Wood, Plywood and Veneer,

Cranbrook, the New Bauhaus and the W. P. A.:

the Origins of the Eames Chair of 1946

by

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> There is no need to qualify the statement. Charles Eames has designed and produced the most important group of furniture ever developed in this country. His achievement is a compound of aesthetic brilliance and technical inventiveness.
>
> --Eliot Noyes, 1946

In 1946, at the opening of the post-War era, a radically new chair was introduced. This chair, designed by Charles and Ray Eames, was available in several variations, and very quickly met with wide success. Its most classic form, which is to say the one with the most pleasing proportions and the one which has become an archetypal image, is the dining chair of plywood shock-mounted onto slender steel rods (figure 1). Along with a related, slightly lower side chair, it is still being manufactured and sold by the Herman Miller Furniture Company of Zeeland, Michigan.

Light in weight, functional and inexpensive, the 1946 dining chair quickly found its way into business, institutional and domestic interiors. In each kind of setting it effectively symbolized something appropriate: a business in the forefront of advancing technology; an institution serving its client-public in an efficient and enlightened manner; or a living environment adapted to an informal, transient lifestyle. It would be hard to cite any

other product which was more successful in symbolizing, and in serving, the aspirations of the early post-War era.

But while it is very much a product of, and is very appropriate to, a specific time and place, viewed in a broader context the 1946 dining chair appears to be the culmination of a number of developments, technical as well as artistic and conceptual, which had taken place in the distant past as well as during more recent times.

Few materials are as intimately intertwined with human culture as is wood. The earliest encounters of man and woman kind with wood are irretrievably lost to history, but there can be little doubt that in the pre-historic era many of the qualities and uses of wood have been independently and repeatedly re-discovered by diverse groups. Within the era of recorded history, it is in Egypt that wood technology has the most ancient lineage,[1 and the earliest known remains of wooden furniture were found there. These fragments date back more than 5,000 years, to the beginning of the dynastic period,[2 and bear evidence of a level of woodworking skill which could only have developed over a number of generations.

It is not too surprising that the earliest use of plywood can also be traced to Egypt, where the plywood remains of a Third Dynasty inner coffin have been found.[3 It dates from the thirtieth century B. C., when the most sophisticated woodworking tools were made of copper. The inner coffin has six layers, each .016 inch thick, laid with the grain in alternating directions. These layers were held together by a system of wooden dowels and pegs. Evidently no adhesives were used between the individual layers,[4 but it is known that adhesives were later routinely employed in making plywood, at least as early as the Middle Kingdom[5, which indicates that this key element in plywood technology is at least 4,000 years old.

Although the visual appeal of veneers must have played a role in the development of plywood, it is

possible that plywood was also valued by the Egyptians as a practical means of making the most efficient use of wood during periods when that material was in short supply. Since there is ample evidence of the use of thick wooden planks in coffins during most periods of Egyptian history, it might be concluded that planks were either preferred or simply found to be easier to employ than plywood. However, it should be noted that the most famous of Egyptian materials, papyrus paper, both antedated plywood and provided a conceptual framework for it. Papyrus paper is itself composed of two layers of strips cut from the stem of the papyrus plant, fused together so that the grain of each layer is at a right angle to the other.

Plywood, as utilized in the modern era, may be defined as thin sheets of wood, usually odd in number, and most commonly three or five, fastened with glue or another adhesive, with the grain of adjacent layers arranged at a right angle or at wide angles. The improvement of adhesives has meant that the use of metal or wooden dowels and pegs has been discontinued.

Throughout European history interest in plywood has gone through cycles.[6 There was much interest in plywood during Roman times,[7 in Renaissance Italy, and in eighteenth-century England. In 1793, Thomas Sheraton wrote that furniture makers could make use of "pannels . . . glued up in three thicknesses, the middle piece being laid with the grain across, and the other two lengthways of the pannel, to prevent its warping."[8 In 1856, John Belter, a New York furniture maker who was a native of Germany, wrote that ". . . veneers glued together with the grain of each layer standing at right angles to the next have long been in use for the purpose of combining strength and lightness."[9 Makers of musical instruments had developed even more sophisticated techniques of using plywood than had furniture makers. Beginning at least as early as the Renaissance, very skillful use was made of veneers and plywood, especially for stringed instruments. But it was only in the late nineteenth century that the modern concern with the improvement of plywood

technology began.

The Eames chair depends not only on plywood, but also on the manner in which that plywood is curved. Both the seat and the back are double-curved, continuous planar masses (figure 2). Practical uses of planar masses of this kind can be dated to the distant past, since they have long been used for such things as boat hulls, helmets, musical instruments and roofs. Curiously, conceptual and artistic treatment can not be found prior to the twentieth century (except in mathematics).

It should be emphasized that only planar masses curved in more than one direction are under discussion here. Thus we are not considering such things as, for example, the serpentine wall designed by Thomas Jefferson for the University of Virginia, nor are we considering spherical or elliptical domes, nor conic sections or portions of single or intersecting cylinders.

Continuous planar masses shaped into compound curves can be formed of discrete elements, such as the tiles used in the helicoidal, or flattened spiral, roof Antoni Gaudi designed in 1909 for the School of the Church of the Sagrada Familia in Barcelona (figure 3);[10 they can be carved out of solid materials such as wood or rock; they can be made of wooden planks, concrete, metal, clay or thermoplastics, which are shaped by carving, warping, bending, stamping, molding or casting; they can be of woven materials, such as wicker employed for furniture or baskets; or they can be shaped from layered material such as plywood.

Bent plywood furniture was anticipated by some of the experiments made by Michael Thonet in Germany, beginning in the 1830s. Using glue, he laminated together narrow, thick strips of wood which had been molded into shape under heat (figure 4). He found it impossible to curve these laminations in more than one direction. Through further experimentation, Thonet developed a method of glueing together twisted, bent strips of wood, each piece square in cross-section. The resulting bundle was rasped to

give it a round or oval cross-section. He was thus able to begin the shaping of the sinuous curves which were to make his bent-wood furniture famous.[11

Thonet was invited to Vienna where he set up a factory which produced his chairs in quantity. Their light weight made them ideal for shipping by means of Europe's expanding railroad network. In seeking to extend his markets to the Western Hemisphere, Thonet ran into trouble because the glue used in his laminated rods became unstable in hot, humid climates. To meet this problem, he developed methods of bending solid wooden canes (figure 5).[12

In the United States, George Gardner began seeking patents for bent plywood furniture in 1872. Soon his family firm of Gardner & Company had furniture of this kind in production, and proved to be especially successful in providing chairs and benches for waiting rooms in railroad stations and hospitals (figures 6 and 7).[13 The firm moved from Glen Gardner, New Jersey, to New York City about 1875. Gardner & Company received much attention from its displays at the Centennial Exposition in Philadelphia in 1876 and at the Universal Exposition in Paris in 1878.[14 In Philadelphia it was noted that:

> These goods were a comparative novelty, especially to foreigners, from whom they have received considerable notice and approval.
> . . . . . .
> They are made by gluing veneers together, so that the fibre of each layer crosses the other at right angles, neatly perforated and shaped . . .[15

Another pioneer in the United States was Isaac I. Cole, but while he did produce a patent model of a bent plywood chair in 1874, he evidently did not put any furniture into production.[16 However, several other American firms did provide competition for the Gardners, including Frost & Peterson, organized in 1880 by Albert Henry Frost and Edwin Peterson.[17 In 1883, Albert Frost and his brother,

George E. Frost, organized Frost's Veneer Seating Company of Sheboygan, Wisconsin. Albert Frost went on to set up the Frost Veneer Seating Company of Newport, Vermont, in 1886, a firm which became the largest veneer manufacturer in the world. Still another Frost enterprise was the New York Veneer Seating Company of Jersey City, launched in 1893.[18

After the death of Michael Thonet, his five sons, who had inherited their father's furniture firm along with his inventive spirit, took a close look at some of this American work. One result was an all-plywood chair with a continuous back and seat curved in only one direction, but with a system of complex curves employed for the legs and stretchers. It proved to be impossible, however, to mass-produce this type of chair economically (figure 8).[19

One of the areas of great importance to the modern history of plywood is the region bordering on the Gulf of Finland (figure 9). Because of frequent changes in the political geography of the area, it is easy to become confused by the out-of-date geographical references which mar the written history of plywood. At the same time, much of this history is clarified if the political and cultural makeup of the region is taken into account.

Prior to 1917 the territory of Imperial Russia included all of Estonia, which lies on the southern shore of the Gulf. Finland, on the northern shore, was a semi-independent grand-duchy within the Russian Empire. Finland became independent in 1917, but it was forced to give up part of its territory to the Soviet Union in 1947, including some birch forests important to its plywood industry. Estonia gained its independence in 1918, but was occupied in 1940 by the Soviet Union, which made it one of the constituent Soviet Republics, a move still not universally recognized by other governments. Estonia once had strong ties with Germany, and the Livonian knights from Germany once constituted its ruling class. After the German occupation of 1941-1944, the Germans were expelled. Finally, it should be noted that the Estonians and the Finns have close cultural ties and the Finnish and Estonian languages are

related. The capital of Finland, Helsinki, is only about fifty miles from Tallinn, the capital of Estonia, if one takes the water route across the Gulf.

In 1884 Christian Luther, the head of a lumber manufacturing concern in Tallinn, Estonia, came across some of the seats made by one of the the Frost companies. Luther (who claimed, incidentally, to be a descendent of Martin Luther) became very excited about the future of plywood, and by 1889 he had in production chairs with bent plywood seats and backs.[20 He influenced the founders of a British firm, Venesta, Ltd., which later amalgamated with Luther's own firm.[21 And, in what was to become an American connection, the young Eliel Saarinen, then practicing with a firm in Hensinki, designed a factory building in Tallinn for Luther's firm in 1904.[22

Luther's chief contribution to plywood technology was the introduction of a new waterproof casein glue, for which he was granted a patent in 1892. Four years later he was granted a patent for a hot plate press.[23 In general, it may be said that the quarter-century preceding World War I was characterized by a rapid pace of development in plywood technology. During this period blood-albumen adhesives were developed in Estonia,[24 and the rotary cutter was perfected in France.[25 The latter device permitted the cutting of individual plies of almost any length.

The pace of development of plywood technology quickened during World War I because plywood was used in the famous "flying crates." Due to its favorable strength-to-weight ratio, plywood proved to be very adaptable to aircraft construction. Aircraft manufacturers rapidly acquired a great amount of skill in the use of adhesives and in the bending and molding of plywood into complex curves.[26

It was immediately following the end of World War I that the Bauhaus was organized by Walter Gropius, a young architect. The school he opened in Weimar, Germany, in 1919 was a combination of a

revived Kunstgewerbeschule which had been suspended during the War, and a traditional fine arts academy which had remained in operation. Significantly, after the fine arts academy withdrew from the arrangement, Gropius continued to include artists in the Bauhaus faculty mix, which also included a group of architects and designers with broad-ranging interests. This faculty proved to be adept at synthesizing, at bringing together and using discoveries made elsewhere by artists, architects, designers, educators and psychologists, while remaining keenly aware of new industrial and technical developments. Many among the faculty and student body served as role models for craftsperson-designers, who would keep abreast of the latest work produced by artists and architects and who, from individual studio-workshops, would produce prototypes for large-scale manufacture by industry.

The involvement of the Bauhaus with wood is usually overlooked, perhaps because it has been overshadowed by other developments during the school's fifteen-year history. Gropius himself was the initial head of the woodworking workshop, and Johannes Itten, who set up the influential foundation course, had a mystical appreciation for wood, along with a keen appreciation of its physical properties (figures 10 and 11). The initial furniture designs of Marcel Breuer, who studied and later taught at the Bauhaus, were all in wood (figure 12).

Breuer, of course, is best known for his metal furniture, as is Ludwig Mies van der Rohe, the last director of the Bauhaus, who came to the school after it had moved to Dessau and who later moved it to Berlin. Breuer and Mies did make important contributions to the development of furniture design by devising new ways of using metal, but equally important was their more general role in creating a sense of excitement about experimental furniture design. The work of Alvar Aalto provides a case in point. He was a Finnish architect whose early furniture designs were based either on traditional forms or on the curved seat-and-back units produced by the Luther firm (figures 13 and 14).[27 His precedent-breaking plywood furniture designs came

after he had joined the C. I. A. M. (Congres Internationaux d'Architecture Moderne) in 1929 and had become aware of the work of Breuer and Mies as well as the work of other architect-designers such as Le Corbusier (figure 15).[28

It was also in 1929 that Charles Eames, then an architect working in St. Louis, visited Stuttgart and first came into contact with European modernism.[29 In Stuttgart he studied the model housing development erected two years earlier, which included buildings designed by Gropius, Mies, Le Corbusier and others, and presumably saw some chair designs by some of these architects, at least in illustrations, at the same time.[30 Also to be seen in Stuttgart in 1929 was an exhibition of the regional affiliate of the German Werkbund. This exhibition included some plywood furniture designed by Gropius.[31

Much of the influence of the Bauhaus in the United States is due to the direct impact of former teachers and students from the school who left Germany beginning in 1933. The most significant of these figures as far as wood is concerned is Hin Bredendieck. He had become interested in the possibilities of bent plywood while still a student at the Bauhaus (figure 16). Until 1937 he had been a furniture designer in Oldenburg, Germany.[32 In that year he moved to Chicago, where he taught the foundation course at the New Bauhaus, a school newly organized by former Bauhaus teacher Laszlo Moholy-Nagy for the Association of Arts and Industries.[33

The New Bauhaus occupied the former Marshall Field mansion on South Prairie Avenue, erected in 1873 from designs of Richard Morris Hunt. It was remodeled for the school by Moholy, assisted by Henry K. Holsman, an architect who was a member of the board of the Association.[34

Some of the exercises Bredendieck devised for his foundation course involved wood. These exercises were due in part to Bredendieck's sophisticated understanding of the possibilities of woodworking, and in part to a unique opportunity: in remodeling

the entrance hall of the Field mansion, much of the interior woodwork was removed (figures 17 and 18). The old staircase at the end of the hall took on a sleek, modern appearance (figures 19 and 20). This meant that there was a lot of fine, rare hardwood, carefully selected and brought in from around the world when the house was built, now made available for student use, free of charge.[35 Bredendieck's exercises included making "wood cuts," which were not prints but rather were exercises in cutting into wooden blocks with hand and power saws and drills (figure 21). There were also hand sculptures, meant to be held in the hand and perceived by the sense of touch (figure 22).

After one year of operation, the New Bauhaus was discontinued because its sponsoring group ran out of money. However, Bredendieck and some of his former students were enabled to continue their interest in wood, this time on a more practical basis, through opportunities provided by John Walley, who was serving as an unusually imaginative and resourceful director of the Design Workshop of the Illinois Art Project, a unit of the Work Projects Administration, a program of the United States Government. Walley has described the Workshop as follows:

> The function of the Design Workshop was to restore, maintain and develop new skills in unemployed craftsmen through the production of useful equipment and environments for tax supported institutions in the municipal, county, state [or] federal governments and any combination of the four. The sponsors provided the budget for materials and services. The Federal Government provided the funds for labor and the basic tools needed to operate the project.[36

Bredendieck was not a United States citizen, but Walley arranged for private funds to enable him to appoint Bredendieck as special consultant to the Design Workshop. As Walley put it, "Bredendieck became a central force in transcending the limited craft concepts that controlled the state-wide shops

before they were placed under our supervision."[37 Bredendieck had brought with him from Germany some knowledge of experimental projects in plywood lamination in the aircraft industry there.[38 Walley has described how Bredendieck dealt with a dispute in the wood shop:

> After a technical dispute in the workshop by some central European workers over the possibility of fabricating a double curvature veneer lamination, Bredendieck asked permission to use a workbench. He brought his personal tool box and prepared to build the forms. The comment of the workers after the demonstration was that as soon as he opened his tool box and put on his apron they knew they had lost the dispute.[39

The best known project of the Design Workshop of the Illinois Art Project was the furniture for the Crow Island Elementary School in Winnetka, in collaboration with the Milwaukee Art Project of the W. P. A. The architects for the school were Eliel & Eero Saarinen, in association with Perkins, Wheeler & Will.[40 Eliel Saarinen had moved to Bloomfield Hills, Michigan, where he headed the newly organized Cranbrook Academy of Art. Eero Saarinen, his son, was a graduate of Yale University School of Architecture, and had worked as an industrial designer in the office of Norman Bel Geddes. Charles Eames assisted Saarinen & Saarinen on the Crow Island School.[41 The other firm, now known as Perkins & Will, is based in Chicago.

The Crow Island School, completed in 1939, was carefully planned around a program developed under the direction of Carleton Washburne, the local school district superintendent, and it is considered a landmark in school design. The furniture, designed by the architects,[42 incorporated seating and back units formed out of continuous curved plywood surfaces (figure 23). All of the curves employed in the furniture were curves in one direction only. Nevertheless Bredendieck, who served as liaison between the two firms of architects, no doubt had the opportunity to show some of the other work of the

Design Workshop to Eames and to the younger Saarinen. These would have included some examples of plywood bent in more than one direction.

Much of the experimental furniture design of the early 1940s is associated with either the School of Design in Chicago, organized by Moholy to replace the New Bauhaus, or with the Cranbrook Academy.

Although Bredendieck did not teach at the School of Design in Chicago,[43 he had an impact there because some of the students had studied with him at the New Bauhaus and had also worked with him in the Design Workshop. There was no instructor specifically in charge of furniture design at the School of Design in Chicago, and many of the student-designers took on teaching responsibilities in other areas concurrently with their furniture experiments. Some of the more imaginative designs in bent plywood were those of Nathan Lerner (figure 24), Charles Niedringhaus (figure 25), and Henry Kann (figure 26). Also notable were the experiments of Niedringhaus and Jack Waldheim in attempting to develop a wooden spring, suitable to replace metal springs in chairs and beds (figure 30).[44 The most intense period of furniture experimentation was during 1940 and 1941.

An exhibition in 1942 marking the first commencement exercises at the School of Design included much of the student-designed furniture (figure 31). Off-campus recognition of some of this student-designed furniture included coverage in Chicago and out-of-town newspapers and in such national publications as the Architectural Forum and Modern Plastics.[45 Some of the furniture was used for commercial interiors executed by the students under Moholy's direction, as a source of income for the school.[46

The buildings designed by Eliel Saarinen for the Cranbrook Academy seem conservative in contrast with the stark modernism of the earlier school Gropius had designed for the Bauhaus in Dessau. Nevertheless, in practice there were many similarities between the operation of Cranbrook, and

the German Bauhaus, and the schools organized in Chicago by Moholy. All of these schools had a faculty mix of of architects, designers and artists, and all were centers of experimentation in furniture design.

Charles Eames went to Cranbrook in 1936 on a fellowship, and was asked to stay on as head of the experimental design workshop. Ray Kaiser, a painter and sculptor who had studied with Hans Hofmann for six years, enrolled at Cranbrook in 1940.[47

It was also in 1940 that the Museum of Modern Art in New York announced a competition with the title, "Organic Design in Home Furnishings," open to all designers in the Western Hemisphere.[48 Entrants from the United States were judged separately, and two of the nine categories were won by Charles Eames and Eero Saarinen. Although she was not credited, Ray Kaiser had aided them with the designs, and had prepared the graphic presentation (figure 32). The panel of judges included Marcel Breuer.[49

Part of the competition rules provided that the designs were to be suitable for mass production and immediately available in sufficient quantities so that sales could begin simultaneously with an exhibition of the winning designs at the Museum of Modern Art in the Autumn of 1941. This exhibition then travelled to a series of other museums (figure 33). Co-sponsors included Bloomingdale's Department Store in New York and a network of department stores across the country, each of which was to sell the furnishings.[50

The winning designs of Eames and Saarinen included two armchairs and a side chair molded from plywood into complex curves, and covered with foam rubber (figure 34). Since manufacturers found the molding of the plywood and the method by which the metal legs were bonded to the wood to be too expensive for production, only a few pieces of the furniture were made, at great expense.[51 The entry of the United States into World War II ended any further attempt to overcome production obstacles.

Charles and Ray Eames were married June 20, 1941. Shortly afterward they moved to Southern California and began a design partnership which ended only with the death of Charles in 1978. He began designing sets for the MGM film studios, and collaborated with Ray on experiments with low cost lamination of wood veneers into compound curves. Sometimes plywood sheets were carried into their small apartment at night to avoid alarming their landlord, and their kitchen stove was used as a heat source for their experiments.[52 In November of 1942 they received a U. S. Navy commission for molded plywood splints. Using space in a vacated bakery and some adjoining stores, they set up a workshop to produce the splints, aided by a group of local designers, an artist, and other interested persons. In 1943 this Southern California enterprise became part of the Detroit-based Evans Products Company, and expanded into production of a molded plywood litter for carrying wounded persons, as well as laminated glider parts.[53

The extent to which World War II was fought with plywood is now only a fading memory. The counterparts of the flying crates used in the earlier global conflict were the later, more sophisticated plywood aircraft made possible by improved technology. After World War I there had been a temporary lapse of interest in wooden planes, due in part to deficiencies in plywood adhesives: casein and blood-albumen adhesives proved to be vulnerable to damage by moisture or bacteria. These problems were solved with the development of synthetic resin adhesives, and there were also technical advances in molding plywood. As one result, a renewed interest in the use of plywood for aircraft manufacture was evident in the 1930s in England, Germany and some other countries. With the outbreak of World War II, an increased demand for aircraft was combined with a shortage of metal.[54 In Great Britain the Mosquito fighter plane, for example, was of nearly all-plywood construction (figure 35), and huge quantities were produced with the aid of shipments of plywood received from the United States and Canada.[55 Plywood was even used in bombers and other heavy aircraft.

Michigan, with a tradition of making wooden furniture as well as wooden vehicles, became a center for the production of plywood gliders and powered aircraft, as well as aircraft parts (figures 36 and 37). Some automobile factories were converted into plywood aircraft factories, thus "retrogressing" to the period when automobile bodies had been made of wood.[56 One Engineer conducted wartime experiments with plywood automobiles, in the expectation that advances in plywood technology would bring back the wooden automobile (figure 38).[57

The most forceful demonstration of progress in plywood technology was provided by the California-built Hughes H-4 Hercules military cargo plane (figure 39). This was not because of its performance record, since it was not flown until 1947, and then only on a brief trial course. It was because of its size, with a 320-foot wingspan, still the largest ever built, that it was dubbed the flying lumberyard and the "Spruce Goose." The Hughes staff, however, called it the "Jesus Christ" plane, because when shown to visitors in its hangar no other comment seemed forthcoming![58 Charles Eames, not incidentally, was one of the consultants for this wooden behemoth.[59

Finally, I should like to emphasize that I am not trying to make a case for the Eames chair as an example of technological determinism. It did not just appear; it was produced by two very special people who were very much aware of the contemporary work of “fine” artists and who managed, in spite of limited resources, to set up a small workshop-studio. While it is difficult to determine the precise role of the fine arts in the artistic and conceptual pre-conditions for the Eames chair, and while it is probably impossible to find out which works of art Charles and Ray Eames had been most keenly aware of, and what influence these works might have had on their design work, it is nevertheless worth noting that except in the field of mathematics, artistic and conceptual treatments of the double-curved planar mass began only in our century. The pioneer would seem to be Pablo Gargallo (figure 40), a Spanish

sculptor who had known Pablo Picasso from an early date, and who shared a studio with him in Barcelona in 1901. The other is Julio Gonzalez (figure 41), who first met Picasso at about the same time as Gargallo. Gargallo and Gonzalez were both drawn to the possibilities of the compound-curved planar mass because of its expressive possibilities in figural sculpture.[60

The pioneers in using this kind of form in abstract sculpture were two brothers: Naum Gabo (figure 42) and Antoine Pevsner.[61 But somehow the central figure seems to be Moholy, as it so often does in dealing with creative work in our century. Moholy began to shape clear thermoplastic into sculpture at least as early as 1940, employing, in spite of what would now be recognized as a health risk, his kitchen stove and his bare hands. In his use of plastic, he anticipated the chairs of the Eameses executed in this type of material beginning in 1950. His use of slender metal rods intersecting with plastic curved planar masses seems especially premonitory (figure 43).[62

A molded plywood sculpture made by Ray Eames in 1942 prefigures some of the furniture designs on which she collaborated with her husband, but also seems to show some awareness of the abstract sculptural work of Gabo, Pevsner and Moholy.[63

In what was still being termed a “one man” show, some of the furniture designed by the Eameses was exhibited at the Museum of Modern Art in March of 1946.[64 Included were side chairs and dining chairs constructed entirely out of plywood. The use of a single material would seem to ensure greater uniformity of design. However, the seat and back, because they are composed of compound-curved planar masses, are conspicuously thin when compared to the supporting structure, curved in one plane only (figure 44). Thus it seemed preferable to use two different kinds of material for two different kinds of functions, and in other versions of these chairs, seen in the same exhibition, the thin metal rods appear to be ultimately more harmonious with the thin plywood planes of the seat and back.[65 It was a

form of this kind of chair, a dining chair developed shortly after the exhibition was held, which was cited at the beginning of this essay as the "most classic form" of the 1946 chairs designed by the Eameses (figure 1). This dining chair is 29 1/2 inches high, and the related side chair is 27 3/8 inches high.

The seats and backs were attached to the metal supports by means of rubber shock-mounts originally developed for engine mountings. The connections between these rubber mounts and the parts of the chair were accomplished through a process known as “Cycleweld,” in which a sheet of synthetic resin is placed between the parts to be joined, and heat is transmitted to the resin electronically. The process is quick, does not involve enough heat to injure the wood, and the joints are waterproof.[66

In 1946, George Nelson was appointed director of design for the Herman Miller Furniture Company, and in one of his first acts, he made a recommendation, which was accepted, that the wood-and-metal versions of the Eames side chairs be be added to the company’s lines.[67 These chairs are still available from Herman Miller.

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2. Schematic drawing by Herbert Matter for Arts & Architecture, reprinted in the *Museum of Modern Art Bulletin*, volume XIV, number 1, Fall, 1946, page [1 (front cover)] (Matter's drawing depicts a

three-legged version of the chair which slightly preceded the version shown in figure 1

3. Antoni Gaudi: School of the Church of the Sagrada Familia, Barcelona, 1909 (illustrated in: George Collins, "The Transfer of Thin Masonry Vaulting from Spain to America," *Journal of the Society of Architectural Historians*, volume XXVII, number 3, October, 1968, figure 15)

4. Michael Thonet: chair [shown with detail] employing laminated strips of wood, made in Boppard, Germany, c. 1838

5. Thonet: an example of chair number 18, first produced c. 1867

6. Gardner & Company: chair, shown in an illustration from: Gardner & Company, *Perforated Veneer Seats* . . . (New York: author, 1884)

7. George Gardner: bench, shown in an illustration from: Gardner & Company, Perforated Veneer Seats; also illustrated in: Nikolaus Pevsner, "The History of Plywood up to 1914," *Architectural Review* (London), volume LXXXVI, number 514, page 129

8. Thonet Brothers: experimental bent plywood chair of c. 1870

9. map of the Gulf of Finland, showing borders before and after 1947

10. Heinrich Busse: preliminary exercise (tactile chart) for the wood workshop at the Bauhaus, Weimar, c. 1922 (photograph from the Bauhaus-Archiv, West Berlin)

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12. Marcel Breuer: children's furniture, including chairs with plywood seats and backs, 1923

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14. Alvar Aalto: chair with bent plywood seat, 1929 (illustrated in: Pearson, *Alvar Aalto*, figure 227 on page 143)

15. Alvar Aalto: scroll-form plywood chair, c. 1930 (Museum of Modern Art, New York)

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19. detail of the staircase as shown in figure 17

20. Henry Holmes Smith: photograph of remodeled staircase in the Marshall Field Mansion, 1938

21. “wood cuts” made by students of Hin Bredendieck at the New Bauhaus, 1937 (photograph from Manuscripts Department, Library of the University of Illinois at Chicago)

22. hand sculptures made of wood by students of Hin Bredendieck at the New Bauhaus, 1937 (photograph from Manuscripts Department, Library of the University of Illinois at Chicago)

23. chair designed for the Crow Island School, Winnetka, Illinois, by Eero Saarinen and Lawrence Perkins, executed by the Design Workshop of the Illinois Art Project in collaboration with the Milwaukee Art Project of the W. P. A.

24. Nathan Lerner: plywood chair, 1940 (collection of Nathan and Kyoko Lerner, Chicago)

25. Charles Niedringhaus: plywood chair, 1940

30. Charles Niedringhaus and Jack Waldheim: experimental wooden spring (photograph from Illinois Institute of Technology Library)

31. 1942 exhibition at the School of Design in Chicago (photograph from Illinois Institute of Technology Library)

32. Ray Kaiser: graphic presentation for an entry by Charles Eames and Eero Saarinen in the "Organic Design in Home Furnishings" competition at the Museum of Modern Art, colored pencil and collage on white poster board, 1940 (illustrated in: Arthur Drexler, *Charles Eames: Furniture from the Design Collection* [New York: Museum of Modern Art, 1973], figure 4 on page 6)

33. "Organic Design in Home Furnishings," as installed in the Cincinnati Art Museum in December, 1941, under the auspices of the Modern Art Society (photograph from the Contemporary Arts Center file, Archives and Rare Books Department, University of Cincinnati Libraries)

34. Charles Eames and Eero Saarinen, assisted by Ray Kaiser: armchair and side chair of molded plywood, 1941

35. The British Mosquito fighter plane in production during World War II {illustrated in: C. Martin Sharp and Michael J. F. Bowyer, *Mosquito* (London: Faber and Faber, Limited, 1967), figure 28}

36. U. S. Plywood Corporation: plywood leading edge of a wing, 1942 (illustrated in: Thomas Doane Perry, "The Uses of Plywood in Aircraft," *Aero Digest*, volume XLI, number 1, July, 1942, page 206)

37. U. S. Plywood Corporation: pilot seat, with molded plywood seat and back, 1952 (illustrated in: Perry, "The Uses of Plywood," page 206)

38. Ray Russell: all-plywood experimental automobile body, on a 1941 Chevrolet chasis and motor, c. 1942

(illustrated in: "Modeling Postwar Motor Car Bodies," *Modern Plastics*, volume XX, number 6, February, 1943, pages [123]-124).

39. Hughes Aircraft: H-4 Hercules Military Cargo Plane, 1942-1947 (illustrated in: Richard C. Knott, *The American Flying Boat; an Illustrated History* {Annapolis, Maryland: Naval Institute Press, 1979}), pages 194 and 197; and Charles Barton, "Spruce Goose; Pterodactyl of World War II," *Popular Mechanics*, volume CXLVIII, number 5, November, 1977, pages 83 and 86)

40. Pablo Gargallo: "Faunesse," sheet metal, 1913 (illustrated in: *Art et Decoration*, volume LVII, number 1, January, 1930, page 19; and in: Robert Melville, "The Ways of Pioneers," *The Architectural Review*, volume CLIV, number 921, page 328)

41. Julio Gonzalez: "La Montserrat," sheet iron, 1937, Stedelijk Museum, Amsterdam (illustrated in: Andrew Cardiff Ritchie, *Sculpture of the Twentieth Century* {New York: Museum of Modern Art, [1952], pages [104]-105})

42. Naum Gabo: "Translucent Variation on a Spherical Theme," 1937 (illustrated in: Ruth Olson and Abraham Chanin, *Naum Gabo [and] Antoine Pevsner* {New York: Museum of Modern Art, 1948}, page 38)

43. Laszlo Moholy-Nagy: "Space Modulator," clear plastic and metal rods, 1940 {illustrated in: Laszlo Moholy-Nagy, "Abstract of an Artist," in his *The New Vision, 1928, fourth Revised edition*, 1947, and Abstract of an Artist (New York: George Wittenborn, Inc., 1947), page 86; and in: *idem*, *Vision in Motion* (Chicago: Paul Theobald, 1947), figure 320 on page 235

44. Charles and Ray Eames: dining chair, molded and bent birch plywood, 1946 (illustrated in: Drexler, Eames, figure 40 on page [40])

END NOTES

1. Alfred Lucas, *Ancient Egyptian Materials & Industries*, third edition, revised (London: Edward Arnold & Co., 1948), pages 508-515; and Hollis S. Baker, *Furniture in the Ancient World; Origins and Evolution, 3100-475 B. C*. (New York: a Giniger Book, in association with The Macmillan Company, 1966), pages 19-29.

2. Baker, *Furniture*, pages 19 and 21.

3. Lucas, *Ancient Egyptian Materials*, pages 511-512; Cecil M. Firth and J. E. Quibell, *Excavations at Saqqara; the Step Pyramid* (Le Caire: Imprimerie de l'Institute Francais d'Archeologie Orientale, 1935), volume I, pages 41-43, volume II, plates 19 and 23.

4. Lucas, *Ancient Egyptian Materials*, pages 8-10; Firth and Quibell, Excavations at Saqqara, volume I, page 42; A[lfred] Lucas, "The Wood of the Third Dynasty Ply-wood Coffin from Saqqara," *Annales du Service des Antiquites de l'Egypte*, volume XXXVI, 1936, pages [1]-4.

5. Andrew Dick Wood, *Plywoods of the World; Their Development, Manufacture and Application*, revised edition (Edinburgh: W. & A. K. Johnston & G. W. Bacon, Limited, 1963), page 1.

   A good example of Middle Kingdom veneering is a coffin in the Metropolitan Museum of Art in New York; it is shown in: Wood, *Plywoods*, plate I on page 2, and in: Metropolitan Museum of Art, *A Handbook of the Egyptian Rooms* (New York: author, 1913), figure 27 on page [59]. The coffin is from the cemetery at Meir, and was used for the body of Nephthys.

6. A still useful summary of the use of plywood through history appeared in: Vernon Knight and Meinrad Wulpi, editors, *Veneers and Plywood* (New York: The Ronald Press Company, 1927), pages 3-109 et passim.

7. Pliny gave a very detailed account of veneering during Roman times in his *Natural History*, book XVI, chapters 83 and 84 (*Natural History*, with an English translation . . . by H. Rackham, volume IV {Cambridge: Harvard University Press, 1945}, pages 534-539).

8. Thomas Sheraton, *The Cabinet-Maker and Upholsterer's Drawing-Book* . . . (London: printed for the author by T. Bender, 1793), page 357.

9. Quoted from the text of a patent application, reprinted in: Clare Vincent, "John Henry Belter: Manufacturer of All Kinds of Fine Furniture," pages 217-218 in: Ian M. G. Quimby and Polly Anne Earl, editors, *Technological Innovation and the Decorative Arts, Winterthur Conference Report, 1973* (Charlottesville: published for the Henry Francis du Pont Winterthur Museum by the University Press of Virginia, 1974).

   Belter was evidently aware of the advantages of bending veneers in more than one direction, but it is unclear if he succeeded in executing any work of this kind (Vincent, pages [212] and 215).

10. George Collins, *Antonio Gaudi* (New York: George Braziller, 1960), figure 8 and plate 95, discussed on pages [23] and 128; *idem*, "The Transfer of Thin Masonry Vaulting from Spain to America," *Journal of the Society of Architectural Historians*, volume XXVII, number 3, October, 1968, pages 176-201.

11. Nikolaus Pevsner, "The History of Plywood to 1914," *Architectural Review*, volume LXXXVI, number 514, page 129; Sigfried Giedion, *Mechanization Takes Command; a Contribution to Anonymous History* (New York: Oxford University Press, 1948), pages 490-491; Hans H. Buchwald, *Form from Process: the Thonet Chair; an Exhibition of Historic Bentwood Furniture from the Collection of John Sailer*, Vienna (Cambridge, Massachusetts: Carpenter Center for the Visual Arts, Harvard University, 1967), unpaged.

12. Buchwald, *Form from Process*, unpaged.

13. Thomas Doane Perry, *Modern Plywood* (New York: Pitman Publishing Corporation, 1942), pages 27-30; *idem*, *Modern Plywood*, second edition (New York: Pitman Publishing Corporation, 1948), pages 35-37; *idem*, "Plywood Pioneers," *Hardwood Record*, volume LXX, number xx, May, 1932, pages 19 and 22-23; Kenneth L. Ames, "Gardner & Company of New York," *Antiques*, volume C, number 2, August, 1971, pages 254-255; David A. Hanks, *Innovative Furniture in America from 1800 to the Present* (New York: Horizon Press, 1981, pages 59-61.

14. Ames, "Gardner & Company," page 253.

15. J. S. Ingram, *The Centennial Exposition, Described and illustrated* . . . (Philadelphia: Hubbard Bros., [1876]), page 223.

16. Hanks, *Innovative Furniture*, pages 56-58.

17. "Frost, Albert Henry," *The National Cyclopaedia of American Biography*, Volume XV (New York: James T. White & Company, 1916), pages 70-71. Frost was born in 1851 and died in 1912.

18. "Frost, Albert Henry," National Cyclopaedia, volume XV, page 70; Perry, "Plywood Pioneers," page 22.

19. Illustrated in: Buchwald, Form from Process, unpaged, and in: Hanks, Innovative Furniture, figure 43 on page 58.

20. Pevsner, "History of Plywood," page 129; Wood, *Plywoods*, page 225.

21. Pevsner, "History of Plywood," page 129; Wood, *Plywoods*, pages 169, 225 and 226.

22. Albert Christ-Janer, *Eliel Saarinen; Finnish-American Architect and Educator*, revised edition (Chicago: University of Chicago Press, 1979) page 142. Saarinen was a member of the Helsinki firm of Gesellius, Lindgren & Saarinen.

23. Pevsner, "History of Plywood," page 129; Wood, *Plywoods*, page 72.

24. Wood, *Plywoods*, page 90.

25. “Products and Practice: Plywood,” *Architectural Forum*, volume LXXIV, number 3, March, 1941, page [198].

26. Perry, *Modern Plywood*, 1942, pages 215-216; *idem*, Modern Plywood, 1948, pages 282-284; L. J. Marhoefer, “Design Considerations for Plywood Structures,” *Aviation*, volume XLI, number 11, November, 1942, pages 114-117 and 340, and volume XLI, number 12, December, 1942, pages 146-149 and 315.

27. Paul David Pearson, *Alvar Aalto and the International Style* (New York: Whitney Library of Design, 1978), pages 141-143. Pearson did not give credit to the role of Alvar Aalto's first wife, Aino, in his design work.

28. Pearson, *Alvar Aalto*, page 104.

29. Published biographical information about Charles and Ray Eames is scanty, despite the renown their work has brought them. The visit of Charles Eames to Europe in the summer of 1929 is, nevertheless, briefly discussed in: “Eames, Charles,” Current Biography Yearbook, 1965 (New York: the H. W. Wilson Company, [1966?]), page 140; and in a "Chronological Table” compiled by Geoffrey Holroyd and “checked and amplified by Charles Eames,” *Architectural Design*, volume XXXVI, number 9, September, 1966, page 433.

30. The Weissenhof Siedlung was opened as an exhibition by the German Werkbund in 1927, after which it functioned as a residential facility of single-family houses and apartment buildings. Charles Eames would at least have seen the exteriors of the Weissenhof Siedlung buildings; this would no doubt have stimulated his interest in the furntiture first shown in these buildings in 1927.

31. For information on the 1929 exhibition in Stuttgart, see: Karl Mang, *History of Modern Furniture* (New York: Harry N. Abrams, Inc., 1979), pages 122 and 125.

32. Wulf Herzogenrath, *Bauhaus: 50 Years; German Exhibition sponsored by the Federal Republic of Germany*, Organized by the Wurttembergischer Kunstverein, Stuttgart, Prepared in Connection with the Bauhaus-Archiv, Darmstadt (Chicago: Illinois Institute of Technology, 1969), page 343.

33. Lloyd C. Engelbrecht, "The Association of Arts and Industries: Background and Origins of the Bauhaus Movement in Chicago," (Ph. D. dissertation, University of Chicago, 1973), pages 277-279 and figures 98-101.

34. Engelbrecht, "The Association of Arts and Industries," pages 220-224 and figures 51-66.

35. This information was supplied by a former New Bauhaus student, Marie-Zoe Greene-Mercier, interviewed by Lloyd C. Engelbrecht in Chicago, February, 1976.

36. John E. Walley, “The Influence of the New Bauhaus in Chicago 1938-1943,” an essay of 1965 in his *Selected Papers [of] John E. Walley* (Chicago: Department of Art, University of Illinois at Chicago Circle, 1975), page 78.

37. Walley, “The Influence of the New Bauhaus," page 76.

38. Walley, “The Influence of the New Bauhaus,” page 78. Walley’s information no doubt came directly from Bredendieck, but it is worth noting that Bredendieck had become interested in bending plywood while still a student at the Bauhaus in Dessau. Dessau was the home of the Junkers aircraft company, which engaged in several projects involving Bauhaus students. After leaving the school, he lived and worked in Berlin during 1930-1931, at just the time when interest in plywood was peaking in the German capital city. In 1930 a plywood research and consulting bureau (Forschungs- und Beratungsstelle fur Sperrholz) was set up in Berlin. This bureau maintained a permanent exhibition illustrating the uses of plywood, and also helped to educate the public at large through lectures and articles, in addition to its direct contacts with industry and with designers. See: A. Herrmann, “Plywood Research Institute and Consulting

Bureau in Berlin," *Engineering Progress*, volume XI, number 1, January, 1930, pages 17-18; and "The Plywood Research Institute and Consulting Bureau in Berlin," *Mechanical Engineering*, volume LII, number 6, June, 1930, page 630.

Berlin was also a center for research in the use of plywood in aircraft, since the German Aeronautical Experiment Station was in Berlin (Die deutsche Versuchsanstalt fur Luftfahrt, E. V., in Berlin-Adlershof). See: Otto Kraemer, "Aufbau und Verleimung von Flugzeugsperrholz," *Luftfahrtforschung*, volume XI, number 2, July 3, 1934, pages [33]-52.

39. Walley, "The Influence of the New Bauhaus," page 77.

40. Christ-Janer, *Eliel Saarinen*, pages 104-105, 108 and plates 131-136; Carleton Washburne *et al*, "Crow Island School, Winnetka, Ill.: Notes on Planning," *The Architectural Forum*, volume LXXV, number 2, August, 1941, pages [79]-92; Carleton Washburn and Lawrence B. Perkins, "Crow Island School─in Winnetka," *The American School and University*, fourteenth annual edition, 1942 (New York: American School Publishing Corporation, 1942), pages 62-69.

41. Holroyd, "Chronological Table," page 435; Hanks, *Innovative Furniture*, page 111.

42. Washburne, "Crow Island School, Winnetka, Ill.: Notes on Planning," page 92; Betty Williams Carbol, *The Making of a Special Place; a History of Crow Island School*, Winnetka, Illinois (Winnetka, Illinois: Advance Reproductions, 1980), unpaged; Sharon Darling, *Chicago Furniture; Art, Craft, & Industry, 1833-1983* (New York: W. W. Norton & Company, 1984), pages 290-291.

All sources indicate a large degree of colloboration in the furniture design, but Perkins and the younger Saarinen evidently played the largest role.

The molded plywood back units for the chairs and benches were supplied by the Welfare Engineering Company, according to Darling (page 290).

43. The School of Design in Chicago existed under that name only from 1939 through 1944. In 1944 it was re-organized and the name was changed to the Institute of Design. Bredendieck did teach at the Institute of Design, from 1946 to 1952.

44. Laszlo Moholy-Nagy, "Modern Designs from Chicago," *Modern Plastics*, volume XX, number 4, December, 1942, pages 62-64; "Wooden Springs Ease Tension on Furniture Men," *Chicago Daily News*, July 9, 1942, page number not available; "Wooden Springs," *Business Week*, October 31, 1942, pages 35-36; "New Slant on New Product Planning," *Modern Industry*, volume 5, number 6, June 15, 1943, page 46.

45. Fritzi Weisenborn, "Design Students Hold Annual Show," *Chicago Sunday Times*, June 23, 1940, page 10-M; Mary Wells Ridley, "Finnish Influence in Modern Furniture; New Designs of Aalto School on Exhibition," *New York World-Telegram*, April 11, 1941, page 10; Walter Rendell Storey, "Home Decoration," *New York Times*, April 13, 1941, page 8-D; "New Furniture," *The Architectural Forum*, volume LXXV, number 2, August, 1941, page [12]; Moholy-Nagy, "Modern Designs from Chicago," pages 62-65, 150 and 152 (this article, cited in full in note 44, above, was reprinted in: *Timber of Canada*, volume III, number 6, February, 1943, pages 19-24); "New Slant on New Product Planning," *Modern Industry*, pages 46-47.

46. A series of four furnished rooms was designed for the Kaufmann department store of Pittsburgh, and exhibited there and in Chicago; see: Weisenborn, "Design Students," page 10-M.

A retail shop interior in Chicago executed by Moholy and his students was illustrated in: Laszlo Moholy-Nagy, *Vision in Motion* (Chicago: Paul Theobald, 1947), page 87.

47. Holroyd, "Chronological Table," page 435; "Ray Eames," *Design Quarterly*, numbers 98/99, 1975, page 60.

48. *Bulletin of the Museum of Modern Art*, volume VIII, number 1, November, 1940, page 12; Drexler, *Eames*,

pages 5 and 10.

49. *Bulletin of the Museum of Modern Art*, volume VIII, number 3, February-March, 1941, pages 13-14; The *Architectural Forum*, volume LXXIV, number 3, March, 1941, pages 20 and 66; Drexler, Eames, pages 4-12; Esther McCoy, "Charles and Ray Eames," *Design Quarterly*, numbers 98/99, 1975, page 21. Breuer was a replacement for Alvar Aalto, who had resigned from the panel to return to Finland.

50. *Bulletin of the Museum of Modern Art*, volume VIII, number 3, February-March, 1941, page 14; Eliot Noyes, *Organic Design in Home Furnishings* (New York: Museum of Modern Art, 1941; reprint edition: New York: Arno Press, 1969); P[eggy] F[rank] to Blodie Courter, November 11, 1941, in the Contemporary Arts Center file, Archives and Rare Books Department, University of Cincinnati Libraries.

51. "Artist in Industry," *Fortune*, volume XXX, number 4, October, 1944, pages 243 and 245; see also the "Price List for Furniture and Furnishings of Organic Design," of The John Shillito Company, Cincinnati, in the Contemporary Arts Center file, Archives and Rare Books Department, University of Cincinnati Libraries. This price list is keyed to the catalog of the exhibition: Noyes, *Organic Design in Home Furnishings*.

52. Eliot Noyes, "Charles Eames," *Art & Architecture*, volume LXIII, number 9, September, 1946, page 38. The extent to which the Eameses were aware of the experiments at the School of Design in Chicago can only be guessed at. They might have seen some of the published references cited above, and in addition they knew many of the Chicago figures because of personal contacts; for example, at least three of the Eames and Saarinen chairs shown in 1941 were covered in fabrics designed by Marli Ehrman, a faculty member at the School of Design in Chicago. See: Noyes, *Organic Design in Home Furnishings*, pages 13 and 15.

Nathan Lerner remembers visits by Charles Eames to the School of Design in Chicago in 1941 or 1942, Lloyd C. Engelbrech interviewing Nathan Lerner,

Chicago, September, 1983.

53. “Artist in Industry,” *Fortune*, pages 243 and 245; “Charles Eames, Creator in Plywood,” *Interiors*, volume CV, number 12, July, 1946, pages 54 and 57; Hanks, Innovative Furniture, page 67.

54. Marhoefer, “Design Considerations,” pages 114 and 117; "New War Planes for the United Nations," *Modern Plastics*, volume XX, number 7, March, 1943, pages 61-69, 152 and 154; Thomas Doane Perry, “The Uses of Plywood in Aircraft,” *Aero Digest*, volume XLI, number 1, July, 1942, pages 200 and 205-206; *idem*, “Molding Curved Plastic-Plywood,” *Modern Plastics*, volume XX, number 12, August, 1943, pages 73-77, 130, 132 and 134; Leo M. Cohn-Wegner, “European Progress in Hot-Press Bonding of Plywood in Last Ten Years,” *Transactions of the American Society of Mechanical Engineers*, volume LX, number 1, January, 1938, pages 69-76. See also: *American Society of Mechanical Engineers, Aircraft Plywood Bibliography* (New York: author, [1945?]).

The Welfare Engineering Company had difficulty in supplying the plywood parts for the furniture for the Crow Island School because it ". . . had been required to transfer most of its work to the preparation of airplane parts in connection with national defense program," according to the Winnetka Talk, September 5, 1940, page 12.

55. Sharp and Bowyer, *Mosquito.*

56. “Gliders from the Wolverine State,” *Modern Plastics*, volume XX, number 8, April, 1943, pages 62-66 and 128.

57. “Modelling Postwar Motor Car Bodies,” *Modern Plastics*, volume XX, number 6, February, 1943, pages [50], 124 and 125.

58. Charles Barton, “Spruce Goose: Pterodactyl of World War II,” *Popular Mechanics*, volume CXLVIII, number 5, November, 1977, pages 83-87, 174, and 176-177; Richard C. Knott, *The American Flying Boat; an*

Illustrated History (Annapolis, Maryland: Naval Institute Press, 1979), pages 193-199.

59. Bertram Berenson, interviewed by Lloyd C. Engelbrecht, in Cincinnati, 1981.

60. Sir Herbert Read, *A Concise History of Modern Sculpture* (New York: Frederick A. Praeger, Publishers, 1964), pages [64-67] and figures 56-60.

61. Read, *A Concise History*, pages 109-114 and figures 108-114.

62. See, for example, "Space Modulator" of 1940, illustrated in: Moholy, "Abstract of an Artist," and in: Moholy, *Vision in Motion*, figure 320 on page 235.

63. Illustrated in: McCoy, "Charles and Ray Eames," page 21; and in: "Charles Eames, Creator in Plywood," *Interiors*, page 53.

64. *Bulletin of the Museum of Modern Art*, volume XIV, number 1, Fall, 1946, pages 5-9 and 14; Drexler, *Eames*, pages [16]-26 and front cover; "Shock-Proof Furniture; Eames's Molded Plywood Models are Equipped with New Rubber Joints," *The Architectural Forum*, volume LXXXIV, number 4, April, 1946, pages 10-12.

65. Actually, the metal-and-plywood versions of these chairs shown in the March, 1946, exhibition had only three legs. The three-legged versions proved to be unstable, and the four-legged version, shown in figure 1 of this essay, was developed later in 1946, and put into production. The statement by Drexler that the four-legged version was included in the 1946 exhibition is in error (Drexler, *Eames*, page 12 and figure 25 on page [17]).

66. Many of the owners of chairs purchased from early production runs reported that the rubber shock mounts separated from the back and seat units.

67. Initially the Eames side chairs were manufactured by the Evans Products Company, and Herman Miller had only marketing and distribution rights, but after two

years, Herman Miller bought manufacturing rights as well. See: Ralph Caplan, *The Design of Herman Miller* (New York: Whitney Library of Design, 1976), pages 43-44; "Charles Eames, Creator in Plywood," Interiors, pages 52-59.

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