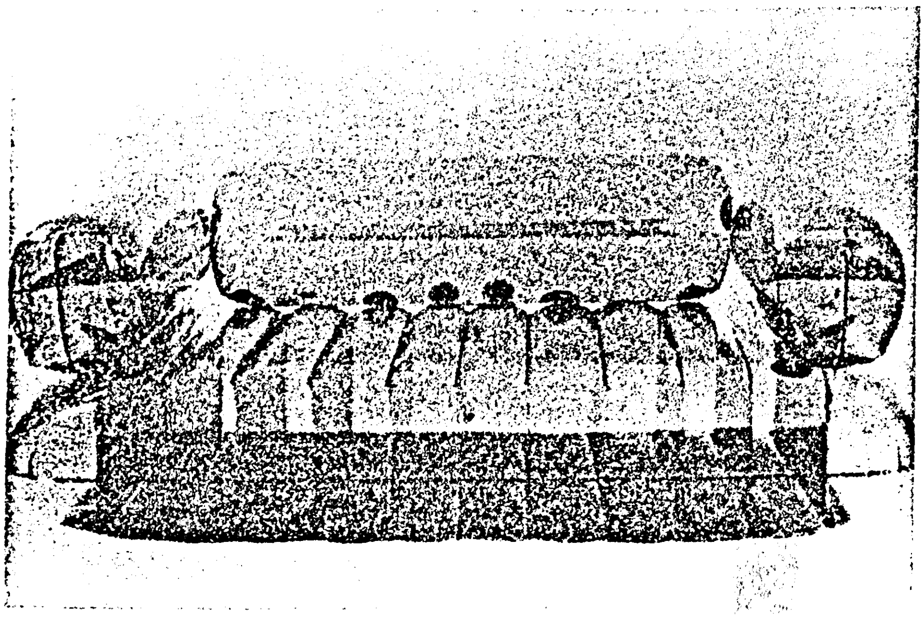
cushions held together by buttons, metal frames, or simply the cover material. Tobia Scarpa's easy chair (and sofa) of 1971, Bonanza (pl. 132), though, shows a different principle. Scarpa's Bonanza is built around a molded plastic seat shell, which defines the structural shape of the chair. The shell forms a straight seat surface and back. The sides are protruding only very little over the seat plane and reach down to the ground, forming the supports of the chair. The molded plastic substructure is only partly visible in the back of the chair. The upholstery attached to the shell is composed of three layers of dacron fiber enveloping the entire chair, except for small section on the back side of the chair. The chair is covered with leather or fabric, defining the seat and back by a tugged-in crease. In the case of the Bonanza chair, the plastic seat shell serves as substructure and only tangentially determines the shape of the chair. Its advantage over other structural materials, though, is its lightness and durability to impact and thrust since it is a seamless molded piece. The three-layered upholstery of dacron fiber allows for controlled softness or hardness respectively, where needed.



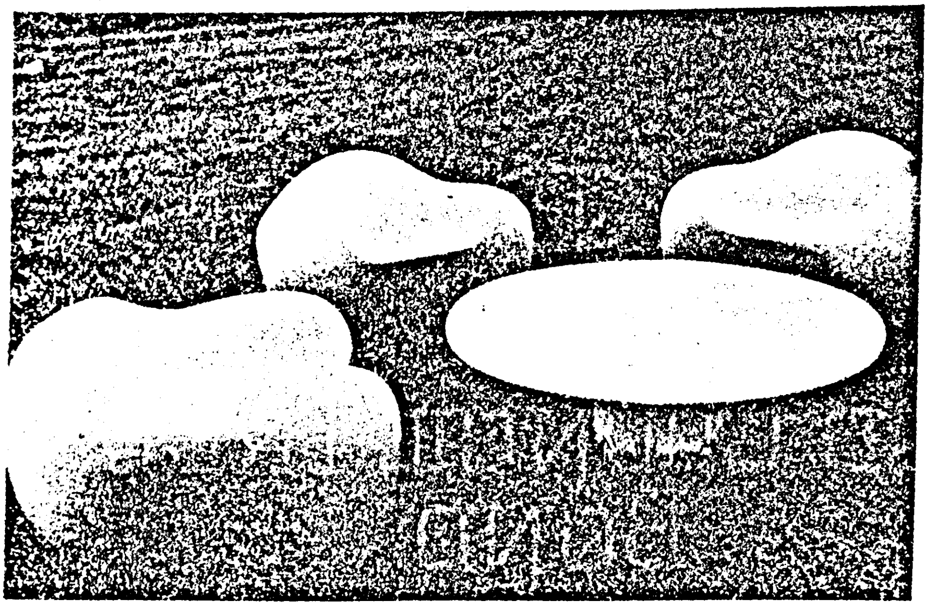
Pl. 132. Bonanza, easy chair, Tobia Scarpa, 1971. In: Hatje, New Furniture 11, p. 41, no. 127.

The French designer, N'Guyen Manh Khanh, developed the inflatable sofa of PVC skin, Chesterfield (pl. 133), further refining the principle of inflatable seating by equipping the seat, arms, and back with subdividing skins. These form chambers inside the chair to equalize the pressure and to avoid the uneven displacement of air by the thrust put on the sofa by one or more sitters. The Chesterfield consists of three airfilled elements, which are held together by metal rings along the back of the seat, at the bottom of the back rest, the front of the arm rests and between the back rest and the arm rests. The sofa is produced in transparent or opaque PVC by c. b. z. International, France.

In 1973, the German designer team, Jochen Claussen-Finks and Jan Armgardt, created the seating range Jumbo (pl. 134). It is made from fiberglass reinforced polyester in a variety of colors for indoor and outdoor use. The shape of the Jumbo is reminiscent of a Henry Moore sculpture. It is three-dimensionally molded with smooth curves and bulges appearing to be organically growing out of the ground. The seat of the chair is scooped out of the molded sheet. The Jumbo



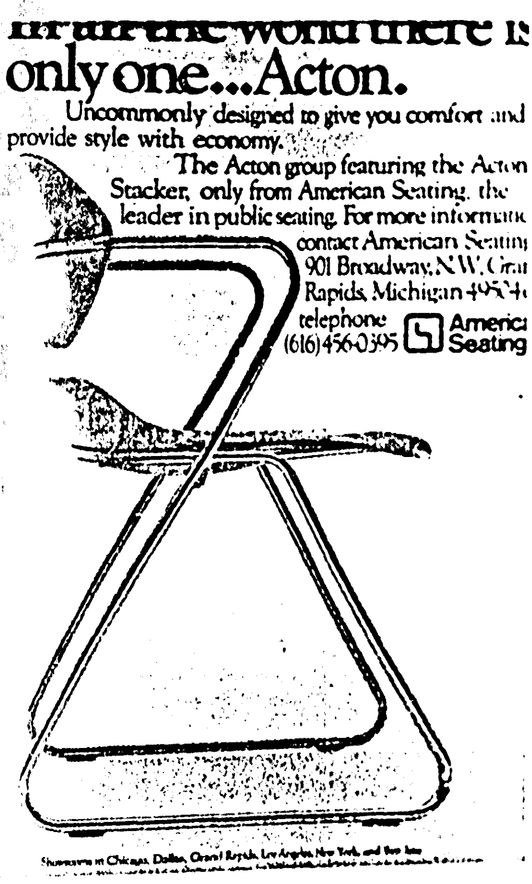
Pl. 133. Chesterfield, inflatable sofa, N'Guyen Manh Khanh, 1971. In: Hatje, New Furniture 11, p. 44, no. 139.



Pl. 134. Jumbo, seating range, Jochen Claussen-Fink and Jan Armgardt, 1973. In: Hatje, New Furniture 11, p. 25, no. 68.

rests on three massive-looking supports, which continue the line of the back and arm rests down to the ground. The principle of design is basically the same as used in Aarnio's Pastilli (pl. 127) chair, although the Jumbo is made out of one piece. Nevertheless, in order to achieve such organic and sculptural a shape, only plastic offers the nearly unlimited moldability, the light-weight and wear-resistance demanded by the consumer.

A more function-oriented design, which seems reminiscent of the principles of the International Style, is Hugh Acton's Acton stacker of 1973 (pl. 135). The construction of the chair relies on the cantilever principle of its chrome-plated tubular steel frame. The seat and back of molded copolymer is formed in consideration of ergonomics. The seat shell rises up in the back to support the lumbar region, and the back panel is curved to give the sitter enough flexibility and yet the necessary support to ensure comfort. The edges of both, the back panel and the seat are rolled. The plastic elements are screwed to the tubular steel structure in a way that prevents the tubes from protruding beyond the edges of the back or seat. The



Pl. 135. Acton, stacking chair, Hugh Acton, 1973. In: Interior Design, September 1979, p. 69.

substructure of the Acton rests on glide runners, rising up diagonally to the seat and arms respectively in opposite direction, in a trapez-like line. The supporting tubes of the seat and back, parallel to each other, and the runners terminate the very harmonious and transparent design and give the chair a self-contained, yet light appearance. The resilient cantilever steel tube construction, the light-weight and wear-resistant material of the seat and back, in addition to the very tight nesting of the Acton stacking chair, make it ideal for public seating.

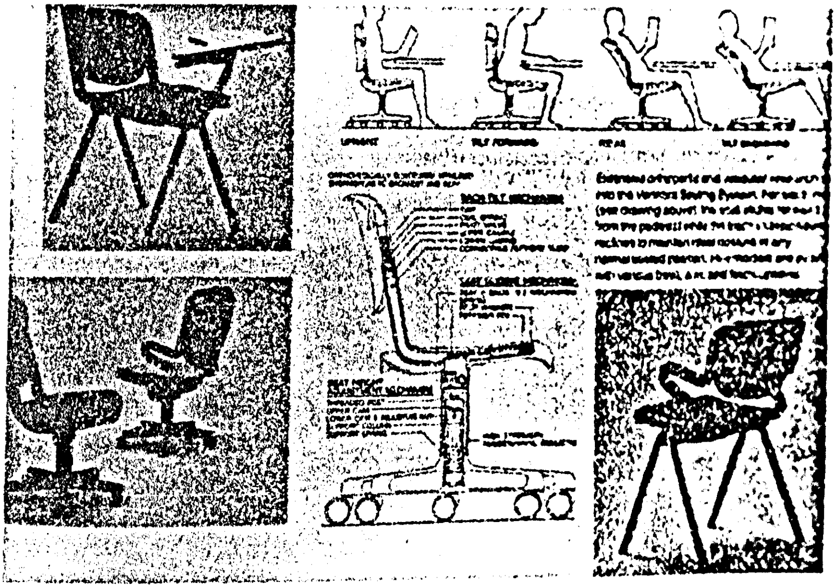
With the trend toward ergonomic chair design, Emilio Ambasz and Giancarlo Piretti invested in a great amount of orthopedic and vascular research in their approach to design the Vertebra (pl. 136), a highly adjustable seating system in 1976. Only after most extensive testing of the prototype did the Vertebra go into production. Ambasz's and Piretti's Vertebra is true to Le Corbusier a <u>machine a s'asseoir'</u>, a sitting machine. It is produced in a number of variations meeting every demand of office or public seating. Highly intricate mechanisms inside the rubber-vinyl bellows of the lateral back rest support the pedestal and the seat, facilitate automatic adjustment to every sitting position, ensuring

Pl. 136. Vertebra, Emilio Ambasz and Giancarlo Piretti, 1976. In: Progressive Architecture, September 1978, p. 181.

the desired support and flexibility to maintain an ideal posture (pl. 137). The five-pronged base and the frame of the chair are made from die cast aluminium with a powder resin finish and tubular steel. The seat and back each consists of two molded ABS high-impact shells, to meet the anatomic requirements. The sliding mechanism imbedded in the seat works independently from the tilt mechanism of the back rest through the connecting side rails and back rest supports. Both the materials used in the chair, as well as the adjustment mechanisms, are maintenance free. The aesthetic values of the Vertebra seem to fit the trend of so-called soft-tech, but they certainly prove Emilio Ambasz' statement, applicable to all his designs: ". . . giving poetic form to the pragmatic."[38] As explained in Progressive Architecture by David Morton:

> In his work one will never see art for its own sake, historical allusion of any sort, or decoration added for effect. All of the projects represent direct answers to pragmatic needs, solved at the conceptual level by poetic means.[39]

Another design, less mechanized yet attempting to solve the problem of ergonomically correct seating, is Peter Buhk's 454 Comfort chair of 1977 (p. 138), manufactured by Steelcase in five versions of office chairs.

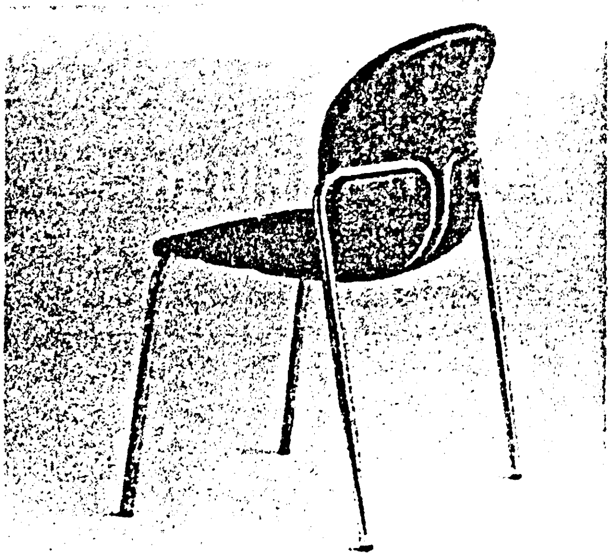


Pl. 137. Vertebra, construction drawing, Ambasz and Piretti, 1976. In: Progressive Architecture, June 1978, p. 99.

Pl. 138. 454 Comfort Chair, Peter Buhk, 1977. In: Progressive Architecture, September 1977, p. D20.

The seat shell of the chair rests on a five-pronged chrome steel base, the prongs of oval-sectioned, curved tubes on casters. The seat consists of a double shell. The outer shell is made of injection molded polypropylene in a continuous surface of seat and back, curved three-dimensionally. The inner shell is contour molded to ensure the correct support for the lumbar region. For added comfort, it is covered with urethane foam padding. The arms of the 454 Comfort are of continuous oval-section chrome-plated steel tubes, forming trapezoid shapes, which fit into the receeding curve of the accented reveal of the back rest. The 454 Comfort chairs, according to their distributor Steelcase, are designed for long-term sitting. Their appearance, due to clear smooth curved lines and generous padding, is more reminiscent of the late International Style than the austere soft-tech designs. The maintenance free, light-weight materials in congruous composition, true to their properties, give the 454 Comfort chair a self-contained, elegant look.

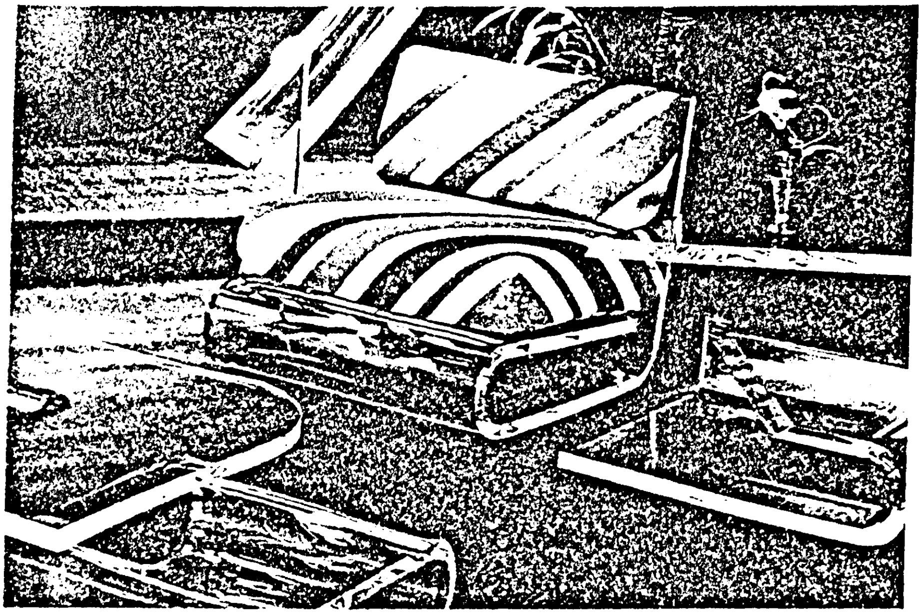
In an attempt to further integrate a metal substructure and a plastic seat shell, Reiner Moll designed the Binar stacking chair (pl. 139) produced since 1979 by Hanseatic Furniture Company. The chrome-plated



Pl. 139. Binar stacking chair, Reiner Moll, 1979. In: Progressive Architecture, July 1979, p. 118.

tubular steel carrier of the Binar consists of a four-legged construction. The slightly slanted front legs curve to support the front edge of the seat, embedded in the polypropylene shell. Parallel to each other they continue backwards, rising up to the middle of the back rest where they curve outward forming a U-like turn and extend into the backwards slanted rear legs of the chair. In order to prevent any protruding of the tubing from the shell, as in most other designs, Moll gave the polypropylene shell enough thickness to be able to countersink the steel tubes into the shell. The Binar chair was designed to be light-weight without sacrificing sitting comfort and to ensure easy stacking and transportation in addition to high impact, wear resistance, and low production cost. All of the qualities mentioned are made possible through the use of steel tubing in combination with polypropylene.

The Plexa chair (pl. 140), designed by Gary Gutterman for the Swedlow Group in the late 1970s, represents one of the examples of transparent all-plastic chairs. The Plexa chair is made of acrivue, a variety of transparent acrylic. The chair consists



Pl. 140. Plexa Chair, Gary Gutterman, 1970s. In: Interior Design, November 1979, p. 37.

of one eleventh-fourth of an inch thick sheet of acrivue, of thirty inch width, which is bent to form a cantilevered seat surface, continuing into the base, which leads back, and rises up in an obtuse angle to act as the back rest. The cantilever principle of the Plexa chair gives it the desired resilience and enhances its comfort. Acrivue, as mentioned, an acrylic base material, was developed by the Sedlow Group in their involvement with the aero-space industry and defense industry since the 1950s. The light-weight, tough, high-impact material is highly wear resistant in spite of its delicate, fragile, crystal-like appearance. Thus, it lends itself very well to furniture production. The appeal of chairs made out of acrylic or acrylic-based plastics evidently lies in the crystal-like clarity of the material, making the chairs seem nearly invisible, weightlessly floating in a room, an effect that can only be achieved with the use of acrylic.

Summary of Characteristic Features of Plastic Chair Design

In summary of the preceding examination of selected plastic chair designs, a continuous development has become evident. Beginning with the increased availability of, and familiarity with, the new plastics and their specific properties, chair designs in plastic became more and more sophisticated.

While plastics were first used as inexpensive substitutes for traditional materials, chair designers became increasingly aware of the advantages concerning unrestricted variation of forms and shapes, lightness, and wear-resistance of the new materials. When, after World War II, the plastic technology could be applied to peace-time production, three-dimensional, sculptural forms had already been introduced in architecture. This tendency of modern design and the improvement of plastics were found to be the primary premises for plastic chair design. The three-dimensional quality of the chair forms began to establish a new aesthetic for plastic chairs, an aesthetic mainly evolving out of the collaboration of designers and industry.

In the beginning, the use of plastic was limited to the forming of conchoidal seat bowls out of a single sheet. The plastic seat bowls were manufactured in a semi-mass-production process and, due to the as yet insufficient strength of the material, they had to be supported by metal legs or pedestals, as seen in Eames' and Saarinen's early chairs. The chairs, though, distinguished themselves by their light-weight, resilience, and wear-resistance, and could be produced in a wide variety of colors. The material of the seat shells, different from cold, bare steel, was pleasant to touch, and maintenance free.

With the improvement of tensile strength and impact strength of plastics, the material could be used to mold entire chairs, including the supports. Consequently, plastic chairs showed hardly any resemblance to traditional wooden chairs any longer, particularly in respect to their construction; they had obviously divorced themselves from customary construction methods. The increasingly sedentary life style led to a stronger concern with ergonomic criteria of chair design, which in turn, resulted in an improvement of anatomically correct chair design and thus sitting comfort. The high wear-resistance and the light-weight of the all-plastic chairs gave them the demanded mobility, and the uninterrupted smooth lines of some chairs began to reflect the futuristic forms of the time of space-age exploration in a playful manner. These forms were expressed in spheres and other shapes, unconventional for chair design, such as inflatable chairs and bean-bag chairs, which were also a symbol of the desire for the relaxed style of living of the 1960s. On the other hand, functional plastic chairs were continuously improved. The nesting of stacking chairs became tighter and the designs for mass-seating and public seating became more practical as well as more comfortable. The attempts to meet the demands of ergonomics led to highly refined mechanical built-in devices and new ways of applying plastics according to their continuously improving properties.

Simplicity and clear lines with smooth, glossy surfaces characterized the aesthetic of modern interiors. With the open space plans of modern residential interiors, the demand for a transparent, suspended appearance of chairs increased. This demand was met by clear plastic chairs and delicate, but strong, metal frames with light-weight plastic seats, enhancing the illusion of weightlessness and invisibility. Thus, contemporary aesthetics combined with the utmost functionalism expressed themselves in innovative chair designs of still improving modern materials.

CONCLUSION

With the new materials, steel and plastic, and the corresponding technologies, the modern chair manufacturers were in the position to make nearly any form and shape possible, with the exception of ornamentation. The aesthetic demand on chair design changed to a rather function and comfort oriented one. Contemporary chair designs are judged by clean lines and integration of materials, as well as by comfort and ergonomic criteria and wear-resistance. And in this, modern chair design has developed specialized types of chairs according to the peculiar requirements of their particular purpose. Subsequently, the criteria mentioned differ in importance, and in that way, Ralph Caplan's statement that chair design is a symbol of our civilization appears to be proved by the great number of chair designs introduced to the market each year.

Ideally, every chair should be an integral part of an interior landscape, as again Caplan explained it in a lecture at the Walker Art Center, Minneapolis, 1976: "If the world is a stage, then all designers are set designers and the chair is the basic prop."

The aim of the Baroque period to create a Gesamtkunstwerk, a total work of art, which had been declared dead, until its renaissance in the Arts and Crafts Movement, was re-established again by modern designers like Ludwig Mies van der Rohe, Le Corbusier and Frank Lloyd Wright.

The rather recent consideration of comfort and practicality in modern contract and residential design, in addition to contemporary aesthetics, led designers and manufacturers to metals and plastics for chairs, as well as their ambient. The materials not only offer economy of production and maintenance, but can also be produced with innumerable surface textures and colors, matching any designated design concept. Chairs of metal or plastics may appear weightlessly floating or solidly static; they can be collapsible, stackable, or deflatable, solving problems of storage space. They virtually leave nothing to be desired by individuality, impossible to achieve in any mass-produced object. And it is just this wish for individuality in the market place that can only be fulfilled by fast changing design trends. This pressure of the consumer market is an accelerating factor for the profit of the manufacturing industries, but not necessarily for the improvement of a design. The proliferation of chair design is also a result of the international sales marketing distribution of modern chairs and the mass-media explosion, both of which have a strong impact on the competition among furniture producers for the percentage of market share. Yet, in spite of, or possibly because of these developments, the number of good designs, satisfying in the functional, economical and aesthetical aspect, seem to increase with each decade.

As the demand for economical, high-quality production for every type of chair rises, so does the designers' ability to utilize better developed materials in improved industrial production processes in combination with ergonomic studies. The former is only made possible through the advancement of modern science, in particular in the field of engineering and chemistry. The latter, represents a rather recent trend in chair design, resulting out of the orthopedic requirements posed by the living and working conditions or positions of modern industrialized society.

The changes in modern chair design, influenced by social and technological progress, but primarily determined by the progress of the development of steel and plastics, and industrial mass-production thus can be regarded to reflect the contemporary *Zeitgeist*.

As Ralph Caplan stated in *Chair*:

> Well, remember that a chair is not an artifact of service but an artifact of culture . . . . A chair is the first thing you need when you don't really need anything, and is therefore a peculiarly compelling symbol of civilization.[40]

APPENDIX A

TABLE I

TIME CHART

DATE	SOCIO-HISTORIC AND CULTURAL BACKGROUND	INDUSTRIAL AND TECHNOLOGICAL DEVELOPMENT	ARCHITECTURE	CHAIRS	
1830-1850s	Industrial Revolution, World Exhibition in London, Social awareness, Karl Marx, and the forming of labor unions	Industrial mass-production, and Bessemar Steel	Crystal Palace	U.S. Patent chairs, Thonet bent-wood chairs, Garden chairs of iron and Iron Rocking chairs	
1860s-1920	Arts and crafts movement, Henry Cole, for union of art and industry, Founding of European Werkbuende, First World War, and the Founding of Weimer Bauhaus by Gropius	Seamless steel tubing by Mannesmann	Chicago School, Functionalism, Industrialized architecture, Influence of Cubism and industrial building in Olbrich's Sezession building, Wagner's Postal Savings Bank both Vienna Gropius' Fagus Factory, Frank Lloyd Wright's Buildings and the Rebuilding of Europe	Utilitarian steel chairs, Reimerschmid mass-produced wooden chairs, Frank Lloyd Wright's wooden chairs influenced by Cubism	
1920-1938	Increasing social awareness, Advent of Nazi Regime, and the beginning of the Second World War	Technology developed during War adapted in peace time production, and the rebuilding of industries in Europe	Weissenhof Housing Project in Stuttgart, Mass-housing with industrialized building methods, and International Style	Marcel Breuer, Mies van der Rohe, Mart Stam, Le Corbusier	Tubular steel chairs, Cantilever principle in chair construct-ion

TIME CHART - (Continued)

DATE	SOCIO-HISTORIC AND CULTURAL BACKGROUND	INDUSTRIAL AND TECHNOLOGICAL DEVELOPMENT	ARCHITECTURE	CHAIRS	
1945-1980	Post-war reconstruction in Europe, Space-age exploration, Advancement of Science Modernism	Industry adjusting to peace-time production, Development of plastic industry, Progress in metal and plastic industries, furthering mass-production	Mass-housing in Europe, three-dimensional architecture succeeds International Style	Eames, Saarinen, Kjaerholm, Jacobsen, Rowland, Penton, Day	advancement in metal chair design, Combination of plastic seat shells with metal sub-structures
1945-1980 cont.				Colombo, Paulin De Pas D'Urbino Lomazzi Piretti Ambasz Tuttle et al.	All-plastic chairs, Furniture chair designs of metal and plastic, Ergonomic chair design, Soft-Tech

APPENDIX B

DEFINITION OF TERMS

ABS: (Acrylonitrile, butadiene, styrene)--A tough, lightweight, highly moldable plastic compound especially suited to fitted parts and interlocking components (Faulkner and Faulkner, Inside Today's Home, 1975, p. 593).

ACRYLIC: A synthetic resin prepared from acrylic acid or from a derivative of acrylic acid. Common trade names are Lucite or Plexiglass. Acrylic is glasslike, strong, rigid, and of exceptional clarity with the ability to "pipe" light (Faulkner and Faulkner, Inside Today's Home, 1975, p. 261).

ARM PAD: The upholstered part of a chair arm (Arson, The Encyclopedia of Furniture, 1977, p. 30).

ARM STUMP: The front vertical support of the arm of a chair (Arson, The Encyclopedia of Furniture, 1977, p. 30).

CANE: Flexible rattan woven in open patterns for chair seats, backs, etc. (Arson, The Encyclopedia of Furniture, 1977, p. 74).

CALENDRING: A process in which a warm doughy mass of plastic (or metal) is passed between series of rollers and emerges in a flat film or sheet (Newman, Plastics as Design Form, 1972, p. 389).

CANTILEVER: . . . any horizontal member . . . projecting beyond its support (Faulkner and Faulkner, Inside Today's Home, 1975, p. 593).

CAST: To mold a substance while it is in a maleable, usually liquid state, allowing it afterward to set or harden. Also the result of such a process (Faulkner and Faulkner, Inside Today's Home, 1975, p. 593).

CELLULOSE: First modern plastic. A mixture of solid camphor and nitrocellulose under heat and pressure Newman, Plastics as Design Form, 1972, p. 389).

CELLULOSIC: A natural high-polymeric carbohydrate found in the fibrous matter of woody plants. Cotton fibers are one of the present forms of cellulose (Newman, Plastics as Design Form, 1972, p. 389).

CHEMICAL RESISTANCE: Resistance of a plastic (or metal) to chemical acids and alkylines (Newman, Plastics as Design Form, 1972, p. 389).

CHROMIUM: A blue-white metal--takes and keeps high polish--widely used as thin plating (where durability, easy maintenance and brillant shine are desirable). It is hard and resists corrosion . . . (Faulkner and Faulkner, Inside Today's Home, 1975, p. 256).

COPOLYMERISATION: Polymerizing one plastic with another at the same time to vary or add prperties to the basic plastic. A copolymer is polyester which is copolymerized with styrene or methyl methacrylate (Newman, Plastics as Design Form, 1972, p. 389).

CROSS STRETCHER: Intersecting X-stretcher, straight or curved, on tables, lowboys, and chairs (Arson, Encyclopedia of Furniture, 1977, p. 154).

CROSS-RAIL: Horizontal bar or rail in a chair back (Arson, Encyclopedia of Furniture, 1977, p. 154).

CURE: Change of physical properties by chemical reaction; usually accomplished by heat and/or catalysts, with or without pressure. Another term is: set (Newman, Plastics as Design Form, 1972, p. 389).

DENSITY: Weight per unit volume of a substance, expressed in grams per cubic centimeter, pounds per cubic foot, etc. (Newman, Plastics as Design Form, 1972, p. 389).

DIMENSIONAL STABILITY: Ability of a plastic object to retain its precise shape without change (Newman, Plastics as Design Form, 1972, p. 389).

ERGONOMICS: Greek: ergo--work and nomos--natural laws. Attempts to study the interaction between man and his workplace, considering anatomy, physiology and psychology. (Nory Miller, "Machines a s'asseoir", in: Progressive Architecture, May 1980, p. 126).

FIBERGLASS: A material made of spun, woven, matted, or chopped fibers of glass made by spinning melted glass onto filaments (Newman, Plastics as Design Form, 1972, p. 390).

FILAMENT: A long, thin, threadlike material (Newman, Plastics as Design Form, 1972, p. 390).

FILLERS: An inert substance added to a plstic to make it less costly, improve physical properties such as hardness, stiffness, and impact strength. The particles are usually smaller than reinforcements (Newman, Plastics as Design Form, 1972, 0. 390).

FLAME RETARDANTS: Chemicals used to reduce or eliminate a plastic's tendency to burn (Newman, Plastics as Design Form, 1972, p. 390).

FLEXUAL MODULUS or STRENGTH: Strength of a material in bending, expressed in tensil stress of the outer-most fibers of a bent test sample at the instant of failure (Newman, Plastics as Design Form, 1972, p. 390).

FLOW: Fluidity of plastic material usually during the molding process (Newman, Plastics as Design Form, 1972, p. 390).

FOOTRAIL: Front stretcher of a chair (Arson, The Encyclopedia of Furniture, 1977, p. 212).

FRP: Fiberglass reinforced plastic--can be molded--types range from stiff to flexible (Faulkner and Faulkner, Inside Today's Home, 1975, p. 262).

FUNCTIONAL: In general use as applied to furniture, serviceable, utilitarian, designed primarily for use rather than for decoration (Arson, The Encyclopedia of Furniture, 1977, p. 234).

GATE: Opening in a mold through which liquid is admitted (Newman, Plastics as Design Form, 1972, p. 390).

GEL COAT: A thin layer of resin, sometimes containing pigment, applied to reinforce plastic molding usually as a cosmetic (Newman, Plastics as Design Form, 1972 p. 390).

GRANULAR STRUCTURE: Nonuniform appearance of finished plastic usually due to incomplete fusion of particles within the mass (Newman, _Plastics as Design Form_, 1972, p. 390).

IMPACT STRENGTH: Ability of material to withstand shock (Newman, _Plastics as Design Form_, 1972, p. 390).

INJECTION MOLDING: A process that feeds pellets into a heating cylinder; with successive strokes a rame or a screw forces the melted material forward through a cylinder nozzel where it is injected into a cold mold (Newman, _Plastics as Design Form_, 1972, p. 391).

INORGANIC PIGMENTS: Natural or synthetic metallic oxides, sulfides, and other salts calcined during process at about 1200-2100° Farhenheit (Newman, _Plastics as Design Form_, 1972, p. 391).

LAMINATE: Superimposed layers of resin--impregnated or coated filler which is bonded together by means of heat and/or pressure to form a single piece (Newman, _Plastics as Design Form_, 1972, p. 391).

MANDRELL BENDING of steel tubes: The tube is slid on to a solid steel mandrel and fixed between a semi-circular former and a back plate. The mandrel is of the same diameter as the inside of the tube, and the former and back plate are grooved to the same diameter as the outside of the tube. As a result the walls of the tube are completely supported at the point of bending and distortion is avoided (Logie, _Furniture from Machines_, 1947, p. 121).

MODERNISM: Stylistic movement which began around 1900 committed to the ideals of functionalism and rational design and increasingly linked to industrial production (Garner, _Twentieth Century Furniture_, 1980, p. 220).

MODULES OF ELASTICITY: Ration of stress to strain in a material that is elastically deformed (Newman, _Plastics as Design Form_, 1972, p. 391).

MONOMER: Relatively simple compound which can react to form a polymer (Newman, _Plastics as Design Form_, 1972, p. 391).

NYLON: The generic term for a family of plastics exhibiting high tensile strength in fiber or sheet form (Faulkner and Faulkner, Inside Today's Home, 1975, p. 594).

PLASTIC MEMORY: Quality of some thermoplastics to return to their original form after reheating (Newman, Plastics as Design Form, 1972, p. 392).

PLASTICITY: Quality of being able to be shaped by plastic flow (Newman, Plastics as Design Form, 1972, p. 392).

POLYAMIDE: A thermoplastic material--often fiber forming (Newman, Plastics as Design Form, 1972, p. 392).

POLYESTER: A thermosetting resin of syrupy consistency (Newman, Plastics as Design Form, 1972, p. 392).

POLYETHYLENE: A thermosetting material formed under elevated temperatures and high pressure (Newman, Plastics as Design Form, 1972, p. 392).

POLYMER: The combined or joined smaller molecules that have formed larger molecules (Newman, Plastics as Design Form, 1972, p. 392).

POLYMERIZATION: The act of combining two or more molecules into a single larger molecule (Newman, Plastics as Design Form, 1972, p. 392).

POLYSTYRENE: A water-white thermoplastic (Newman, Plastics as Design Form, 1972, p. 392).

PRESTRESSED CONCRETE: Development of ordinary reinforced concrete. The reinforcing steel is replaced by wire cables in ducts, so positioned that compression can be induced in the tension area of the concrete before it is located. This is done by stretching or tensioning the cables before or after casting the concrete (Fleming, Honour, and Pevsner, Penguin Dictionary of Architecture, 1972, pp. 227-228.

PROPERTIES: Physical qualities of plastics that enable differentiation of different plastics among themselves and other materials (Newman, Plastics as Design Form, 1972, p. 392).

RESILIENCY: Ability of a plastic to quickly regain its original shape after having been strained or distorted (Newman, Plastics as Design Form, 1972, p. 392).

RESIN: A solid or semi-solid complex amorphus component or mixture of organic substances having no definite melting point and showing no tendency to crystalize (Newman, Plastics as Design Form, 1972, p. 392).

ROCKER or RUNNER: Curved slat fastened to the feet of a chair to permit it to be rocked back and forth (Arson, The Encyclopedia of Furniture, 1972, p. 356).

SET: Converting liquid resin to a solid state of curing by evaporation of a solvent, suspending medium, or geling (Newman, Plastics as Design Form, 1972, p. 392).

SHRINKAGE: Thermal contraction, continuing polymerization or cure, relaxing strains reducing the volume of plastic (Newman, Plastics as Design Form, 1972, p. 392).

SPACE FRAME: Three-dimensional framework for enclosing spaces, in which all members are interconnected and act as single entity, resisting loads applied in any direction (Fleming, Honour, and Pevsner, The Penguin Dictionary of Architecture, 1972, p. 269).

SPAN RAIL: Crosspiece between two uprights, as on a chair (Arson, The Encyclopedia of Furniture, 1977, p. 411).

STAINLESS STEEL: Durable, blue-gray steel made rust and stain-resistant by the inclusion of chromium (Faulkner and Faulkner, Inside Today's Home, 1975, p. 595).

STRETCH FORMING: A forming technique where a heated thermoplastic sheet is stretched over a mold and subsequently cooled (Newman, Plastics as Design Form, 1972, p. 399).

TENSILE STRENGTH: Measure of resistance against being pulled (Newman, Plastics as Design Form, 1972, p. 393).

THERMOPLASTIC: Material that softens when heated and hardens when cooling (Newman, Plastics as Design Form, 1972, p. 393).

TOP RAIL: Top cross member of the back of a chair (Aronson The Encyclopedia of Furniture, 1977, p. 440).

TRANSLUCENT: Letting light pass through but diffusing it so that objects on the other side cannot be distinguished (Newman, Plastics as Design Form, 1972, p. 393).

TRANSPARENT: Transmitting light rays so that objects on the other side can be seen (Newman, Plastics as Design Form, 1972, p. 393).

UPHOLSTERY: A soft covering of fabric on seating units, sometimes but not necessarily over padding, stuffing and possibly springs (Faulkner and Faulkner, Inside Today's Home, 1975, p. 595).

VINYL: A thermoplastic material formed through addition polymerization (Newman, Plastics as Design Form, 1972, p. 393).

WELDING: Joining thermoplastic (or metal) pieces by one of several heat softening processess; e.g., torch, friction (Newman, Plastics as Design Form, 1972, p. 393).

FOOTNOTES

Chapter 1

[1]Siegfreid Giedion, Mechanization Takes Command (Oxford: Oxford University Press, 1948. New York: Norton Library, 1969), p. 348.

[2]Ibid., p. 350.

[3]Ibid., pp. 401-402.

[4]Ibid., p. 406

[5]Nikolaus Pevsner, The Sources of Modern Architecture and Design (New York and Toronto: Oxford Unveristy Press, World of Art Series, 1968), p. 16.

[6]Ibid., p. 165.

[7]Ibid.

[8]Ibid., p. 147.

[9]Gilbert Frey, The Modern Chair: 1850 to Today, Teufen: Arthur Niggli Ltd., 1970), p. 29.

[10]Gottfried Lindemann and Hermann Boekhoff, Lexikon der Kunststile, vol. 2 (Braunschweig: Georg Westermann Verlag, 1970): p. 158.

[11]Frank Lloyd Wright, The Natural House (New York and Scarborough, Ontario: New American Library, London: New English Library, 1970), p. 44.

[12]Frey, The Modern Chair, p. 73.

[13]Giedion, Mechanization Takes Command, pp. 8-9.

[14]Paul Heyer, Architects on Architecture, New Directions in American, new enl. ed., (New York: Walker and Co., 1978), p. 243.

[15]Le Corbusier/Pierre Jeanneret, "Five Points Toward a New Architecture", in: Programs and Manifestoes on Twentieth Century Architecture, ed. Ulrich Conrads, transl. by Michael Bullock, (Cambridge, Mass.: MIT Press, 1975): p. 101.

[16]Walter Gropius, "Principles of Bauhaus Production (Dessau)," (Excerpt), In: Programs and Manifestoes on Twentieth Century Architecture, ed. Ulrich Conrads, transl. by Michael Bullock, (Cambridge, Mass.: MIT Press, 1975): p. 95.

[17]Ibid., p. 96.

[18]Heyer, Architects on Architecture, p. 22.

[19]Ludwig Mies van der Rohe, "Working Theses", In: Programs and Manifestoes on Twentieth Century Architecture, ed. Ulrich Conrads, transl. by Michael Bullock, (Cambridge, Mass.: MIT Press, 1975), p. 74.

[20]Ludwig Mies van der Rohe, "Industralized Building", In: Programs and Manifestoes on Twentieth Century Architecture, ed. Ulrich Conrads, transl. by Michael Bullock, (Cambridge, Mass.: MIT Press, 1975): p. 81.

[21]Frey, The Modern Chair, p. 74.

[22]Karl Mang, History of Modern Furniture, trans. John William Gabriel, ed. Bitite Vinkler (New York: Harry N. Abrams, 1979), p. 109.

[23]Patricia Kane, 300 Years of American Seating Furniture (Boston: New York Graphic Society, 1975), p. 278.

[24]H. Bayer, W. Gropius and I. Gropius, ed, Bauhaus, (New York: The Museum of Modern Art, 1938), p. 126.

[25]Mang, History of Modern Furniture, p. 112, no. 235.

[26]Charles Jencks, Le Corbusier and the Tragic View of Architecture, 3rd ed., (Cambridge, Mass.: Harvard University Press, 1976), pp. 79-80.

[27]Clement Meadmore, The Modern Chair: Classics in Production (New York: Van Nostrand Reinhold Co., 1979), p. 72.

[28]Ludwig Glaeser, Mies van der Rohe, Furniture and Furniture Drawings from the Design Collection and the Mies van der Rohe Archive, 2d printing, (New York: Museum of Modern Art, 1969), pp. 62-64.

[29]Meadmore, p. 96.

[30]Douglas Allan Fisher, The Epic of Steel (New York: Evanston, London: Harper and Row Publishers, 1963), p. 165.

[31]Ibid., p. 164.

[32]Ibid., p. 160.

[33]Ibid., p. 246.

[34]Ibid.

[35]Gordon Logie, Furniture from Machines (London: George Allen an Unwin, Ruskin House, 1947), p. 48.

[36]John W. W. Sullivan, The Story of Metals (Cleveland, Ohio: American Society for Metals and Ames, Iowa: Iowa State College Press, 1951), p. 272.

[37]Logie, p. 49.

[38]Ibid., p. 48

[39]Ibid., p. 49.

[40]Mang, p. 157.

[41]Arthur Drexler, Charles Eames, Furniture from the Design Collection (New York: Museum of Modern Art, 1973), p. 24.

[42]Meadmore, p. 103.

[43]Drexler, p. 21.

[44]Ibid., p. 34.

[45]Mang, p. 151.

[46]Ibid.

[47]Ibid.

[48]Meadmore, p. 118.

[49]Ibid., p. 146.

[50]Ibid., p. 158.

[51]Ibid.

[52]Progressive Architecture, May 1978, "Advertisement for Vecta Contract, Gibilterra Seating Series," pp. 14-15.

[53]Ibid.

[54]Lorelei McDewitt, "Pacifica, An Industry Supported Competition", Designers West, March 1980, p. 32.

Chapter II

[1]Thelma R. Newman, Plastics as Design Form (Philadelphia: Chilton Book Co., 1972), p. 30.

[2]Ibid., pp. 34-35.

[3]Ibid., pp. 38-39.

[4]Ibid., pp. 36-37.

[5]Ibid

[6]Ibid., pp. 38-39.

[7]Ibid.

[8]Ibid., pp. 40-41.

[9]Ibid.

[10]Morris Kaufman, Giant Molecules, Doubleday Science Series, (Garden City, New York: Doubleday & Company, Inc., 1968), p. 134.

[11]Heyer, p. 204.

[12]Charles Jenckes, Modern Movements In Architecture (Garden City, New York: Anchor Press/Doubleday, 1973), p. 243.

[13]Ibid., p. 25.

[14]Peter O. Muller, Kenneth C. Meyer, and Roman A. Cybriwsky, Philadelphia, A Study of Conflicts and Social Cleavages (Cambridge, Mass.: Ballinger Publishing Co., 1976), p. 47.

[15]Martin Pawley, Architecture Versus Housing, ed., Mary Kling, (New York and Washington: Praeger Publishers, 1971), p. 97.

[16]Ludwig Mies van der Rohe, "Technology and Architecture," in Programs and Manifestoes on Twentieth Century Architecture, ed. Ulrich Conrads, Transl. by Michael Bullock, (Cambridge, Mass.: MIT Press, 1975), p. 154.

[17]Ibid.

[18]Hundertwasser, "Mould Manifesto Against Rationalism in Architecture," in Programs and Manifestoes on Twentieth Century Architecture, ed. Ulrich Conrads, transl. by Michael Bullock, (Cambridge, Mass: MIT Press, 1975), p. 157.

[19]Reinhard Gieselmann and Oswald Mathias Ungers, "Towards a New Architecture," in Programs and Manifestoes on Twentieth Century Architecture, ed. Ulrich Conrads, transl. by Michael Bullock, (Cambridge, Mass.: MIT Press, 1975), p. 165.

[20]Newman, p. 10.

[21]John McHale, "The Plastic Partheon," in Kitsch. The World of Bad Taste, by Gillo Dorles, 2d print., (New York: Universe Books, 1970), p. 103.

[22]Edward Lucie-Smith, Furniture, A Concise History (New York and Toronto: Oxford University Press, 1979), p. 189.

[23]Glaeser, p. 16.

[24]Ibid.

[25]Drexler, p. 34.

[26]Meadmore, p. 111.

[27]Drexler, p. 36.

[28]Meadmore, p. 111.

[29]Ibid., pp. 111-112.

[30]Drexler, p. 36.

[31]Mang, p. 153.

[32]Moody, p. 117.

[33]Edie Lee Cohen, "Milan '79: An Overview of the 1979 Salone del Mobile." In: Interior Design, January 1980, p. 106.

[34]Moody, p. 121.

[35]Frey, p. 127.

[36]Ibid.

[37]Contract, August 1980, "Advertisement for the Nova System by Atelier International," p. 2.

[38]David Morton, "Emilio Ambasz, Poetic Pragmatism." In: Progressive Architecture, September 1978, p. 98.

[39]Ibid.

[40]Ralph Caplan, "Ralph Caplan: His Perspective, Chairs as Symbols of Civilization and Cultures." In: Chair, ed. Barbara Prete, produced by Peter Bradford, (New York: Thomas Y. Cromwell, 1978), p. 19.

[41]Ibid.

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