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AUGUST 1966 / .75

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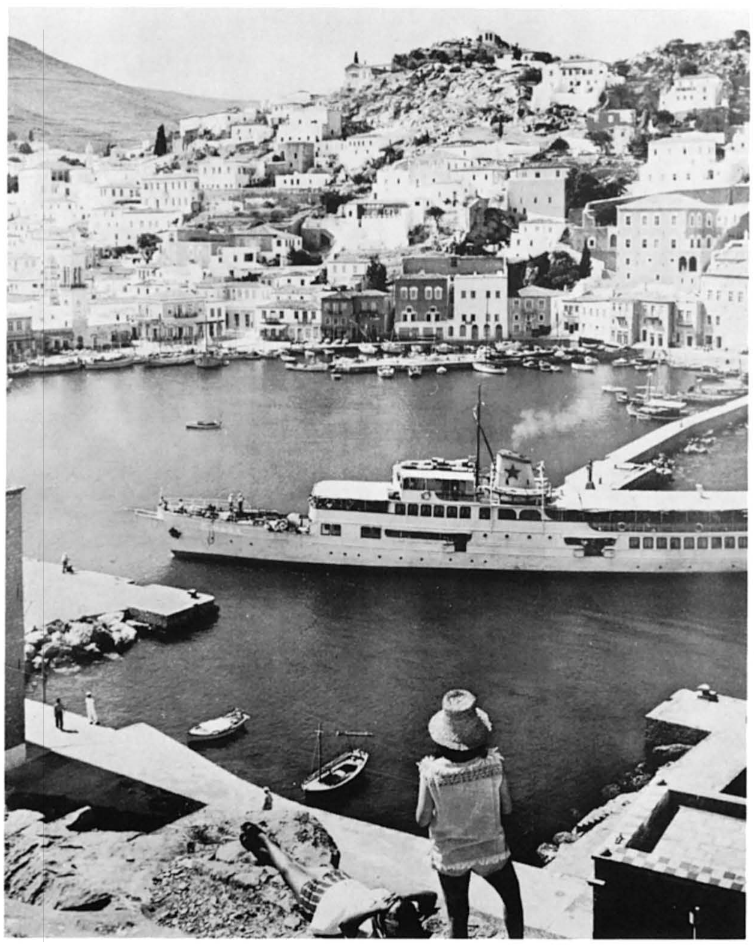

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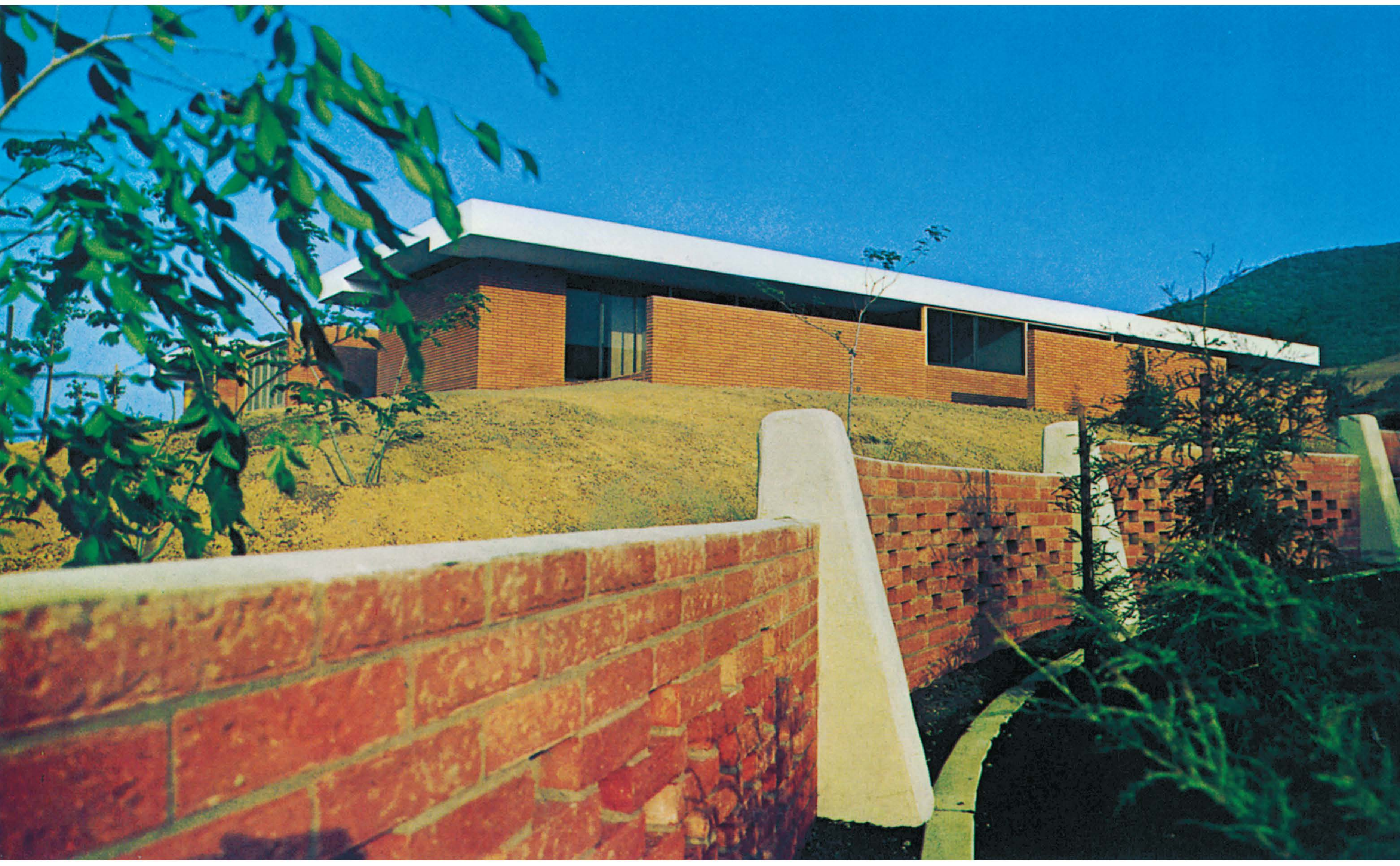

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Tub & Shower Enclosures: Stitch Bros., Inc., Los Angeles
Wardrobe Doors: Glide-All Division of Woodall, Inc., El Monte

Cover: Detail of new Knoll Table (see page 6)

arts & architecture

ERRATUM:

An unfortunate printer's error garbled the title of last month's article by Gifford Phillips which should have read "Art in a Democratic Society" instead of "Domestic" Society.

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Vol. 83, No. 7

Furniture

NEW KNOLL COLLECTION
BY WARREN PLATNER, ARCHITECT

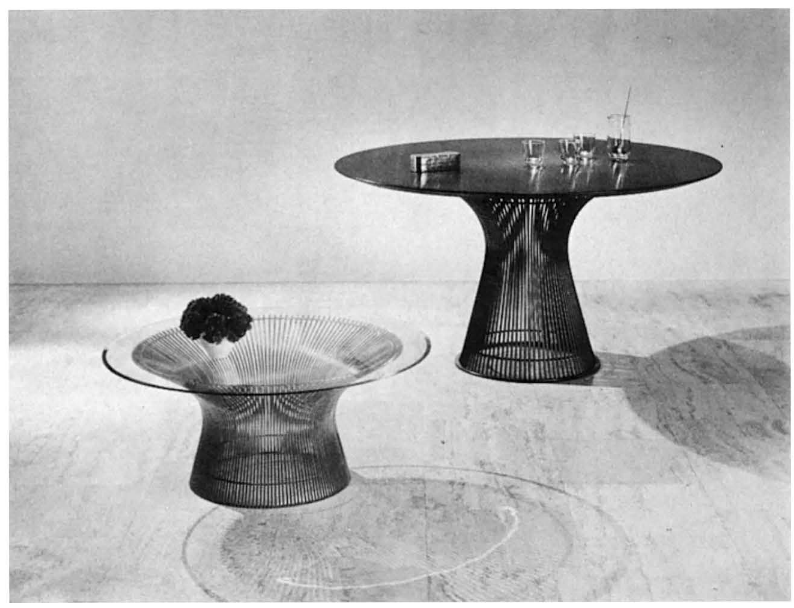
Developed under a grant from the Graham Foundation for Advanced Studies in the Fine Arts

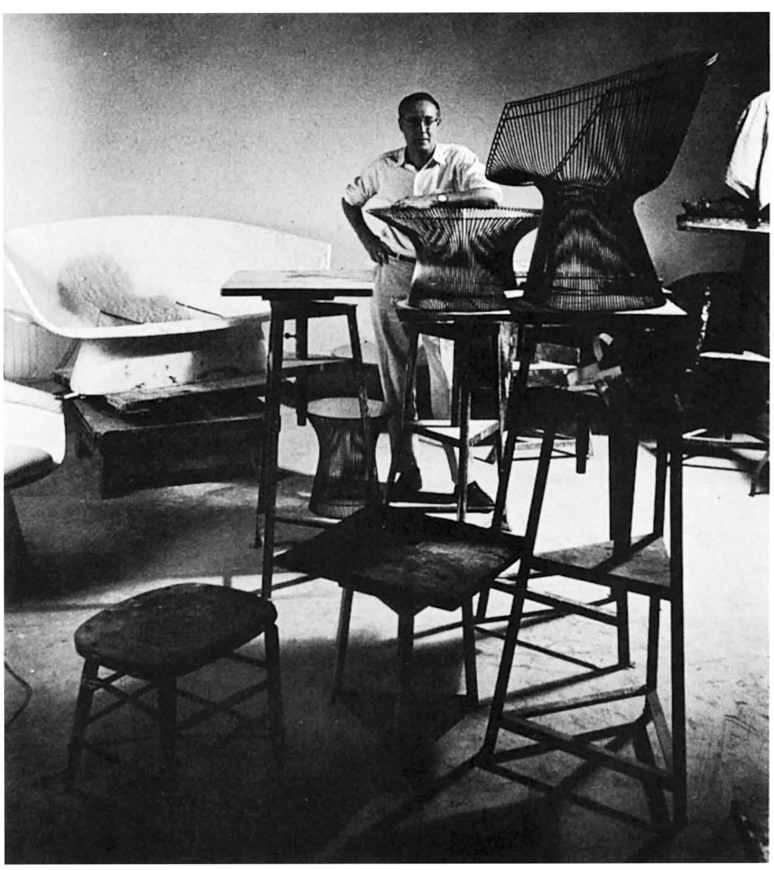
This new collection for Knoll Associates resulted from the designer's concept that 1) the pieces be single forms starting at the floor and complete themselves within one simple shape (not a seat top on legs or pedestal); and 2) they have elegant and small-scale detail—the kind that would make them relate well to the personal scale and detail of man and the many little things he surrounds himself with in his interior spaces—this detail to be inherent in the structures and the way they are put together rather than applied decoration.

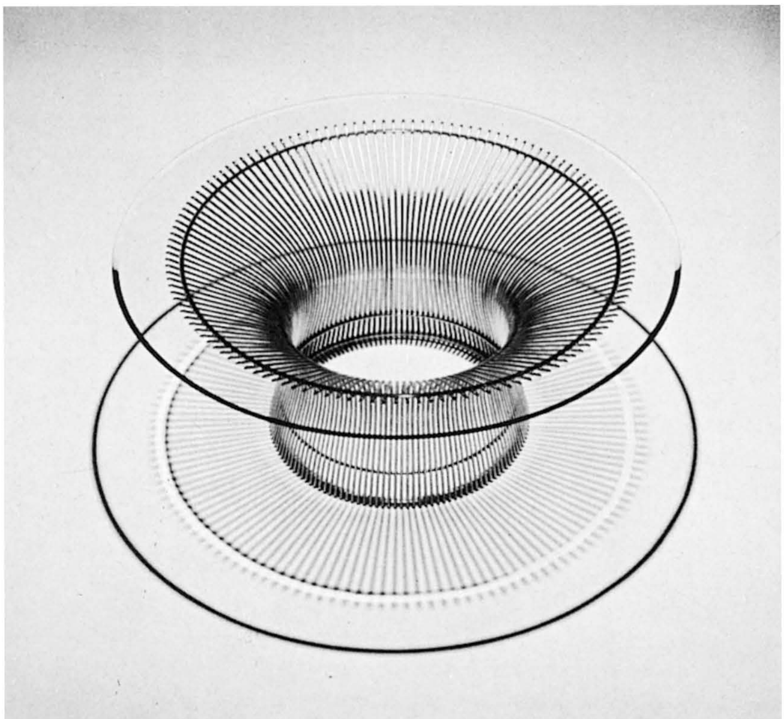
Platner further determined that the forms should be visually strong and clear but that they should have an airy quality. The materials contribute to this: golden nickel soft and glowing, just metallic enough to be reflective but not assertive. The different pieces were conceived as a family but also as individuals which would mix gracefully with others and be at ease in any good covering, printed fabric or embroidery as well as smoking room leather.

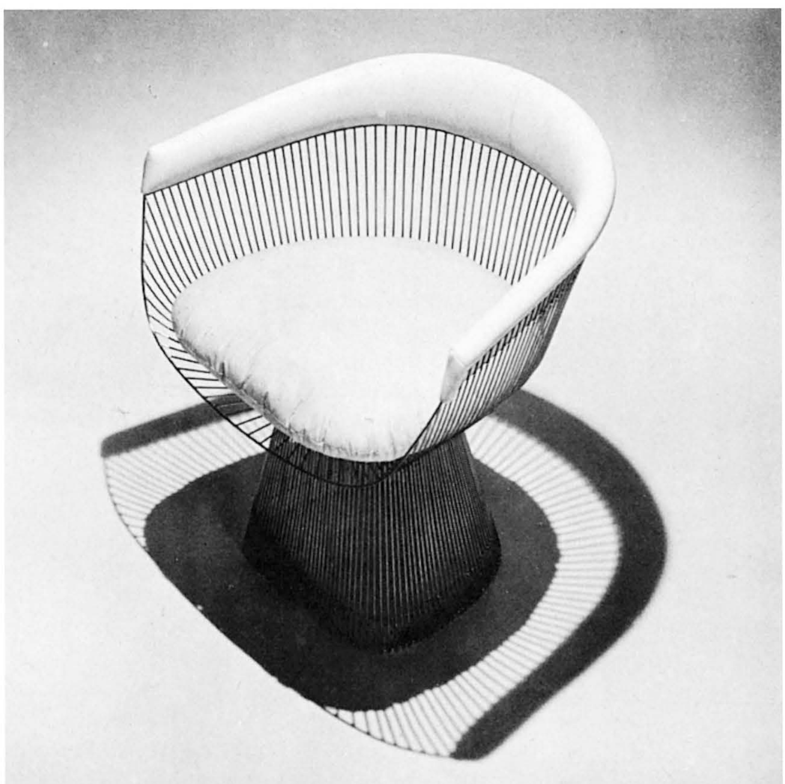
While developing the structural and mechanical details, Platner visited several manufacturing plants making wire products by sophisticated methods and machinery in order to determine that the pieces could be commercially produced.

Upon completion of each prototype, Knoll started to work on the tools. There was, of course, a choice as to whether the tools would be elaborate and precise or whether there would be an emphasis on craftsmanship and less sophisticated tools. "Happily, Knoll chose the former and the result is very close fidelity to my prototypes," said Platner who is a member of the firm of Eero Saarinen and Associates.









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Q: Should brick construction be kept wet to make it cure properly, and if so, for how long?
A: There is more than enough water in reinforced, grouted, brick masonry construction to completely hydrate the cement. It is not recommended to wet down brick masonry during or after construction except in extreme hot, dry weather where there is evidence that the bricks are absorbing water too fast from the mortar. This can be noted by wet edges around the brick adjacent to the mortar joints. In such cases, the masonry walls should have their surfaces dampened only by a light fog spray after the mortar is set, being careful that water does not run down the face of the wall.

Q: My problem has to do with ventilators for installation in a masonry wall. Do you have any information?
A: The Riesner aluminum vent brick is a louvered wall ventilator built into an exterior wall in the form of a hollow metal casting made in standard brick sizes. The face of the ventilator is louvered and has water drips at top and bottom to prevent water from entering. The units are built in by the mason as the wall goes up with the louvered face to the outer air and the duct or flue to the inside. These are stocked in cast aluminum, iron or bronze and come in two types for connection to round duct or pipe or to rectangular ducts.

Q: I have a client who wants cabinets of wood in her kitchen. She has very definite ideas as to their appearance and arrangement and I want her to pick them out. Where can she see quality cabinets?
A: The custombilt hardwood cabinets by Coppes Napanee are featured in the kitchen display at the Building Center. These are available in door styles including Continental, Country Door or Early American, Contemporary and Ranch Door, in oak or maple, in an extensive assortment of wall, base, range, oven units and accessories, and in a wide selection of colors in furniture finishes of either stain or catalytic enamel. A planning service by kitchen specialists is also available if you and your client want assistance.

Q: I understand there is a new metal door frame now available that can be installed in 15 minutes. Have you heard of it and does it have any advantages other than speed of installation?
A: This frame has quite a list of patented features that make it advantageous to use. It is expressly designed for use with prefitted wood doors and is adaptable to most wall conditions including wood and metal stud walls, solid and semi-solid drywall and plaster partitions. It is available in twelve different wall thicknesses ranging from 2″ to 7⅜″, is completely prefinished with a baked-on enamel and has a snap-on casing that conceals all nailing or other devices used to secure it to the wall. It has even more exclusive features all of which you can see in one of the new displays at the Building Center.

Building Center 7933 West Third Street Los Angeles, California

music

PETER YATES

WILLIAM FISCHER, BERTRAM TURETZKY, AND VIRGIL THOMSON

William Fischer is a composer who teaches composition at Xavier University in New Orleans. Last year the New Orleans orchestra, which has been rising to favorable recognition even in New York, included a composition by Fischer for speaking choir and orchestra in the extra-week program sponsored by the Rockefeller Foundation. Since then he has been in Vienna on a Fulbright, studying with Gottfried von Einem. He has composed an orchestra piece for strings and percussion, a "free sound" that "happens" for 12 minutes with 212 rhythmic possibilities, which will be published in Germany. He has also written several works for 16 instruments and soloists out of his performing experience in jazz. And he has composed an opera, which will be performed next April by the large and experienced opera group at Xavier University. Though he has had an offer to give the world premiere in Germany, he prefers that his own community should be the first to hear it. He believes, as I do, that American composers should work to develop musical life in their own sections of the country, instead of turning to New York. He doesn't wish to be a "Negro composer," whose work is heard for that reason, but an American composer with a native language, aware of but not bound by regionalism.

I like his attitude. He wrote me: "I believe . . . Einem and Blacher are not bitter"—he is comparing them with the often embittered so called avant-garde composers—"but enjoy writing and show it in personal relationships. It's the same kind of thing I left in jazz. Jazz, where much is done because of the pleasure and happiness in the actual creative process, where life is reflected subconsciously." For this reason his sympathy lies with the experimental jazz composers, who are instrumentalists, instead of with the international theorists. "Roland Kirk just recorded an electronic rendition on a commercial label, Yusuf Latief has just done the same. John Coltrane has recorded an album in which the whole effort is toward improvised sounds using the upper harmonics of the saxophone. These musicians are known for their jazz, but they sound quite differently in the albums I'm referring to. Richie Davis has done some things on the bass which will justify the music being as 'far out' as it is, and his album will sell—in fact, all of these albums are selling, especially in Europe, and many people are listening."

Music need not be confined to theoretical data; it need not deny the independent evolution of instruments. It need not intend masterpieces: I have written this before and have been contradicted by composers who fear that I shall be understood to say that they do not seriously work to the full of their skill. We forget how many of the classical works which today bring us pleasure were written for immediate use, written indeed like Mozart's divertimentos and serenades, and the bassoon and horn concertos, for the pleasure of the performers, without thought of posterity. Nobody would question that these works were composed to the full measure of Mozart's ability. We need more such music, not cramped within the imitative classical movements of *gebrauchsmusik* or wrested to the extremities of contemporary theory but growing out of native idiom, like the work of Ives. I hope that the people of New Orleans will welcome Bill Fischer's opera in the spirit in which he brings it to them, not his work alone but theirs. We need a lot more of that spirit in this country.

Bertram Turetzky is a bass fiddle virtuoso; one would think that sufficient cause to chain him to his doghouse in the backyard of some orchestra or chamber group. (But let's not forget our own John Henry Lewis, who came forward from the bass section of the Los Angeles Philharmonic to be assistant conductor of the orchestra and is now a traveler on the conductor's circuit.) After all, what classical repertory is there for string bass? Bert Turetzky met this limitation head on and started commissioning composers of his acquaintance to write for him. (A good many instrumentalists have tried this; too often they back out on the agreement. To make it work, you have to give as much to the composer as he gives, and that includes repeated performance.) His wife, Nancy, is a flutist, a far-off instrument to combine with string bass in a duo. Accepting these conditions, the Turetzkys have accumulated a repertory of some hundred compositions, for bass alone, for flute and bass, and in combination with voice and other instruments. Bert has toured widely, alone and with Nancy; he is director of the Hartt Chamber Players at the University of Hartford, assistant director of the Hartt *Collegium Musicum,* and editor-in-chief of a *Music for Double Bass* series, which is publishing the long-needed literature.

From this repertory he has now issued two records: *Advance Recordings FGR-1* and *Medea Records MCLP 1001,* including ten works by nine composers. The quality of both records, considering that they are put together of tapes recorded by different engineers in different studios, is surprisingly consistent.

The velvet rumble of Turetzky's lowest bowed tones lightens to an atmospheric translucence; his upper tones can be clear as a cello or take on the broader twang peculiar to the bass. No technical devices suitable to string instruments have been omitted from this catalog of pieces, and these are supplemented by a variety of new microtonal and pseudo-electronic sounds and technics. From gentle melodiousness and delicate pizzicato to forceful single sounds, pluckings, and thwacks, Bert Turetzky is always in the right place in complete control. The two records are a virtuoso lexicon of achieved devices.

Donald Erb's *VII Miscellaneous* "takes its title from a listening guide used in an introduction to music class" and includes demonstration of many special effects. The three works for contrabass alone, by William Sydeman, George Perle, and Peter Phillips, explore, as far as one can tell, every auditory possibility of the solo instrument, for the listener's reward. Ben Johnston's Duo sets bass and flute in serialized conversation, sometimes covering and sometimes exploiting the great distance between the two ranges. Alvin Epstein mingles bass with percussion; the recorded movement is one part of a four movement suite for "all possible combinations of a bass, flute, and percussion ensemble." Donald Martino furnishes a divertimento, Sydeman a trio. Kenneth Gaburo translates a poem into a rhetorical dialog for voice and bass, showing, "as the text progresses in mood . . . an increase in the incidence of particular sounds . . . and shorter phonetic durations . . . Through pitch-registral association with points on a grammatic diagram of the poem, a basis for musical shapes was obtained." Charles Whittenberg's *Electronic Study II with Contrabass* takes the instrument all the way into the field of sound for its own sake.

One's critical inclination to distribute praise and blame among these compositions or award points for novelty or excellence needs to be restrained. As a whole, the composers represent their generation, make conservative use of radical techniques, are more academic than daring within their chosen media and adapt themselves to the requirements of their unusual principal instrument with a thorough knowledge of its possibilities. Perle has cultivated a special skill in writing for solo instruments of many types and Sydeman in writing for string bass.

Listeners who have trouble adapting to solo violin and solo cello will tire of the prevailingly deep voice. Those who expect styles and effects suitable to jazz will be disappointed; indeed this is one serious lack among the compositions selected for recording. In jazz, string bass became a solo instrument; it has contributed materially to that art. I should hope that before long one of Bert Turetzky's multitude of composers would provide him with a bass solo challenging the best possibilities of the instrument in jazz idiom. The formalities of serial composing, which prevails among these compositions, do not release the lute-like rhythmic thrumming that is one of the best gifts of the instrument. Turetzky has studied with the lutenist, Joseph Iadone; this aspect of his instrument, its adaptability as a bass lute, raises the chance of a music more delicately lyrical than any of these compositions.

However one's taste may qualify these records for the pleasure of general listening, they belong in the library of every bass player, as

(Continued on page 34)

notes

in passing

Dr. C. A. Doxiadis was presented the 1966 Aspen Award at ceremonies July 29 at Aspen, Colorado. The following are excerpts from his speech made in accepting the $30,000 award for humanistic achievement:

"The human society does not operate as it did in the past since natural human contacts are fewer in our cities with increasingly lower densities. Of course we have cars—but not all of us do, certainly not the children who miss their grandparents, and certainly not the underprivileged citizens. Of course we have tele-communications —but how can a telephone replace a father at bedtime, and how can television replace the contact of the two sexes? More and more people pour into the cities and often social or racial elements come into conflict which we are not prepared to face.

We have built larger and taller buildings, but at the same time we have isolated man inside them. . . . We have limited our life, within their sterilized atmosphere, and we have eliminated such natural expressions of it as works of art in the open. The age-old-love-affair between man and buildings is being destroyed in our cities.

We must now face the fact that modern man has failed to build adequate cities. In the past his problems were simpler, and he solved them by trial and error. Now human forces and mechanical ones are mixed and man is confused, he tries and fails. We say he will become adapted. Yes, he is *running the danger* of becoming adapted, since adaption is only meaningful if it means the welfare of man. Prisoners too become adapted to conditions! We cannot justify our actions by examining only the *behaviour* of man in the city of today. For man to adapt to our present cities would be a mistake since he is the great prisoner. Not only is man unsafe in his prison, but he is facing a great crisis, and heading for disaster.

It has often been said that man may exterminate himself through science. What we must also say is that man's hopes for a much better evolution lie in science which, after all, is the only acquisition of a proven universal value that he can transmit from generation to generation. The whole difference between extermination and evolution lies in the goal that science will set.

Personally I am convinced that the root of all problems in our cities lies in our minds, in our loss of belief in man and in his ability to set goals and to implement them. This is why I decided today to speak about goals and conceptions, to emphasize that there is where the solution lies. . . .

But dreaming and conceiving is not enough. We have to carve the stones and lift them and this is why I try hard to help build all sorts of cities because we can learn only by building and suffering.

Faced with the practical every-day difficulties I turn to myself and ask whether we can build the human city. My body is beginning to get weaker, my senses, especially my eyesight, do not help me as in the past, but my mind advances in knowledge and sees the confirmation of this possibility, and my soul mobilizes my whole self into a very positive affirmation: Yes, mankind can build the human city."

From time to time we hear grumbles about our editorials tending to be overly querulous and exaggerated in their intimations of disaster. It is interesting that Dr. Doxiadis also foresees "disaster ahead."

Others quoted recently whose views similarly tend to be bleak:

Lewis Mumford—"The process of metropolitan extension and aggrandizement has gone on steadily in New York, London, Paris, Rome, and Tokyo without producing anything except congestion, blight and urban decay; and the fact that the same processes are now at work in some 41 other metropolitan areas in the United States does not improve the prospects for urban living or architecture: quite the contrary. . . . Art and architecture have both begun to tell the same story, embracing accident and chance, belittling purposeful order and humane design. Behind the smooth bureaucratic and technological facade, chaos continues to widen, for only machines can prosper in the environment we are now mechanically creating."

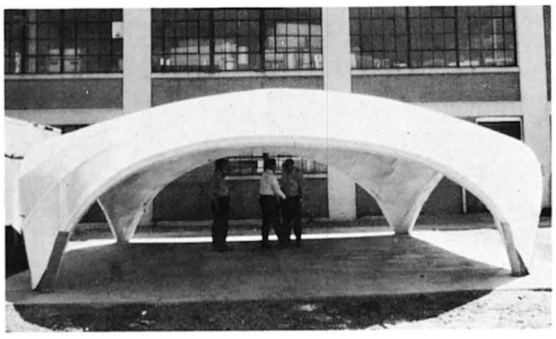
Tomas Maldonado, director of the Hochschule fur Gestaltung at Ulm — "The glorification of construction details in building, so brilliantly practiced by one of the purest architects of our times, has now become the commonplace of the most perfectly commercial and the most commercially perfect architecture.

The ambitious program of industrializing building has ended in the clumsy and indiscriminate use of the "certain wall" and, what is even worse, with the aid of the more advanced technology, in the construction of dwellings whose architectural depravity and futility is without precedence. . . .

Some have abandoned every form of problematization in their activity and have submerged themselves without reserve in what might be called professional amnesia: namely, oblivion of all that has been thought and defended before, and this in the interest of social adjustment —or better still—of a smooth undeviating professional adjustment.

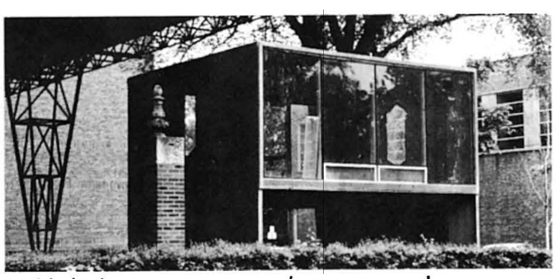
Others have adhered to various forms of sublimation. One of these, perhaps nowadays the most important, is the neo-romantic, neo-baroque, neo-expressionist formalism. It is in architecture, although not there alone, that we lately find the most alarming examples of this tendency. Indeed, many architects are the animated creators of monuments where it would seem that their chief, if not only, concern is to document their individuality. . . ."

Polyurethane dome (top) and folding armature system —primary structural uses.



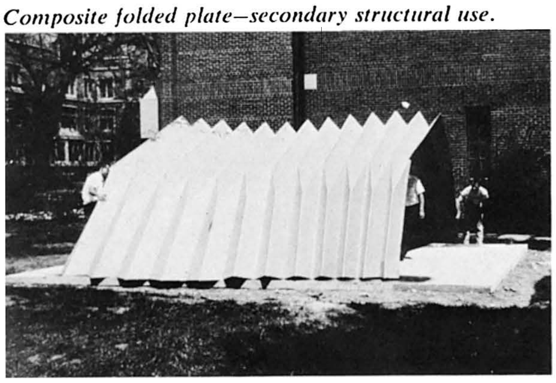
THE STRUCTURAL USE OF FOAM PLASTICS

Umbrella shells—primary structural use.



Folded plate system—secondary structural use.

Composite folded plate—secondary structural use.



We present here excerpts from a report by the Architectural Research Laboratory of the University of Michigan which explored the structural potentials of foam plastics for housing in the underdeveloped areas of the world. We have omitted those sections of the report dealing with the feasibility and methods of establishing plastics industries in such countries in order to present more fully the structural systems and applications investigated, which are shown on the following pages.

It is our feeling that those portions of the report summarized here have significance beyond the confines of the underdeveloped areas of the world since they explore the current problems and potentialities of construction in plastics in any country no matter what its state of development. However, it is our hope that the full report will be read widely. It contains a thorough investigation of the physical properties and marketing aspects of synthetic materials and pertinent suggestions to the plastics industry which if followed could make of it a new building resource.

The project was sponsored by the Agency for International Development (AID) of the U.S. Department of State and conducted by the Architectural Research Laboratory and directed by Professor Stephen C. A. Paraskevopoulos. The report can be obtained from the University or the AID.

It has been the primary objective of this research program to demonstrate what can be done with the new plastics materials structurally and to present the potentials of an overseas housing market in the hope that the plastics industry will contribute its resources towards international development in its own enlightened self-interest. The main research goal can therefore be considered to be the development of total systems involving the design, production and marketing of foam plastic structures in which adjustments can be readily made to cover the widest possible range of housing requirements in each developing country.

The Michigan report is intended to be primarily a discussion of ideas rather than techniques. The illustrated techniques, intriguing as they may be, do not constitute an end in themselves. Although novel, they have not been conceived for the purpose of creating structural innovations but rather as means for the realization of better housing in the emerging areas of the world within a framework of industrial and international development. The structural research represents an effort to explore and utilize the potential of an advanced technology to resolve the housing problem within such context. It is from this standpoint that the foam plastics and the structural systems presented in this report should be seen and evaluated.

Throughout this research the selected foam plastics have been explored for what they can do in their own right as structural materials, rather than as substitutes for other materials. They have been investigated as primary, secondary and contributing structural materials, but in each case the aim has been to discover what new or better solutions to structural problems can be realized through their use and to investigate as many different structural possibilities as were permissible within the limitations of time and resources. Thus the structures presented in this report have been conceived not as independent or isolated entities but as exemplary parts of various basic systems; each case represents only one of many different possibilities.

Theoretically, as synthetic materials, plastics offer two lines of development: 1) for the existing materials to be accepted with their limitations and then a range of structures to be developed within these limitations; 2) for new concepts of building performance to be established and then the materials needed for such development to be synthesized. We are still in the first of these lines of development.

Building codes are usually blamed by the plastics industry for the lack of acceptance of foam plastics in the building market. Up to a point it is true that codes have inhibited the use of plastics. Many codes are archaic and need revision, since they are usually based on materials and dimensional specifications rather than on desired performance standards.

However, the project staff did not have any difficulty in obtaining a building permit for the polystyrene dome structure (shown with other experimental structures on the following pages) erected in collaboration with Dow Chemical, which is now serving as a golf clubhouse.

Other areas of potential use will have to be found in order that more meaningful design data may be produced and that the public may become familiar with the potential of plastics in building. Certain directions suggested themselves which offer promising market potentials and at the same time could contribute towards the development of foam plastics technology and the uncovering of new application possibilities: military projects, ranging from building uses to medical uses; industrial and recreational buildings; shelters for equipment, storage and similar specialized use (such applications could be started by plastics companies which, with a few exceptions, have not applied their own materials to their own use—a situation that cannot be expected to create a favorable reaction on the part of prospective outside users); vacation homes, many of which are located in areas relatively immune to prevailing building codes; other possible immediate markets include farming and transportation which are also outside the conventional building market and could be similarly explored.

In the opinion of the project staff, a prerequisite for the successful realization of all these markets is a change in the attitude of the foam plastics industry as to its role relative to the building industry. As long as this role is conceived of as being confined to that of a raw materials or product supplier, without much control over the application, there will be very little progress. The major materials producers will have to assume a much more active role in the building field, even to the extent that wherever major structural use is made of their materials they actually become the building industry—a new kind of building industry to be sure, but one which is geared to industrial rather than handicraft methods of production and distribution.

To give industry as broad an informational base as possible, no attempt was made to develop one system in depth at the expense of other possibilities. It was felt that only through a comprehensive investigation could the feasibility of using cellular plastics as a structural material be demonstrated. Thus, although several prototype structures have been erected, the main effort of the project staff has been to conduct broad research in structures, not to design a specific kind of dwelling unit or universal type of structure.

Two criteria must be considered in the development of any structure: 1) adequate strength to stand up against external forces for a prolonged period of time; 2) adequate rigidity so that any deformation, either temporary or remaining, will not lead to deterioration and loss of strength or create uncomfortable feelings in persons using the structure.

The axiom that a stronger material is a better material is one of the most difficult for an architect to rid himself. Even though the physical properties of cellular plastics are considerably lower than those of conventional structural materials with which architects are familiar, it is nevertheless possible to design and construct structures utilizing these low density (i.e., low strength) materials which will meet the established criteria of adequate strength and rigidity.

Cellular plastics offer a unique potential for the development of structures since they can be made according to a wide range of performance specifications. The desired physical properties can be obtained by varying the density of the material and its chemical composition. This in turn allows one either to start with a material and develop a structure or to start with a structural concept and then develop the necessary material.

It must be kept in mind that there are some inherent limitations with each of these approaches. When one considers the physical properties of cellular plastics, or for that matter any plastic material, it becomes apparent that there is a fundamental limitation for structural design which lies in their relatively low moduli of elasticity as compared with conventional materials.

Since we must deal with relatively low modulus E values, we are limited to working with structural forms which allow us to eliminate excess deformations by increasing structural stiffness through geometry. Structural forms which allow for an increase in structural stiffness will also usually tend to have reduced stress levels. These low stress levels in a structure are essential, not only because of low material strength, but also because the creep, or plastic flow, of the materials is dependent on stress levels in the materials. Creep allows the initial deflection of a material due to load to increase over time if the load is sustained. All structural materials exhibit some creep. However, unreinforced plastics are subject to more than conventional materials. (A weight causing a 1″ stretch upon loading, will cause wood to have stretched 2.3″ after 20 years and rigid plastic foam 7.5″. Eliminating, or at least minimizing this effect, is a necessary prerequisite for the successful use of cellular plastics as a primary structural material. The plastics industry has done relatively little to discover the factors of chemical composition which affect plastic flow.)

It is apparent that structural forms which offer the largest potential for cellular plastic construction are those in which the stress levels can be kept low by the distribution of loads throughout the structure and where load and stress concentrations are avoided as much as possible. Therefore the solutions the research project has sought have been within the family of surface structures, especially shells and folded plates, which have such characteristics. By contrast, it is evident that post and beam systems would be undesirable since this type of construction collects the loads and transfers them to linear structural elements of relatively small but highly stressed cross sections.

Cellular plastics, along with other structural materials, are much stronger in axial stress then they are in bending stress. Therefore, relatively weak materials, such as the cellular plastics, hold possibilities for achieving fairly large doubly curved shell structures when used as the primary structural material. If the use of cellular plastics as a primary structural material is to be made most efficient, then shell forms must be determined on the basis of forces rather than a defined geometry.

Investigation of available production techniques as related to structural form indicated the following conclusions:

Molding. With rigid thermosetting foam plastics such as polyurethane and epoxy: 1) parts with varying shapes, such as those having doubly curved or warped surfaces, can be produced by molding if adequate controls can be maintained; 2) skins of high strength can be integrally molded to conform with such variations in curvature; 3) large size molds can easily be made at relatively low cost and it is conceivable that entire structures, or at least major structural components, can be molded at one time.

Spraying. 1) spray techniques offer good possibilities for the construction of total structures using either air-inflated or lightweight armatures as form work; 2) the present crude appearance of sprayed form products can be overcome by mechanizing the spray gun or possibly by using highly skilled operators; 3) it is possible to have a high output of industrial production of structural components.

Slab stock. This is one of the most common forms in which cellular plastics are available. Conclusions: 1) slab stock production methods currently offer the largest degree of control over physical and chemical properties and the resulting uniformity holds high promise for production of modular structural components; 2) foam plastics in slab form are a promising possibility for the development of slab and folded plate structures in combination with other materials; 3) skins made of various materials can easily be laminated or coated on slab stock.

Extrusion. From a study of the technology involved in extruding thermoplastic and thermosetting foams the following structural implications were drawn: 1) foam core structural sandwich panel units using a variety of foam plastic materials can be produced on a continuous basis; 2) large, singly curved components having integral skins in a variety of materials can be similarly produced.

Vacuum Forming. Techniques of this sort hold the promise of producing large structural components from thermoplastic materials. The material in sheet form is clamped in a stationary frame, heated and then drawn into a female mold by vacuum. The method is technically very well developed; equipment is readily available and production costs are relatively low even for large components.

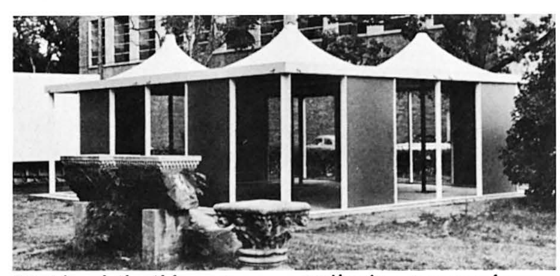
Foam Inflation. This is a method of producing structures by utilizing a double-walled bag, tailored in such a way that when foam components are placed in the bag they expand and "inflate" the structure. If certain technical problems can be overcome (e.g., proper method of placing foam materials in the bags, control of density variations due to changes in transit), then total structures of varied shapes and sizes can be produced, stored and inflated as needed. However, with present technology it is not possible to produce economic structures by this method.

Rigidization. The Michigan team is currently experimenting with promising materials in the area of rigidizable space structures. One of these, a moisture-curing, one-component urethane resin, offers the possibility that a flexible, reticulated urethane foam can be put into moisture-free packages and stored until needed, then taken out and erected on site and allowed to cure by exposure to atmospheric moisture. No chemical processing would be required in the field.

There are many possible combinations of structural concepts, production methods and erection techniques which will lead to logical and economical cellular plastics structures. Within the framework of this approach, the project staff developed a variety of structural systems —the folded plate, spray polyurethane, rigidized flexible, and the filament wound systems. It has also encouraged the development of other systems like the Dow "Spiral Generation" system and the Plydom folded plate system shown further on.

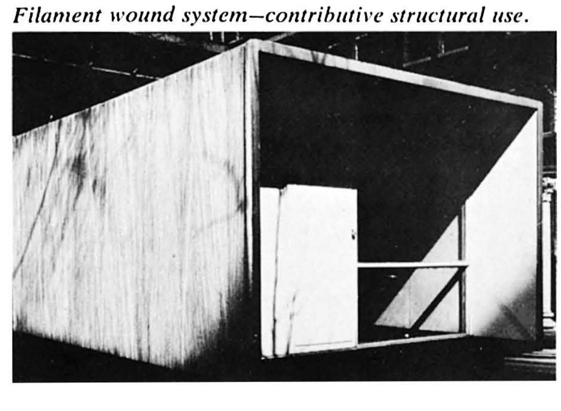
From its analyses of these structures, the Michigan research staff found that there are three ways in which cellular plastics can be used as a structural material: 1) as a primary structural material which carries the principal loads and stresses; 2) as a secondary structural material which takes secondary stresses while allowing another material to carry the primary stresses; 3) as a contributing structural material, either as a form-giving device which allows a production technique to be utilized, or as a tertiary structural material which braces another material acting as a secondary element. The various systems developed and investigated by the project staff are illustrated and analyzed on the following pages.

Members of the Architectural Research Laboratory project staff at the University of Michigan, in addition to Prof. Paraskevopoulos, were: research associates Harold J. Borkin, J. Sterling Crandall, James L. Haecker, Willard A. Oberdick; C. Theodore Larson, project consultant; research assistants Wayne Bredvick, Rudolf Welter; technical consultants Robert M. Darvas, Irving Einhorn (adjunct professor of chemical engineering at Wayne State University) and Allan M. Marra.



Rigidized-flexible system—contributive structural use.

Filament wound system—contributive structural use.



PRIMARY STRUCTURAL USES

In primary structural applications, foam plastics constitute the building element or elements necessary for the overall stability of a structure. In addition to possessing sufficient strength, primary structural components should be able to demonstrate limited time-related deflections and to maintain their properties under adverse conditions of exposure to use and elements.

The compressive, tensile and bending strengths of foam plastics are comparable to those of common structural materials. However, a comparison of the moduli of elasticity of the two structural materials is quite unfavorable: polyurethane foam would have a strain 60 times that of concrete, if both were stressed to 50% of their respective ultimate capacities. In addition, cellular plastics are subject to substantial continued deformation under sustained stress.

The parameters of structural shape are determined by the mechanical properties of the materials, and thus, the applications discussed in this section pertain to doubly curved shells whose shapes in themselves provide a reasonable basis for such primary use of foam plastics. Relatively moderate deflections can be accepted and minimum stresses will occur as a result of sustained load and larger movements than those normally associated with building structures can be safely accepted. The specific structural shapes have also been determined to a large extent by the production and erection techniques discussed which are an integral part of foam plastics technology.

SPIRAL GENERATION

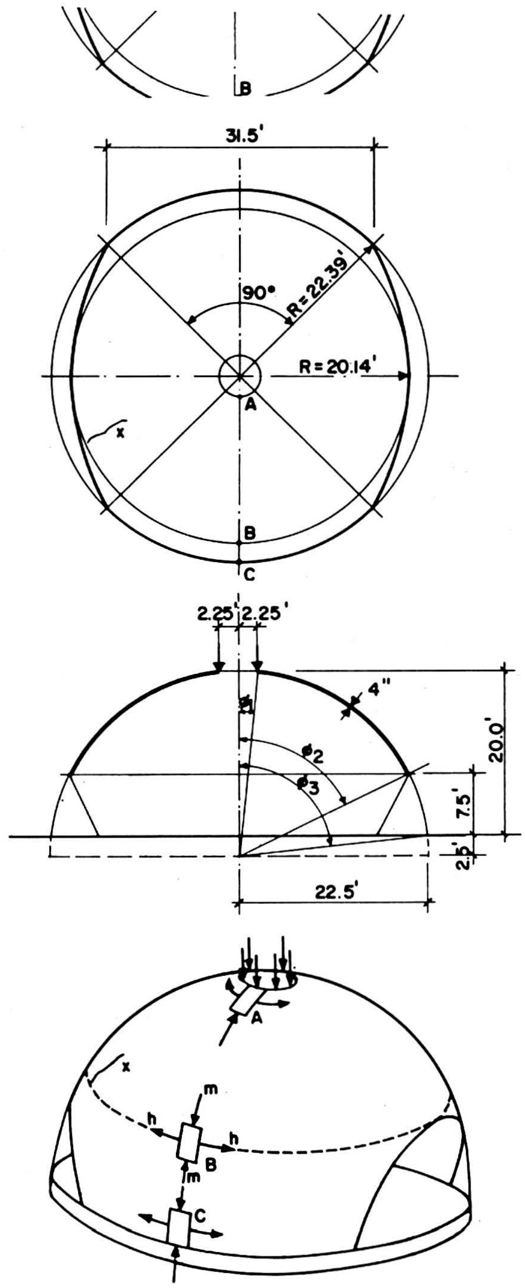
This process, invented by Donald R. Wright, was developed by the Dow Chemical Company and involves the use of a specially designed machine which bends, places and fastens together boards of polystyrene foam into predetermined structural shapes, a variety of which can be achieved by programming the machine. The machine head which revolves on a pivot mechanism and forms and seals it layer upon layer into a rising structural spiral.

A structural evaluation of the hemispherical shell dome shows that it basically meets the requirements of low stresses and deflection without distortion. However, low membrane stresses are dependent upon full support at the boundaries and because of necessary openings in the golf clubhouse shown here, only 50% of the lower boundary is fully supported. The remaining edges were therefore stiffened against local forces with glass tape and epoxy resin.

The clubhouse has performed satisfactorily without serious deformation during its 2½-year exposure to winds and snow (several small cracks developed). In general, creep and thermal movements have been minor and are of concern only at the window wall.

Although the present method of construction improves some limitations as to form, it is anticipated that mechanical innovations will permit the construction of other types of doubly curved shells.

The total average cost of the clubhouse came to $2.75 per square foot of floor area, including finishing on both interior and exterior surfaces. The largest percentage of the labor cost (82%) and a considerable percentage of materials (28%) are related to finishing. It is apparent that the most significant cost reduction can be made in this aspect and future research should be directed to simplifying the finishing of spirally generated polystyrene domes.



Material: "Styrofoam" Planks
Density 1.9 P.C.F.
Moduli of Elasticity P.S.I.
E_i Elastic 2100
E_j Sustained 26 Mo. 1320
E_{20} Sustained 20 Yrs. 1000
Poisson's Ratio μ=0.25
Coefficient of Thermal
Expansion 4×10^{-5} IN/IN °/F

General Formulae for a Spherical Shell Under Dead Load:

Meridional Stress

$$m = -\frac{2\omega r}{\sin^2\phi}\left[\sin\frac{(\phi+\phi)}{2}\ \sin\frac{(\phi-\phi)}{2}\right] - \frac{p \sin\phi_1}{\sin^2\phi}$$

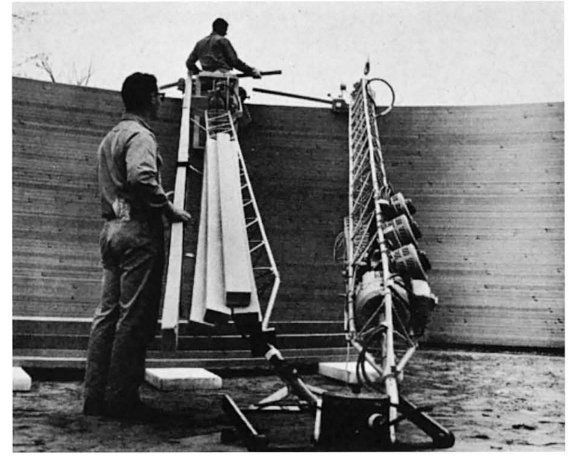
Hoop Stress

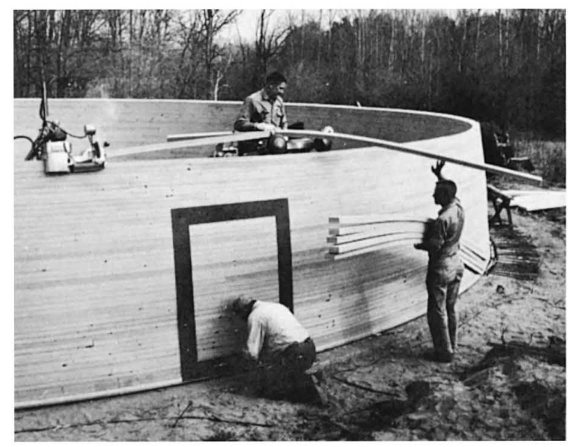
$$h = -m - (\omega r \cos\phi)$$

Deflection at Crown

$$\Delta = \frac{r^2\omega}{2Et}(\mu - 1)$$

Unit Dead Load w=0.7 Lbs/Sq. Ft.
Total Surface Area 2480 Sq. Ft.
Weight Surface 1730 Lbs
Skylight 120 Lbs
Total 1850 Lbs





Values are in Lbs./Ft.

Position	A	B	C
Meridional Stress (m)	−80	−12	−15*/−26
Hoop Stress (h)	+64	+ 5	+13

*Average value based on a complete dome. The other value is an approximation for the actual dome.

Deflection at Crown
Elastic + Creep
Dead Load (26 Mo.) Δ=0.025"
Dead Load (20 Yrs.) Δ=0.033"

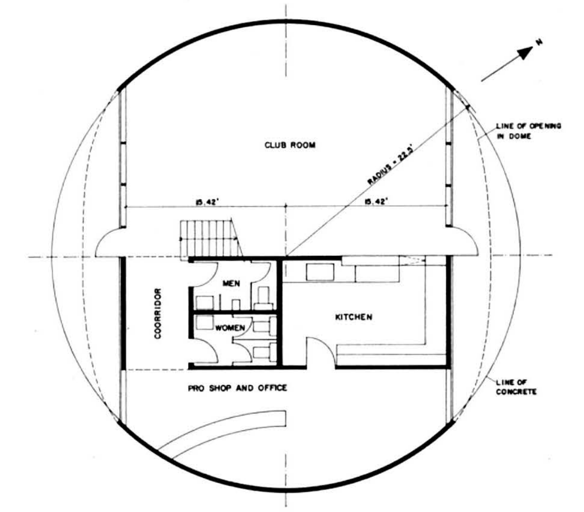
Elastic
Live Load (20 P.S.F.) Δ=0.46"

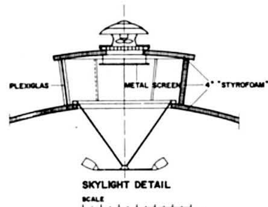
Thermal Movement 50°F Differential
Δ=0.48" Up or Down

COST

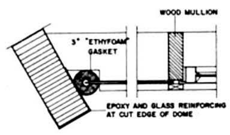
Materials	
12,720 board feet "Styrofoam"	$1490
90 gallons latex paint	457
20 bags vermiculite	60
9 gallons epoxy resin	96
24 square yards of glass cloth	16
angle iron base ring	150
Total	$2269

Labor	*Man Hours*	*Percentage*	*Cost*
preparation	24	7	$154
generation	36	11	230
finishing	266	82	1702
Totals	326	100	$2086

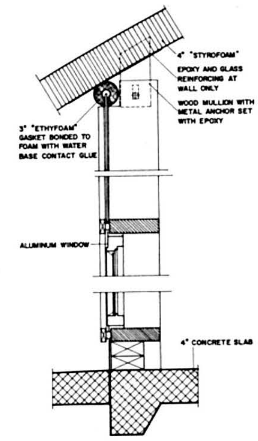




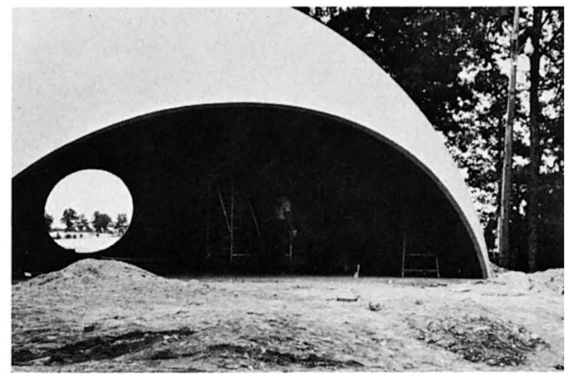
SKYLIGHT DETAIL

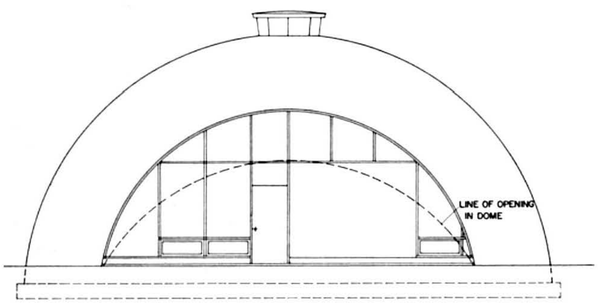


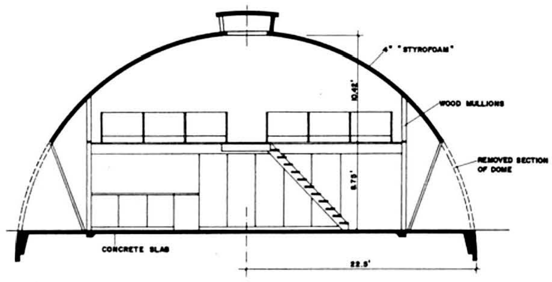
HORIZONTAL WALL SECTION

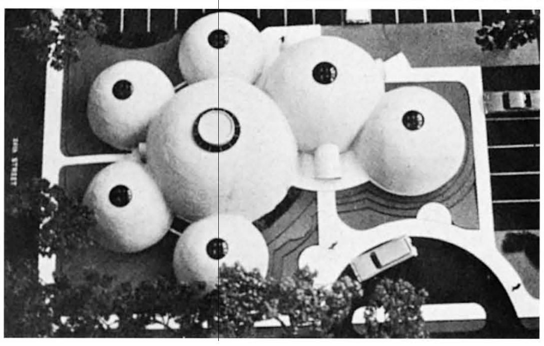


VERTICAL WALL SECTION





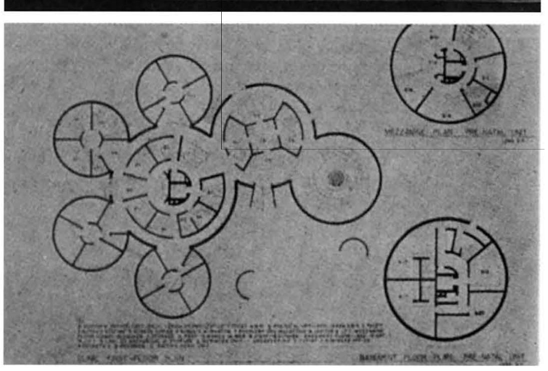




PROFESSIONAL CENTER CORPORATION
LAFAYETTE, INDIANA

Architect: E. H. Brenner, A.I.A.

This cluster of spirally generated hemispheric domes ranging in diameter from 26 to 44 feet will serve as a women's medical clinic. The complex will be completed in an estimated total of ten days. These free standing structures will support a uniform load of 50 lbs. (design live load in addition to the dead load of a "non-structural" exterior stucco finish.)



FOLDING ARMATURE SYSTEM

Spray application of polyurethane is one of the most promising methods for obtaining rigid foam plastics components. Transportability of equipment and the ease of creating structural shells in varying thicknesses offer definite advantages.

An essential element in any spray application is the form-giving surface against which the foam components are to be sprayed. A lightweight wood lattice was devised as an armature in the Michigan project to obtain doubly curved shell forms. The armature is composed of wood slats bolted together in a uniform grid capable of being folded. As such, it can be prefabricated and transported to the site.

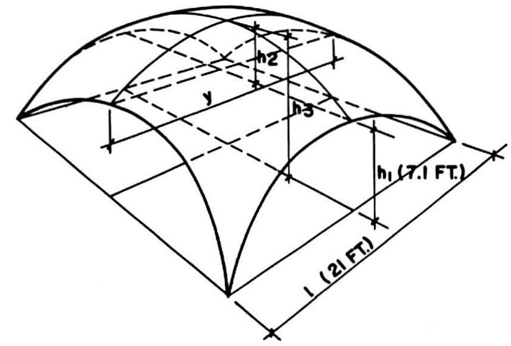
The shell form determined by the wood armature may be classified as an eliptical sinusoid, based on the assumption that the elastic curve of a linear member loaded as a column will be approximately a sine curve. The size of the wood slats depends on the size of the armature and the amount of bending required. Sizes used to date have been selected empirically. The wood lattice was transported in four sections to the site and assembled into a 27′ x 27′ grid. After the armature was adjusted to its final shape by using tension chords, the joints were bolted and intermediate wire introduced to make the frame rigid. Curved edges were reinforced with additional wood strips and the entire structure covered with a stapled-on nylon reinforced paper skin.

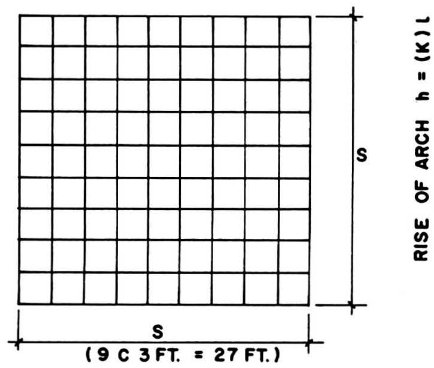
Early model studies indicated that the armature would not be capable of supporting the total weight of the structure. Therefore, the sequence of spraying operations became an important consideration in order to allow the foam itself to begin working structurally during the spraying process. After completion, some deflection was observed at the midpoint of the edge member. This increased over a period of six weeks to a point where the edges sagged from an initial average height of 84″ at the center down to 70″.

The polyurethane foam wood armature dome displayed several deficiencies. First, the edge supports are inadequate. Initially, the shell was supported on only four points, but subsequently the stiffening of the triangular areas provided partial support along a circumference defined by a horizontal plane intersecting the shell at the 7-foot level. However, considered as a dome on buttresses, it is provided full tangential support only in region "A" (see drawing). Regions marked "B" have only vertical support. A shell without full edge supports would be expected to be subject to bending stresses. Second, the general form of the shell is based on construction rather than on geometry or forces. Third, the shell has a low rise-to-span ratio and large deflections could be expected to result from minor strains.

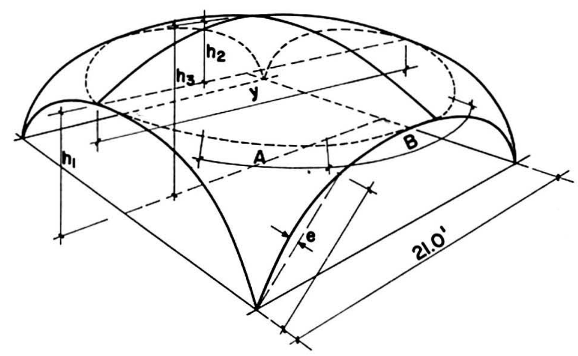
Stiffened at the edges with arch-type trusses when erected and tied effectively in a circumferential pattern, the folding wood armature provides adequate support without distortion of the foam, and one can assume that the concept of spray application for a folding armature dome offers reasonable basis for a primary structural use of cellular plastics.

The quality of the foam depends on formulation, environmental conditions and spraying techniques. For the interior surface of the dome





GEOMETRY OF THE FOLDING ARMATURE



Physical and Mechanical Properties of Sprayed Polyurethane Rigid Foam Used In the Wood Armature Dome

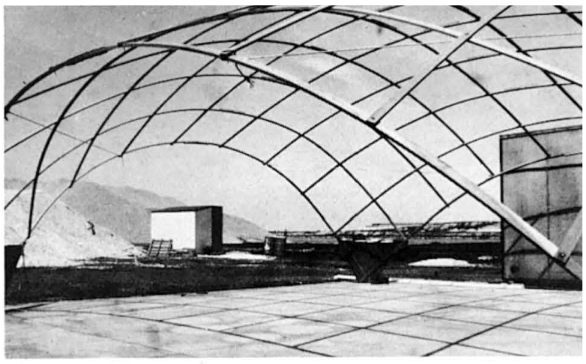
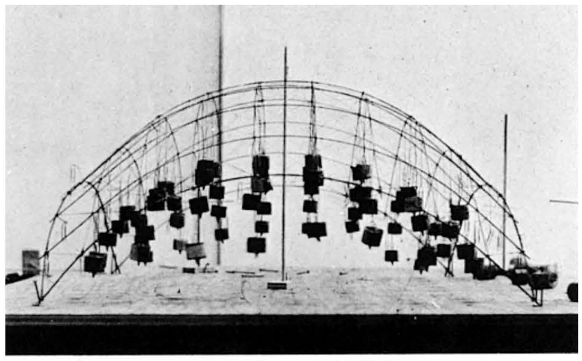
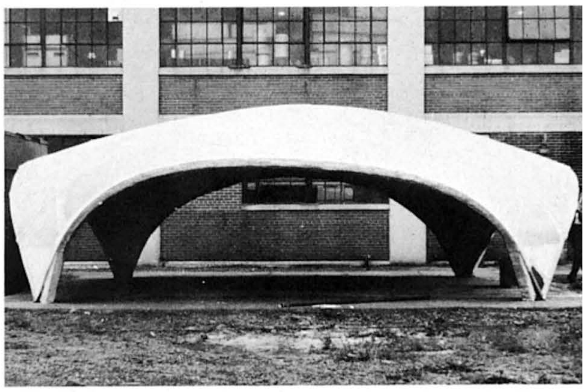
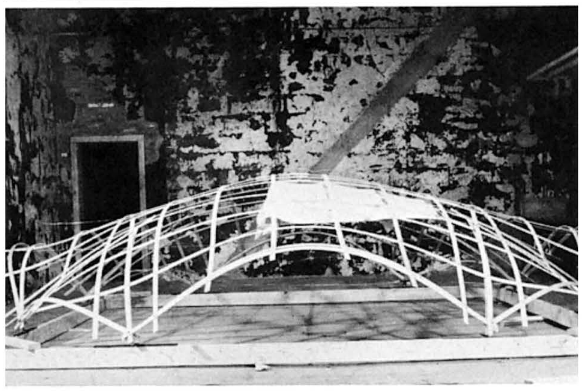
Density: 2.5 P.C.F.	
Closed Cells: 90 ±5%	
K-Factor at 75°F. Mean Temperature: 0.12	
Flame Test ASTMD 1692–59T: Non Burning	
Yield Strength at a Specific Strain: (Compression)	Parallel to Rise–30.8 P.S.I. at 3.1% Perpend. to Rise–14.4 P.S.I. at 2.6% Perpend. to Rise–21.9 P.S.I. at 7%
Modulus of Elasticity:	Initial Compression 560 P.S.I. Initial Flexural 1060 P.S.I.
Rate of Creep (70°F)–Flexural:	20 Days 86% 40 Days 108% 1 Year 220% 20 Years 600%
Poisson's Ratio: μ=0.27	

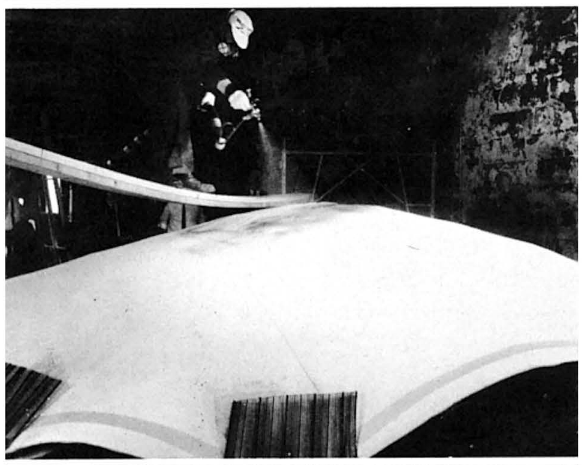
Deflection Record of Polyurethane Foam Wood Armature Dome

Dimensions* (inches)

Condition	h 1	h 2	h 3	e av.	e max.	y
1 Initial Armature No Foam	(83)**	(35)**	(120)**	(8)**	–	–
2 20 Days After Spraying	76	36.7	112.7	10.2	13	26.39
3 40 Days After Spraying	70.4	37.4	107.8	13.2	16	26.29
4 40 Days + 8 Days Pull Back of Buttress	84.4	34.4	118.8	7.4	9	26.37
5 40 Days + 16 Days	84.1	33.9	118.0	7.4***	9***	26.42
6 40 Days + 56 Days	83.9	33.4	117.3	7.4***	9***	26.42
7 40 Days + 329 Days	(83.7)**	32.3	116.0	7.4***	9***	26.23

*All values are taken at the top surface.
**Estimated values.
***Values recorded included the edge truss and as such are not comparable, however, no subsequent change was noted.

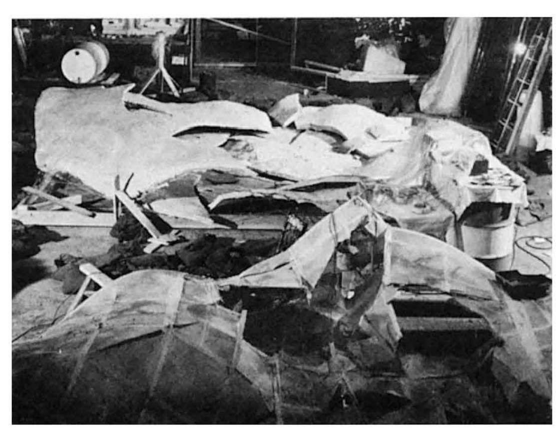



it was satisfactory. However, its consistency as a structural material is questionable since certain voids were found to exist adjacent to the wood strips. More research in the technique of application is required to improve the foam's consistency and to establish safety factors for the completed structure.

Costs, estimated only on the basis of the construction of the prototype structure, were approximately \$1.05 per square foot for materials and labor for the armature and \$0.75 for the sprayed foam.

The folding armature system is adaptable to on-site construction, thus complementing the inherent flexibility of the spray system. Standardization or prefabrication is not essential. Feasibility depends on efficiency of the shell form and on quality of the polyurethane foam. The project's search for improvement of these two factors resulted in development of the following two shells.

Photos show folding armature system under construction and prior testing of elements to the point of failure.



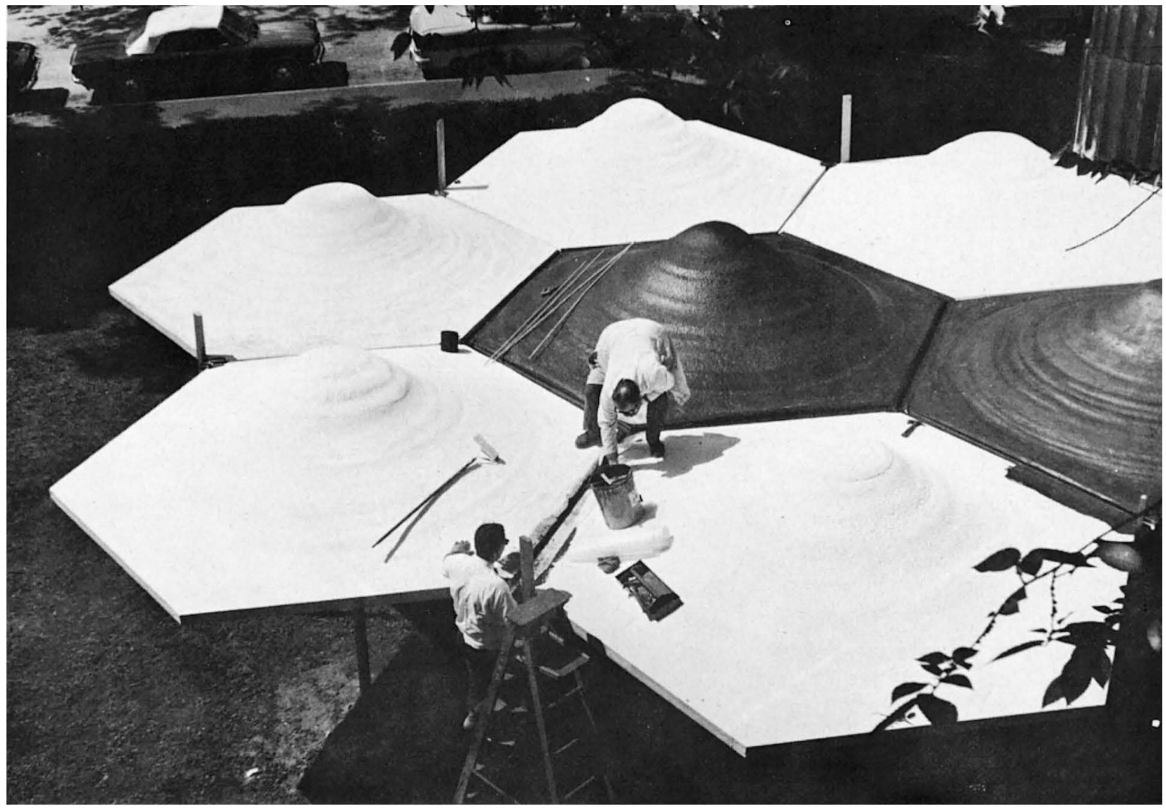
UMBRELLA SHELLS

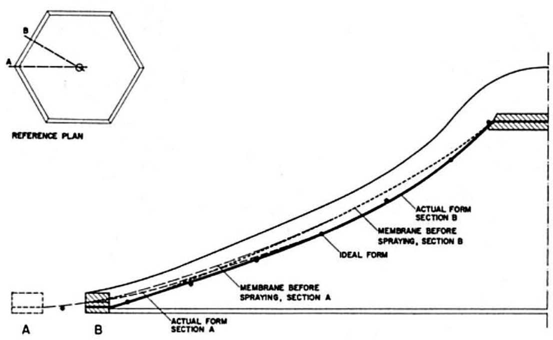
After some further unsuccessful investigation of synclastic domes, made largely inconclusive because of the inconsistency of spray techniques, the dome form was abandoned in favor of anticlastic membrane umbrella shells. Earlier exploration by the project staff of rigidizable membranes (see section on "Contributing Applications") and further study of the concept of minimum structure or structural membrane suggested the use of the flexible membrane as a form-giving device for the spray application of polyurethane foam. Further, the hexagonal type of umbrella was considered reasonably close to a surface of revolution to indicate a method of mechanization of spray technique that could lead to improvement in material quality.

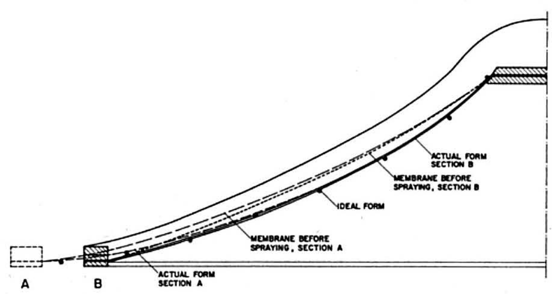
A pavilion structure consisting of 7 such shells was erected. The design approach consisted of assuming an independent radial sector and then determining the forces on this sector. The outside edge member is assumed to provide only horizontal support to the sector and the inside disk, horizontal and vertical support.

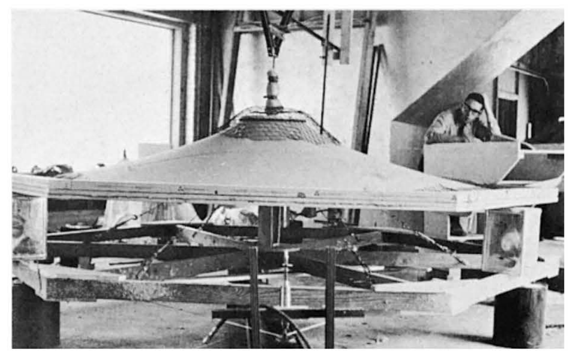
All shells were coated with liquid elastomer before being exposed to the weather. The weight of the total shell and its supporting pipe column is 450 pounds, with about half of this weight in the column and the wood edge member.

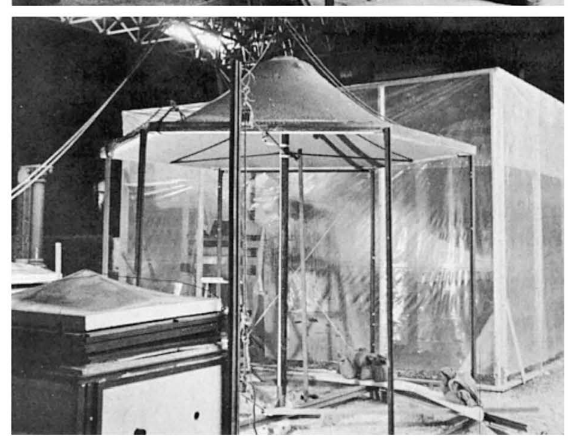
Tests have substantiated the system's structural sufficiency. The surface is stiff enough to support the weight of a workman and after four months there was no evidence of deterioration or excessive deflection. Cost of materials is estimated to have been $1.75 a square foot. Erection and finishing is estimated at an additional $0.75 a square foot. Considering that a total roof system is provided — weatherproofing, structure, insulation and acoustical material — it is believed that this system could be readily marketed.

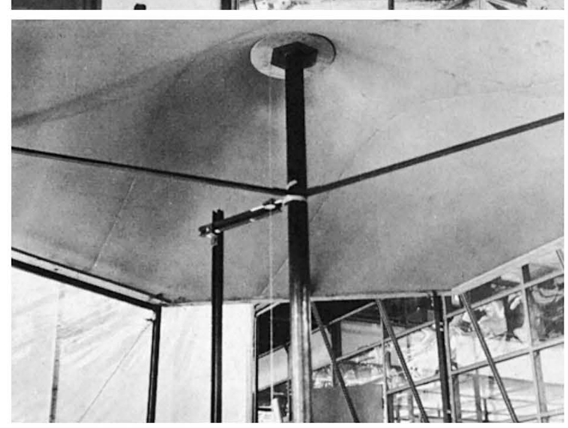


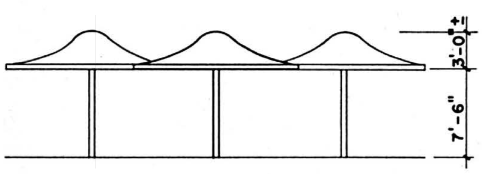


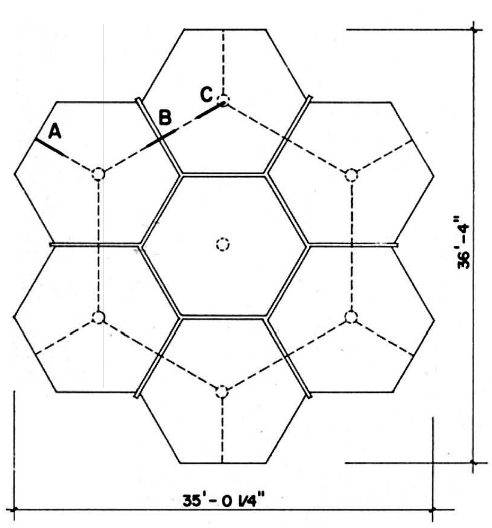


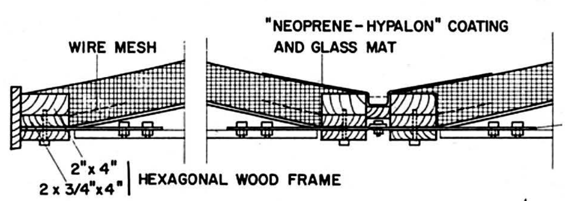


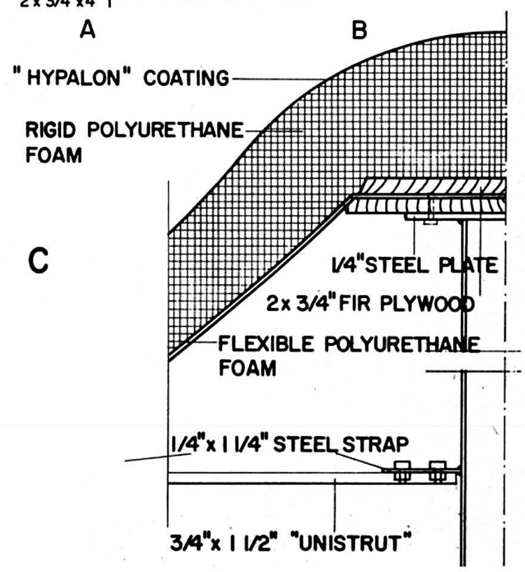












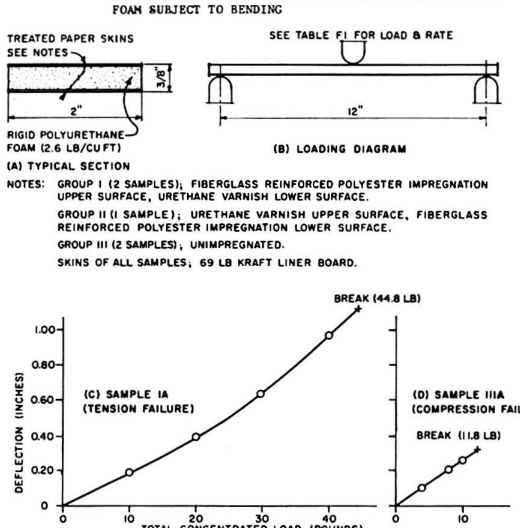
SECONDARY STRUCTURAL USES

In the examples described in this section, the function of the foam plastics is to provide bracing or stiffening for other materials which act in a primary structural capacity but are not proportioned to resist buckling on their own. Linear and composite folded plate structures in which the foam plastics become the core material of laminated boards appeared to offer the most promise. Because of the secondary role of the material, the range of possible applications was extended to include singly curved shells, folded plate structures and slab and panel structures which may be constructed with sandwich panels.

In general, the presence of permanent high shear stresses in the foam required the introduction of an additional material between the skins to resist this shear; otherwise, shear creep of the core material will produce intolerable deflections. The foam plastics, then, serve only to restrain buckling of the skins and to provide additional capacity for transient loads.

The project staff sought a panel that would be truly representative of foam plastics technology, where the primary structural material could be kept to a minimum, and whose properties and method of production would play a major role in the resulting structural forms.

INITIAL TEST RESULTS FOR PAPER-LAMINATED POLYURETHANE FOAM SUBJECT TO BENDING

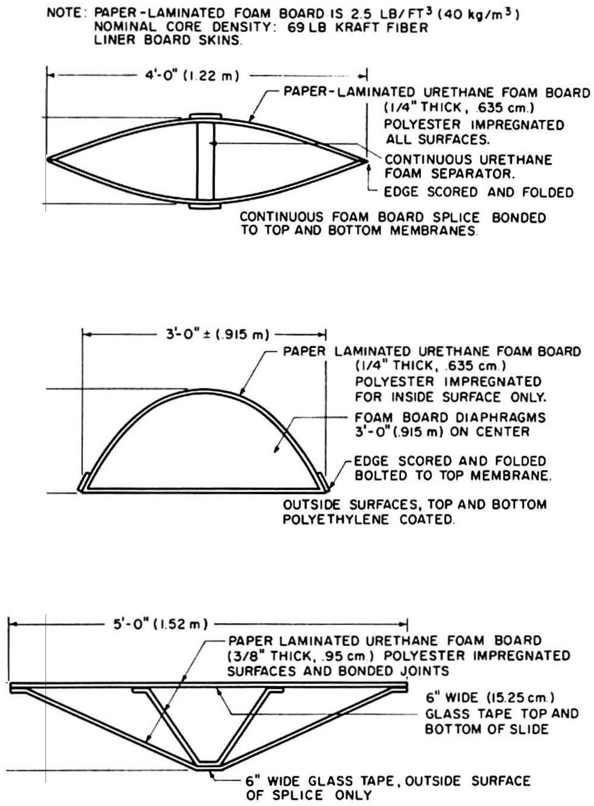


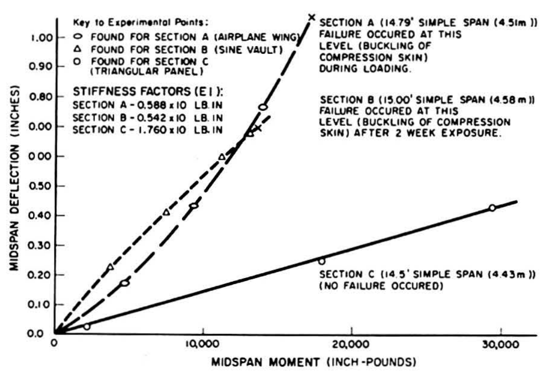
This kind of product was found to be a 3/8″ paper-laminated polyurethane foam board. Samples obtained from Union Carbide consisted of a polyurethane foam core of a 2.6 pcf density with skins of 69-pound kraft fiber liner board.

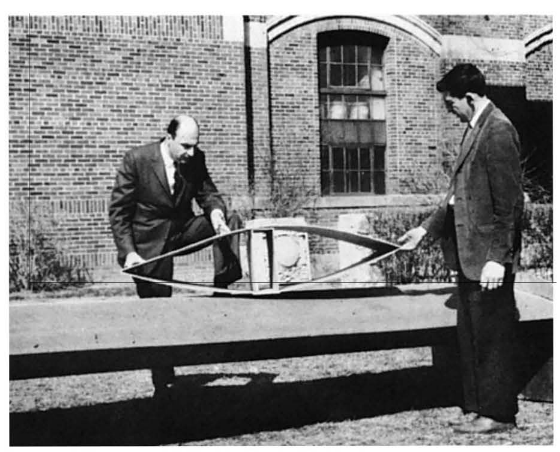
After initial investigation of the material's mechanical properties it was decided to develop singly curved and folded plate components which would utilize the ease with which the material can be scored and bent in production, thereby determining the ultimate shape of the structure.

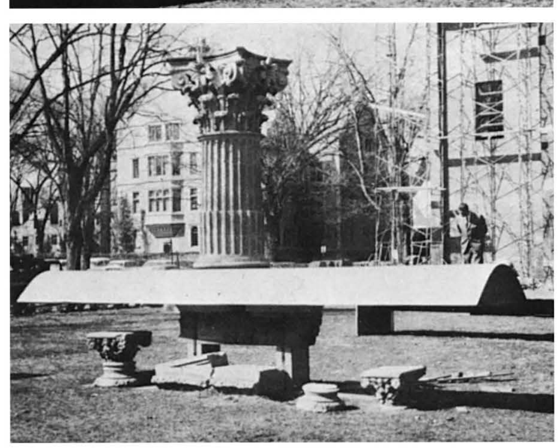
Of the three sections constructed and tested, the triangular section C proved to have the greatest capacity and its flat surface lent itself best to use as a floor system. (An important factor from the standpoint of human occupancy is the "feel" of a structure. On the basis of tests, the triangulated structure, spanning 15′ between supports, will deflect .13″ producing no detectable difference in feel from a conventional wood frame structure supported by 2″ x 8″ joists 16″ o.c. which will deflect .10″.)

INITIAL TEST STRUCTURES UTILIZING PAPER-LAMINATED POLYURETHANE FOAM BOARD







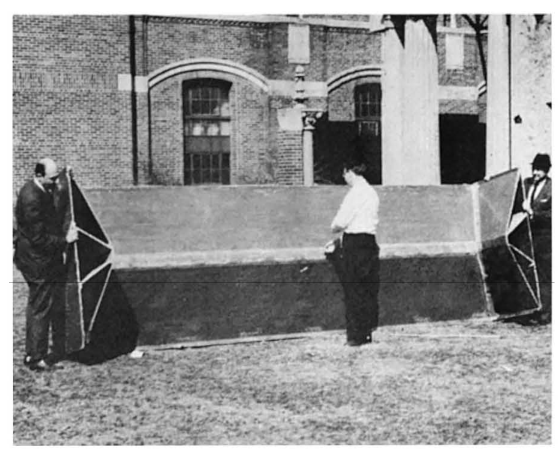


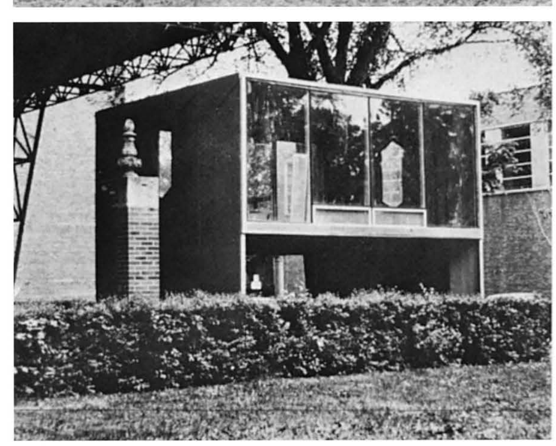
FOLDED PLATE STRUCTURE

The structural system developed for the prototype, using the triangular section panel, is a series of rigid two-story bents which do not require additional bracing or shear walls to resist horizontal loading. It was found that joints for structural systems of paper-laminated foam board can be designed to depend on the bonding and reinforcing properties of impregnant polyester resin and glass fiber tape to achieve any required degree of rigidity.

Considering the many hand operations which might have been better performed by machinery, the cost of the prototype structure seems reasonable. The 576 square feet of enclosable space cost about $1900, or $3.30 per square foot, which is competitive with existing methods of construction since the panel system includes excellent insulation. Assembly of the four finished components into a single bent—comprising two walls, floor and roof—required five hours of labor. Including incidental materials, this represents a very small part of the total cost—approximately $0.12 per square foot.

In view of the possibility of mass production of components, the system is felt to hold great promise from an economic as well as structural point of view.





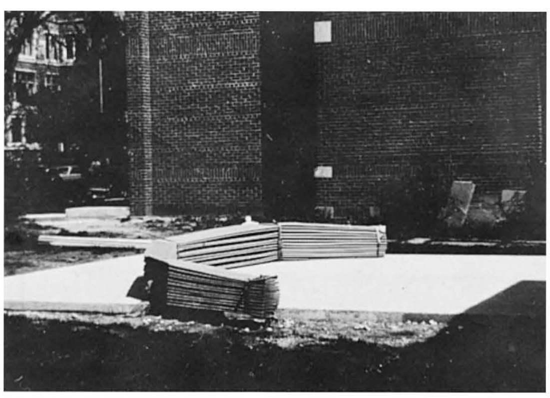
COMPOSITE FOLDED PLATE STRUCTURE

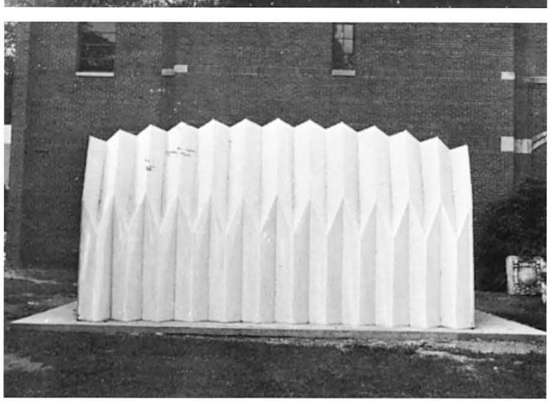
This is an adaptation of an earlier concept of Canadian designer Herbert Yates and is presently being produced and marketed by Plydom, a U.S. firm. The shell was erected last year at Michigan University in less than one hour and has since been recommended by the project staff for housing of migrant workers in California, for classroom use in developing countries and for community development programs.

The basic material used is the same paper-laminated board as in the previous structure, except that the board is 1/4″-thick instead of 3/8″. The shell weighs 105 pounds and is delivered to the site in two components that are folded into two 12″-thick packages. The two parts are joined with tape which becomes the ridge of the assembled structure. The joined components are then lifted, unfolded and anchored to the floor by means of tabs and coated with pigmented polyester resin.

The structure has not yet been fully tested but it easily took the weight of a person sitting on the ridge to waterproof the joint. It has also held up well through high winds and rain storms and shows no evidence of failure despite repeated saturation of the paper near the ground.

The unit measures 17 by 19 feet in plan and encloses 2500 cubic feet. Retail price is about $450 (which could be reduced substantially by volume production), representing the lowest shell cost investigated by the project staff.





CONTRIBUTING STRUCTURAL USES

Besides the primary and secondary structural applications, a number of construction uses have been made of foam plastics which do not depend on the capacity of the material to resist the structural loads. Such applications include the forming of structures which have been designed to be constructed from other materials such as concrete and reinforced plastics. In this case the mechanical properties of foam plastics have to be considered only to the extent that the form-giving system will have to be self-supporting until the structural materials take their final set.

"FLEXIBLE RIGIDIZED" SHELLS

Study centered on the rigidization of flexible membranes, such as the tent form, for permanent use. (Research on this concept preceded, and contributed to, that on the anticlastic umbrella shells discussed in the section on primary structural uses of foam plastics.) Three concurrent developments in plastics combined early in 1964 to indicate the feasibility of such structures. Scott Paper Company was producing large cell, flexible polyurethane foam in large sheets. The walls of this material could be removed completely, creating a linear cell structure which could be economically impregnated with resin. At the same time, a slow-curing, humidity-catalyzed urethane impregnating resin was developed by Wyandotte Chemical Company and a flexible adhesive which cured with the same stretch characteristics as the elastic membrane was discovered. Four 12′ x 12′ shells supported on 4″ round steel columns were erected to test their potential as a roof structure. Two of the shells were given rigid foam cores by the impregnating process alluded to above; a third type had a flexible foam core and the fourth utilized the membrane as a flexible foam form. The membranes were fastened continuously to wood edge members which became incorporated in the final shell structure, serving to provide stiffening against surface forces; also the shells were bolted together through them.

Tests of the square reinforced plastic umbrellas were encouraging and, as noted, the technique was later applied to the rigid foam umbrellas described previously. The difference in form between the square and the hexagonal umbrellas is a direct result of the later more demanding requirements. In particular, the hexagonal plan was chosen to reduce the high corner moments revealed in testing the polyester-fiberglass shells and still permit straightforward assembly of the finished components.

Because of the many variations in details and techniques utilized, the costs of this system cannot be estimated with great accuracy. The best estimates to date indicate a material and labor cost of about $1.75 to $2 per square foot.

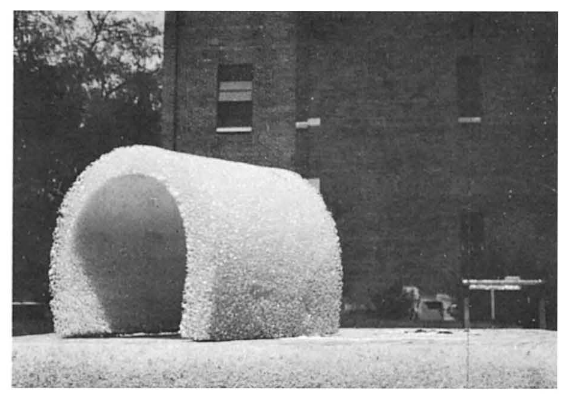
Use of the flexible foam membrane as a forming device or as a rigid core material for doubly curved structures is considered by the project staff to be a promising application. Its main contribution is to make practical structural systems that have heretofore been uneconomical because of high labor costs involved in forming.

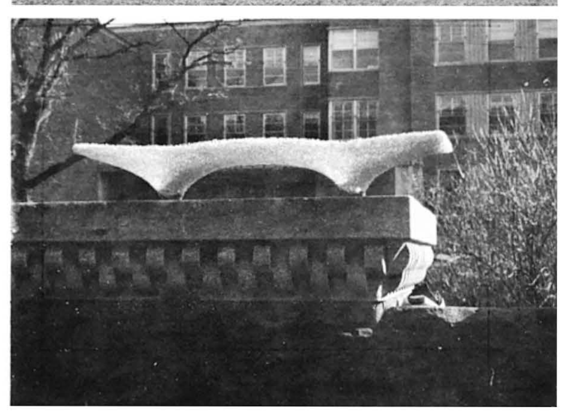
FILAMENT WINDING SYSTEM

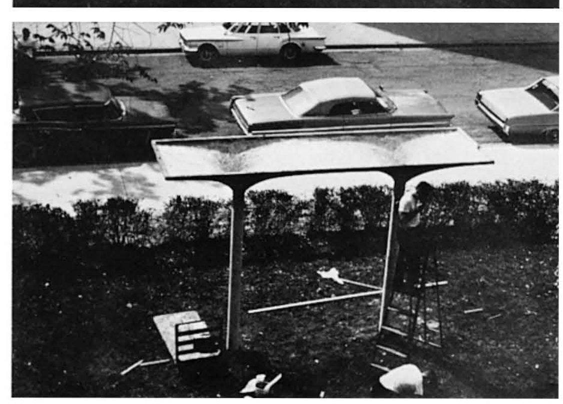
The filament winding system method of fabricating reinforced plastics is similar in principal to the spinning of a cocoon. Single, continuous filaments of reinforcing fiber are coated with a binding resin and deposited on a forming surface called a mandrel. The mandrel is made to rotate at a programmed angular speed and at the same time a delivery system for the coated fibers moves back and forth along the mandrel according to a present pattern.

One of the most important advantages of filament winding is that it uses both reinforcement and binder very economically. The strands are just one manufacturing stage away from liquid raw materials and the plastic binder can be pumped directly from storage drums to the delivery system. It also has structural significance since reinforcing can be laid down in a pattern suited to the distribution of stresses in the structure.

As early discussions proceeded, the concept of a room-size module was chosen for further development. Long span structural components may have an equally fruitful potential, but a number of factors favored the modular unit. For example, a room-size module has many applications outside the housing realm—as a refrigerated shipping container, or van body, both unaffected by building codes. Since such a unit is equally applicable to housing use as, say, a "plug-in" module for highrise structures, school







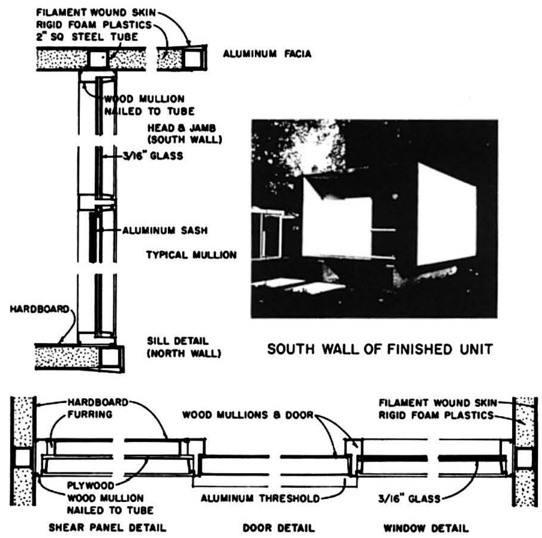
buildings, etc., it was attractive to the project staff.

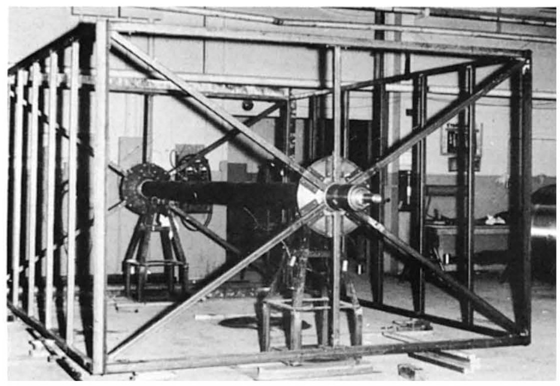
It was found during tests that, depending on filament tension, each revolution of the mandrel added about 40 pounds per inch of force, squeezing in on the supporting structure. (It is theoretically possible to wind the filament without tension but not at this time because of frictional resistance in the delivery system.) It was determined that the most economical structure for this purpose would be a continuous steel tube frame. The frame was finished in hard board and in filled with foam board panels, then the entire unit was filament wound.

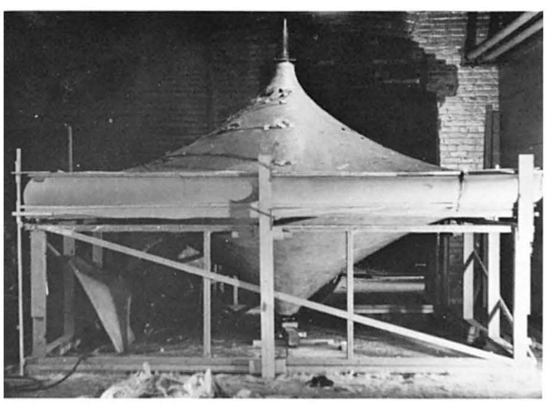
The entire operation of producing a room-size component took only a few hours over a period of three days. It weighed about 2500 pounds. After erection on the site, the masonite interior surfaces were painted and the ends closed with 3/16″ sheet glass. (Polypropylene carpeting was installed, supporting the point made repeatedly about the plastics industry: the company which has the facility to produce the shelter module is also active in the production of commercial fibers which may be used in furnishing it.)

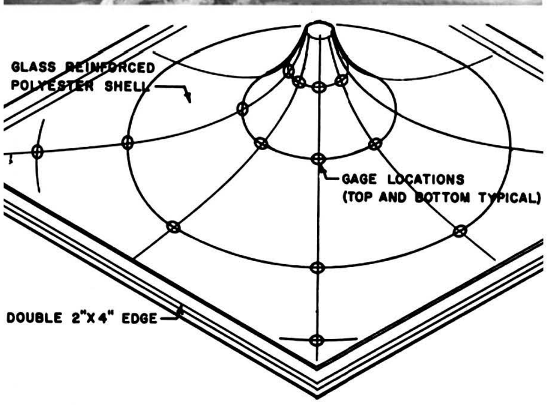
Cost of the completely finished 12″ x 16″ x 8″-unit, excluding transportation, was $1400, and filament wound modular structures are felt to be a reasonable area for further research and development, demonstrating another promising and practical application of plastics to construction.

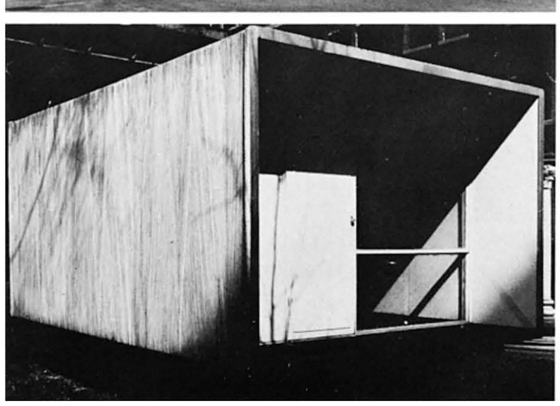
DETAILS OF COMPLETED FILAMENT-WOUND PROTOTYPE STRUCTURE











STRUCTURAL PLASTICS IN EUROPE

BY Z. S. MAKOWSKI

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The advantages of plastics are realised by many engineers and architects who appreciate the unusual feature of these materials of combining various desirable properties at the same time, e.g., light weight, great strength, attractive appearance, high corrosion resistance and translucency.

In the past, the use of plastics has been confined almost exclusively to non-load bearing elements. However, during recent years considerable interest has been focused on semi— and even fully structural applications of plastics. Most of such applications are still largely of experimental nature, but with the great interest expressed in plastics materials and with the rapidly increasing volume of research on structural plastics now being carried out at many universities and government research establishments, one can expect with every confidence a real breakthrough in structural use of plastics during the next decade.

Plastics are a new class of materials and should not be treated as direct substitutes for steel, aluminum or timber. If used merely as a replacement for other materials, plastics may well prove to be more expensive, but if applied in an intelligent way in shapes appropriate to their characteristics, the unique properties of plastics may lead to efficient and economical solutions.

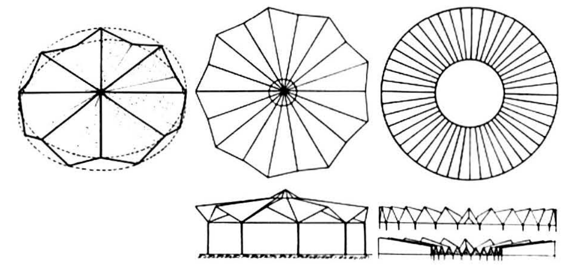
The cost of plastics structures is often compared with that of other materials. However, one has to take into account not only the initial cost of the raw material, but also the costs of the manufacture, installation and maintenance. If all these factors are examined in an unbiased way, plastics often prove to be highly competitive. The increased interest in plastics is also influenced by the recent developments of plastics materials showing marked improvements in dimensional stability, greater temperature resistance and various ways of increasing flame retardance.

One of the main disadvantages of plastics is the low value of the modulus of elasticity E; this has been thought to be the chief barrier against the structural use of plastics. However, it has been shown that the lack of stiffness of plastics can be effectively overcome by the proper choice of structural form.

Surface structures, such as shells and folded plate systems demonstrate convincingly that their strength is primarily a function of the geometry or configuration of the interconnected elements and depends to only a limited extent upon the properties of the material of which they are made (Fig. 1, 2).

This is, no doubt, the reason why all-plastics structures which have been built during recent years are, as a rule, curvilinear, being typical examples of stressed-skin construction in which the skin forms not only the enclosure but also contributes substantially in carrying the external loads.

Plastics are ideal for the prefabrication of sandwich panels which can be used as basic components in stressed-skin structures. Such panels consist of thin, but strong, weather- and wear-resistant plastics skins, bonded to low density insulating cores (Fig. 3). This arrangement results in a rigid and strong panel, at the same time light in weight. In addition to its structural strength, the panel acts as an excellent thermal insulation and water vapour barrier. The tests carried out on plastics sandwich panels proved their remarkable rigidity and it is obvious that



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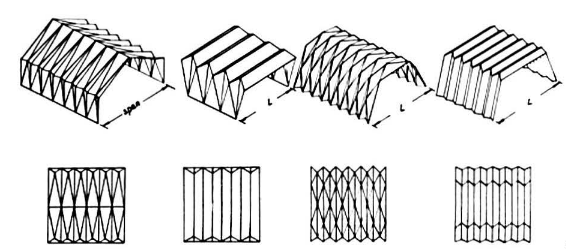

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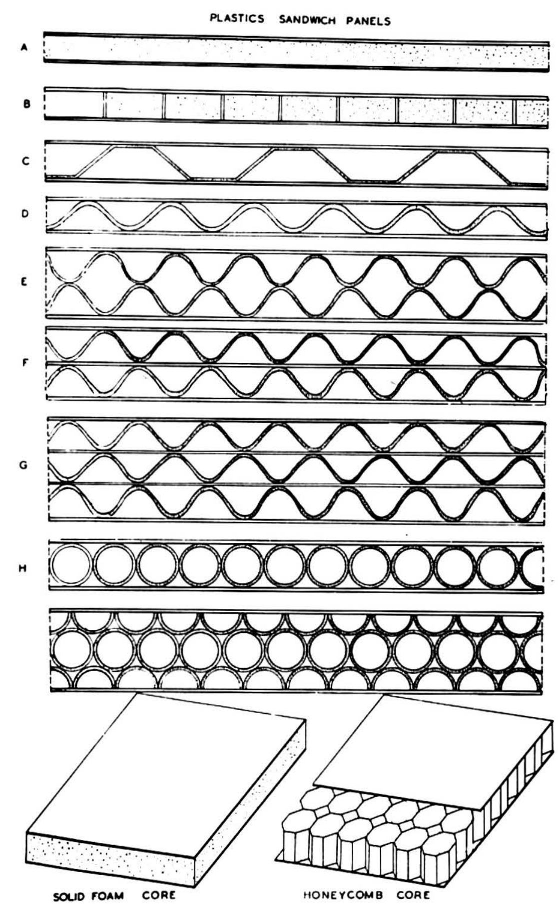

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in many cases such panels can resist with an adequate factor of safety all the loads encountered in practical building applications.

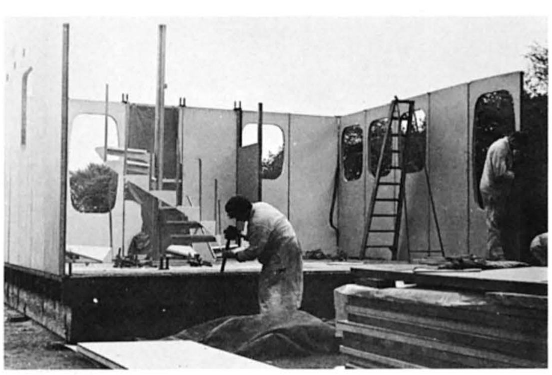
Their poor fire resistance is often the only reason why plastics sandwich panels are not allowed to be used structurally. However, the problem of fire resistance is not as hopeless as it may sound. During the last decade significant advances have been made in obtaining a substantial increase in the fire resistance of various types of plastics by imparting to them self-extinguishing properties. Very satisfactory results have been obtained using plastics in conjunction with other materials, which provide the required fire resistance.

The recent exhibition of industrialised building systems and components held in London (IBSAC 10th-21st May 1966), included a number of prefabricated systems of construction of one- or two-story buildings with external walls consisting of large factory-made plastics sandwich panels. Often the exterior skins are of aluminum, steel, plywood or asbestos cement. The core of the sandwich panels is, as a rule, in foamed plastics.

Reports from Germany suggest that all-plastics sandwich panels have been produced there having the skins in polyester/glass laminates and the core consisting of phenolic resin foam. It is claimed that such panels survived the one hour fire tests.

Special mention must also be made of the "Indulex" panels approved by the Greater London Authority for multi-story buildings (Fig. 4). The "Indulex" panels are reinforced plastics external wall units, supplied in one piece, complete with windows, internal finish and jointing gaskets. Due to the light weight of the panels it is possible to assemble several panels at the same time. These plastics panels have a G.R.P. skin on the outside, an expanded plastics filling and an asbestos lining on the inside. The "Indulex" panels meet London building requirements in respect of thermal insulation (the panels have a U value of 0.2), fire resistance and wind loading.

Expanded plastics foams are finding increasing application as the core for sandwich construction and the following types of foam are frequently used: phenolic, rigid polyurethane, expanded polystyrene, P.V.C.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The first two are thermosetting, the other two thermoplastic materials. Polyurethane can be foamed in-situ, producing a good bond between the skins and obviating the use of expensive glues. In the past, plastics sandwich panels have been manufactured by bonding the foam core (cut from slabs) to the outer skin.

Significant improvements have been introduced during the last few years in the manufacturing of sandwich panels using the foam-in-place technique, which is particularly suited to the factory production of prefabricated structures and fully automated production lines. The use of foam-in-place technique eliminates wasting due to cutting and shaping of pre-cast foam. In the case of polyurethane foam, it eliminates also the cost of adhesive and reduces considerably labor costs. The urethane foam bonds firmly to all surfaces with which it comes into contact, thus providing an integral structure of high strength and rigidity.

The density of the foam can be easily controlled within narrow limits. The structural strength of the foam depends largely on its density. The compression strength of rigid urethane foam varies between 20 lb/in^2 (density 2 lb/cu. ft.) to well over 1100 lb/in^2 (at density 20 lb/cu. ft.)

Ease and rapidity of production, lightness in weight plus durability, ease of handling and installation are the reasons for the great popularity of plastics sandwich panels and their rapidly increasing use for curtain walling and system-built structures in many European countries, especially in Great Britain, France, Germany and Italy where a large number of schools, hospitals, flats and prefabricated industrial buildings have been constructed during recent years using plastics sandwich panels in semi-structural and in some cases even in fully structural applications.

One has to mention here the recent development work of the British Iron and Steel Research Association which produced a two-story building utilising wholly load-bearing panels of novel design. The panels consist of tubular steel framework clad with plastics-coated steel plates and having their core filled with urethane foam by direct injection (Fig. 5). The loading is carried entirely by the panels themselves. Tests proved convincingly that the rigid plastics foam increases significantly the overall strength of the panels.

Many of the earlier attempts to use plastics structurally proved that during the first stage of development all-plastics structures could not compete on a cost basis with traditional techniques even taking into account all the advantages offered by plastics. This, however, is changing rapidly and there is evidence that the cost of some recently built all-plastics structures is only marginally higher than that of most other types of prefabricated buildings constructed in conventional structural materials. This is partly due to the ever-increasing prices of traditional materials and greatly increased labor charges because of the general shortage of skilled tradesmen. No doubt, this is also due to the introduction of several new and much better types of plastics, as well as improvements in the manufacturing techniques and general decrease in the price of basic plastics materials.

Because of a great demand for housing, the interest in prefabricated plastics houses is now rapidly increasing and indeed, it is difficult to find any civilised country in the world where no work has been done on plastics structures. France, Italy, Germany, U.K., Switzerland, Austria, Japan, Australia, Canada, U.S.A.—reports come from all these countries of commercial firms starting to produce "plastics" houses.

To the names of the well-known pioneers of plastics such as Smithson, Schein, Magnant & Coulon, Goody, Dietz, Pea, one had to add now a long string of names of plastics enthusiasts who through their research and realisations proved that plastics structures are not a dream, but have now become a reality. The work of Giordano Forti with his team of young architects from the Milan Polytechnic, Schwabe, Doernach, Schulze, Frenz, Quarmby, Zerning, Piano, Taylor of Mickleover Transport Ltd, is now receiving an increasing amount of publicity.

The time is now arriving when plastics structures will compete on a cost basis with established traditional materials. A German firm, Die Ohler Eisenwerke is now selling a prefabricated large-span greenhouse consisting of prefabricated, single-skin glass reinforced polyester segments in the form of a very rigid barrel vault. During the last few years, several firms have put on the market large prefabricated glass reinforced plastics shelters. In three countries there are now commercially available plastics bungalows. The idea of a lightweight, inexpensive, prefabricated holiday house in plastics has attracted the attention of many designers and several structures of this type are now being produced commercially, though most of them are built in composite or mixed systems in which the framework is constructed in steel, timber or aluminum with plastics sandwich panels used semi-structurally as the infilling.

An Italian firm of Holiday Sp.A., Milan, is now producing prefabricated, fully transportable "Minolina" holiday cabins using plastics sandwich panels.

In Japan, lightweight construction is very popular and the introduction of prefabricated plastics houses has met with a considerable commercial success. Two Japanese houses are especially well known—the Sekisui House and the Econ House; these two types are ideal for cheap beach houses or holiday chalets. The core of plastics sandwich panels used for the walls in these houses are polystyrene, the ceiling and roof units are made of hard vinyl chloride sheets with ribs.

Recently the Sekisui House was introduced into Germany, where it will be produced under a licence by the German firm of Kowalski Ltd. of Hamburg-Wandsbek and from Vienna comes a report of another plastics house produced by Osterr, Kunststoffwerke Heinr. Schmidberger A.O.

The impact of the plastics "House of the future," the Monsanto House, has been very significant upon the architectural profession. As a direct result of this investigation, various projects on all-plastics houses have been put forward by architects and engineers. These designs illustrate in a convincing way the firm belief of architects that plastics will play an important role in building construction. Out of many such studies a special mention must be made of the experimental French all-plastics house built in 1956 for the Salon des Arts Menagers de Paris, according to the design of Ionel Schein, Yves Magnant and R. A. Coulon. This

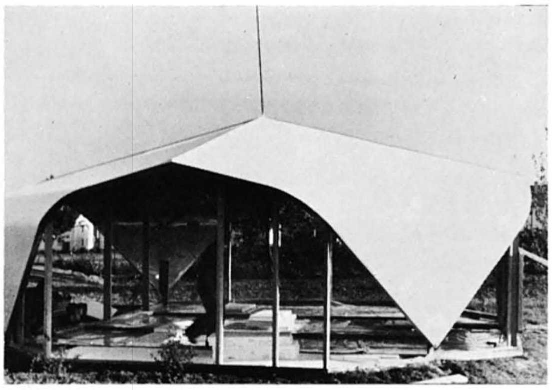
1. Circular plastics stressed-skin structures.

2. Plastics barrel vaults which can be built from prefabricated sandwich panels.

3. Plastics sandwich panels.

4. Indulex plastics wall units.

5. The British Iron and Steel Research Association's experimental house built in load-bearing sandwich panels having their core filled with urethane foam.



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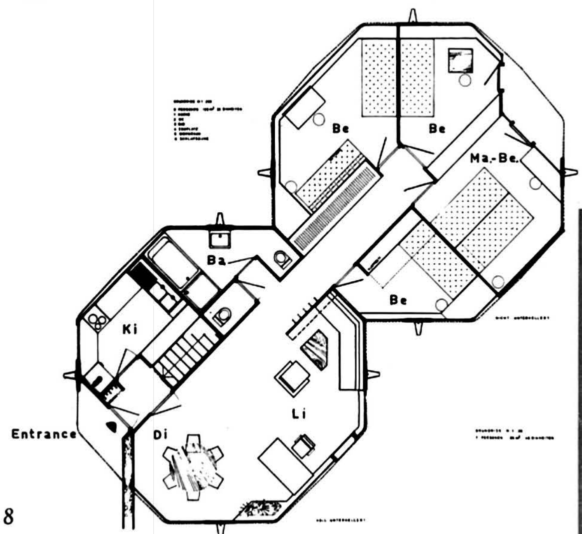

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structure is an excellent example of a prefabricated panelized system.

The circular core of the house consists of 8 prefabricated segments. The roof is constructed of 8 light units overhanging along the perimeter and joined together to a central hollow column collecting the rainwater from the whole roof area. The main feature of the design of this house is its flexibility—one can add one, two, three or four rooms to the central core, according to the needs of the occupants. The floor consists of strong and light plastics sandwich units, the wall panels are filled with plastics foam giving the required stiffness and thermal insulation. All the interior partitions in the house are also made in light glass reinforced polyester sections, including the built-in plastic furniture in the bedrooms, kitchen and bathroom.

The windows, in clear acrylics, are built into the wall units and form an integral part of the load-carrying elements. The whole house weighs only 1800 lb. and has 6000 ft^3 of useful volume.

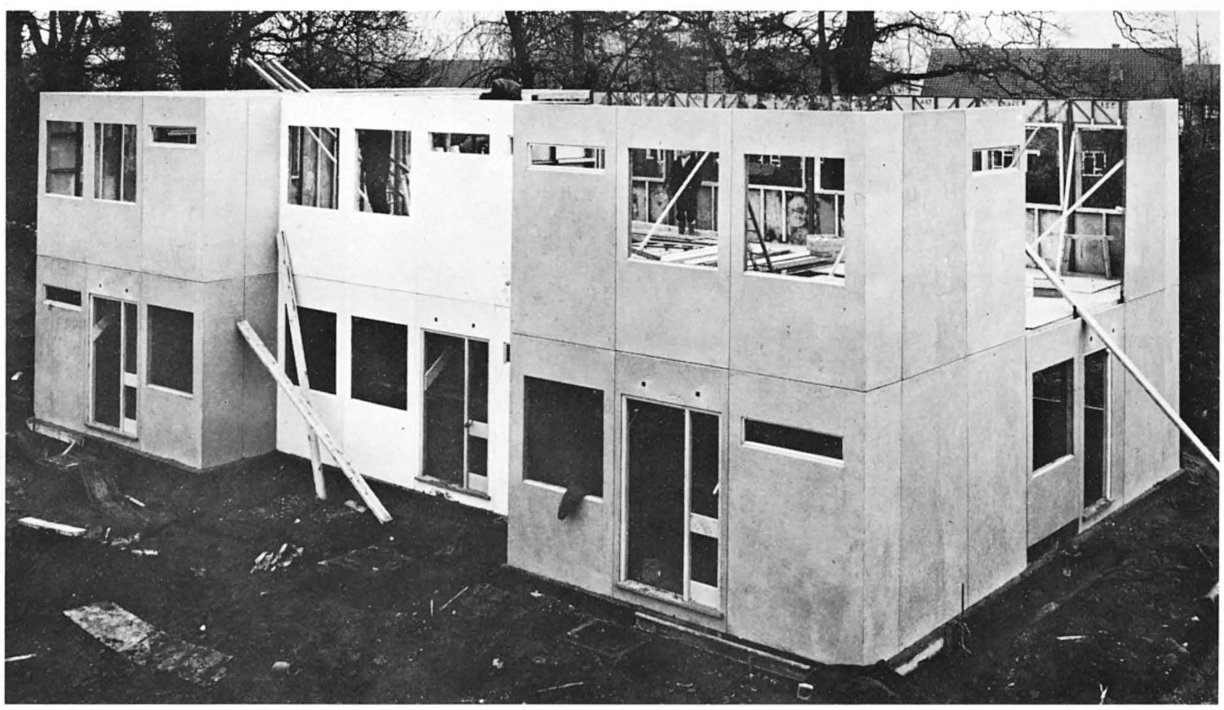
The same designers produced also in 1956, a most interesting plastics cabin, which could be used as a beach hut or a temporary hotel cabin for tourists. This cabin consists of two upper and two lower moulds and includes a bathroom in a bulged portion to the right of the entrance door.

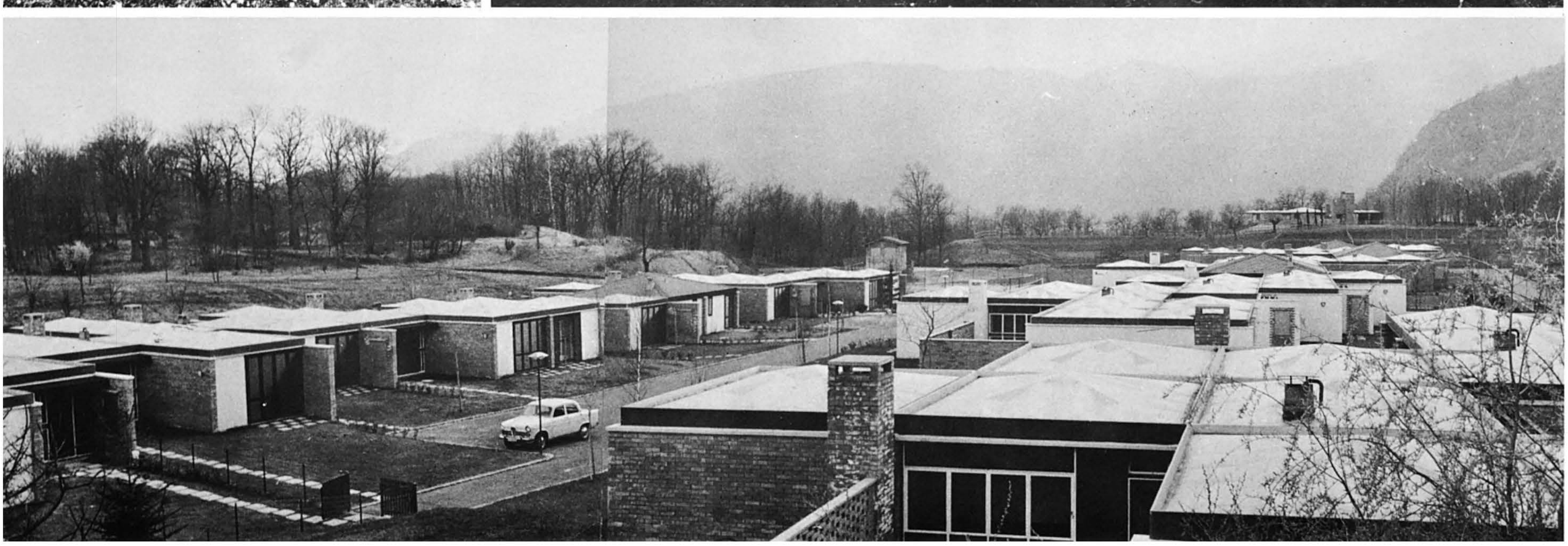
As a result of another early development during the Interbau—the industrial exhibition in Berlin in 1957—the Owopor house was constructed using prefabricated plastics segments. These units consisted of 2″-thick Styropor foam core having the outer facings in glass reinforced plastics, the inner ones being in plywood. It was a modest but highly interesting project.

In 1958, a German architect, Rudolph Doernach, displayed at the Stuttgart Plastics Exhibition, another version of a prefabricated plastics house using doubly curved segments consisting of plastics foam core covered with thin aluminum skin. The structure was supported at four corners only and was meant to be a small weekend country house. Two or more units could be linked to provide increased accommodation (Figs. 6-9).

In the year 1957, during the Milan Triennale a considerable amount of attention was drawn to an Italian all plastics house designed by an architect, Cesare Pea. The prototype consisted of a box built of 4 identical segments constructed in glass reinforced polyester resin with saturated paper honeycomb core. These prefabricated plastic boxes can be jointed in a variety of ways forming larger houses.

In some of these plastics houses, electrical heating elements have been embedded in the plastics floor or wall units, using a special type of graphite coated glass cloth. In other experi-





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mental houses, the wall and floor units are plastic panels ducted for air conditioning.

Recent reports from Russia suggest that several government sponsored investigations are being carried out there on prefabricated plastics houses. The first Russian all-plastics house built in Leningrad in 1962, is probably well-known to many Western designers. Because of its external appearance, which raised many objections from the architects, it has been nicknamed "a television set," but from purely structural points of view the Russian experiment confirmed once again that glass reinforced plastics used together with lightweight plastics foams, provide a reliable structural material. The investigations carried out on the Leningrad all-plastics house exerted a considerable influence upon the research on structural use of plastics in various other countries, notably Poland and Hungary.

The plastic development house of the I.C.I. (Plastics Division), erected in 1962 in Welwyn Garden City, has created considerable interest among architects and engineers. This structure was in no sense intended to be an "all-plastics" house. The aim was rather to demonstrate how plastics might be used to advantage in conjunction with traditional materials. It included many novel features, however, some experimental and some already commercially established, emphasising various aspects of the present or immediate future use of plastics in building construction.

One should mention perhaps the development work done recently by another British firm, William Old Ltd., on the Resiform House, constructed with factory made standard components. Panels are 8′9″ x 5′ wide, manufactured of glass reinforced polyester resin on a backing of fibrous asbestos and bonded to Dexion slotted steel angle framework (Fig. 11). This is a typical example of the interest expressed now in plastics by an increasing number of firms of builders and civil engineering contractors.

From the very recent developments, one must refer to the "Novery" circular plastics structures now being produced in France, the "Trigon" houses in Switzerland, the circular prefabricated house in glass reinforced plastics in Australia, manufactured by Rondavel Productions Pty. Ltd. according to the design of the Canberra architect R. G. Warren. In this structure curved wall-roof sections are joined together to form a self-supporting shell.

Out of many recent developments in Italy, one has to mention the highly successful design of modular roof sections for houses and industrial buildings carried out by Resine Prodotti Derivati of Milan according to the project of Mario Scheichenbauer. His design is a typical example of a plastics folded plate system. The prefabricated roof units are made in glass fibre reinforced polyester filled with expanded polystyrene for insulation (Fig. 10). The triangular pieces weigh 300 kg. each. A pair of them cover an area of 20 sq. in. These plastics roofs have already been used on a number of low-size building projects in Italy and in Switzerland. The same architect produced also an interesting design of a portable "cabana" of reinforced polyester. It is hexagonal in shape, weighs only 60 kg. and when dismantled can be carried on a car roof. The firm producing these cabanas claim that they can be erected within 15 minutes.

6/7. All-plastics house built by an architect R. W. Doernach.

8. Plan of two interconnected plastics housing units developed by Doernach.

9. A view of a holiday village built using Doernach's plastics houses.

10. A general view of a holiday village built recently in Lugano, the houses are covered by G.R.P. roof modules, design by the architect Mario Scheichenbauer in collaboration with the architect Ermanno Steinberg. The roof units produced by R.P.D.—Milan.

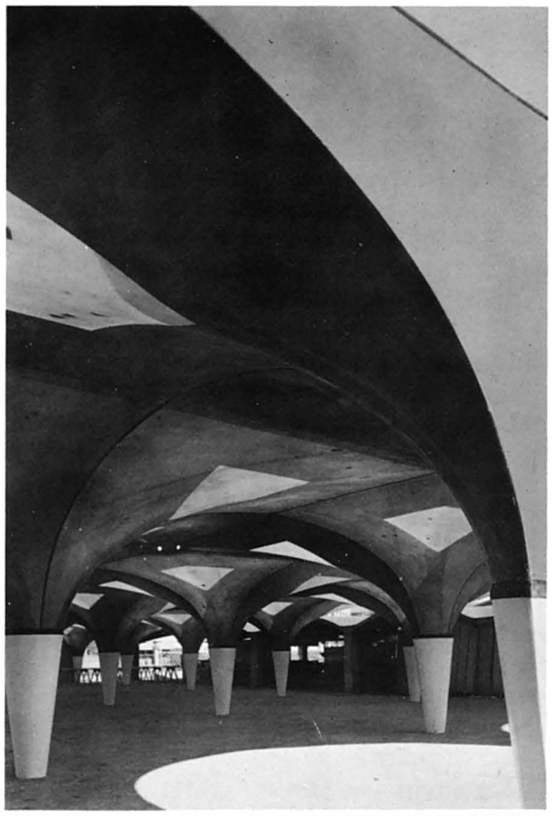
11. The erection of the Resiform double-story dwellings at Pinner, Middx., England.

12. Interior view of the all-plastics structure covering the market in Fresnes, France.

13. Erection of the all-plastics roof structure in Fresnes.

14. All-plastics roof structure over a market in Ivry, France.

15. Folded plate roof built in prefabricated plastics modules in Epinay-sur-Seine, France.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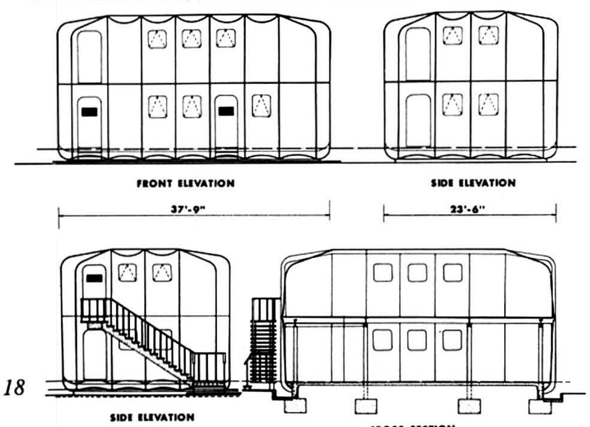

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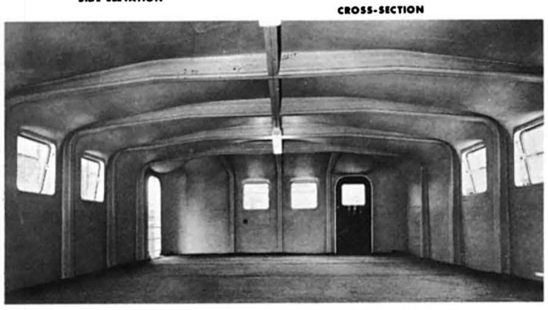
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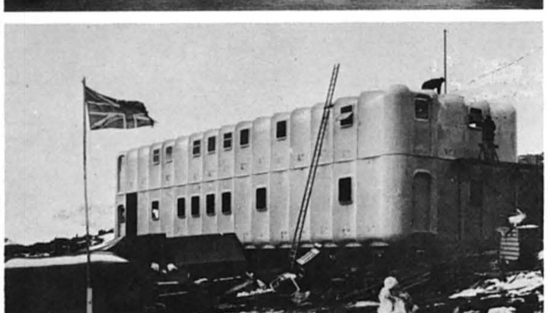
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After the dramatic use of translucent polyester fibreglass umbrellas designed for the American Exhibition in Moscow in 1959, another equally exciting design in fibreglass reinforced plastics has recently been carried out in France, where a market in Fresnes was covered with 18 large size interconnected plastics umbrellas. Owing to the low-bearing strength of the ground, use of steel or concrete was ruled out, and the construction was possible due to the light weight of the plastics. Certain parts of the umbrellas were translucent, transmitting light to the interior of the building (Figs. 12, 13). A very similar technique has been used by the same firm Societe des Chantiers Reunis Loire-Normandie, for a second market in Ivry, built a few months ago (Fig. 14). The Ivry market is composed of four rows of vaults, covering an area of 1,620 sq. ft. Each vault is made up of four elements resting on a central column which is also made of plastics. Elements were bolted together, two by two, on the ground and the half-vaults made in this way are raised by a small crane and placed on the columns. The hollow columns are bolted to small cubes of concrete which provide the entire foundations for the market.

Assembly of elements in the Fresnes structure was carried out with glue and bolts. It was found that use of adhesives on the site was not satisfactory and at Ivry these were eliminated. On the curved parts of the umbrellas, bolts are screwed through small rectangular plates which rise above the raised edge of the vault elements. These plates are placed alternatively on either side of the joint and the raised parts serve as a guide for a thick pvc cover strip clipped on after the elements are bolted. A thicker plastic has been used for the roof at Ivry because it was found that the fibreglass reinforcement required a heavier coating if it was not to show on the surface after a few months.

It is interesting to note that in 1965, also in France, another large market in Epinay-sur-Seine was covered by prefabricated glass fibre reinforced plastics roof consisting of folded plate elements. The result, architecturally and structurally, is most satisfying (Fig. 15).

Although chronologically the developments of plastics structures in Great Britian have been, perhaps, late in comparison with the U.S.A. or France, the practical achievements in the field of all-plastics structures are here much more pronounced than in many other countries. This is mainly because of the activities of a London firm, Mickleover Transport Ltd. Having wide experience in the construction of glass-reinforced plastics bodies for vehicles, this firm has now turned its attention to buildings and within the last few years has established a world-wide reputation as a universally recognised exponent of the structural use of plastics.

In 1961, Mickleover Transport Ltd. developed special prefabricated plastics relay buildings for the signalling system on British Railway's Eastern Region (Figs. 16, 17). The introduction of automatic signalling required the construction of new relay rooms for housing electrical equipment at existing signal boxes. These rooms are often needed at sites where there is no easy access and are required to be capable of enlargement. The main advantages of a plastic building for this use was that it could be erected within a few hours, did not need painting and required no maintenance.

The all-plastic buildings developed for this purpose by Mickleover Transport Ltd. are composed of three basic types of unit: a corner unit and side units of two different spans. A unit comprises wall and roof in one shell of double curvature. There is an outer laminate of polyester reinforced with glass fibre and $\frac{1}{8}$"-thick with a smooth face from the mould and a core of $\frac{3}{4}$"-thick phenolic foam to give thermal insulation and fire resistance. The inner laminate is of polyester reinforced with glass fibre about $\frac{1}{8}$"-thick formulated to give a low surface flame spread and faced with a surfacing mat. The units are bolted together with stiffening flanges of solid polyester.

These plastics structures have been also recently used as substations for the South of Scotland Electricity Board. The same firm built, in 1963, a two-story telephone exchange-office block in Birmingham using the same technique of prefabricated plastics sandwich panel units consisting of skins in polyester resin reinforced with glass fibre bonded to a core of phenolic foam. The same type of all-plastics prefabricated buildings have been constructed recently by Mickleover Transport Ltd. for the British Antarctic Survey and used with very great success (Fig. 20).

The full-size tests on prototype units proved the exceptional rigidity of this form of construction. Tests on the phenolic foam used for core showed also that it has a Class 1 surface spread of flame rating according to the British Standard No. 476, that it does not soften with heat and is self-extinguishing.

The same firm has also developed portable, large size, all-plastics cabins for British Railways (Fig. 21). These units, complete with roofs and floors, provide personnel accommodation and have all services built in, so that they can be dropped into the desired position and have only to be connected to a source of electrical power to be ready for use whenever the need arises.

One should also mention the construction of a highly efficient large vehicle-washing tunnel built recently in reinforced plastics single-skin sections for a large London firm of aerated water manufacturers. Although the structure is

16. The prefabricated all-plastics railroad relay house in course of erection manufactured by Mickleover Transport Limited.

17. All-plastics relay house built for the British Railways.

18. Elevation and cross-section of the office building erected for Messrs. Bakelite Limited in Birmingham.

19. Internal view of the all-plastics building in Birmingham.

20. The all-plastics two-story building manufactured by Mickleover Transport Limited for the British Antarctic survey team—erected at the Signy Island.

21. One piece—moulded reinforced plastics shunters cabins manufactured by Mickleover Transport Ltd.

22. Roofing of a gymnasium with prefabricated glass-reinforced plastics units.

23. Details of the G.R.P. folded plate roof modules developed by Mickleover Transport Limited.

24/26. Building in Northern Ireland covered with folded plate G.R.P. roof units developed by Mickleover Transport Ltd.

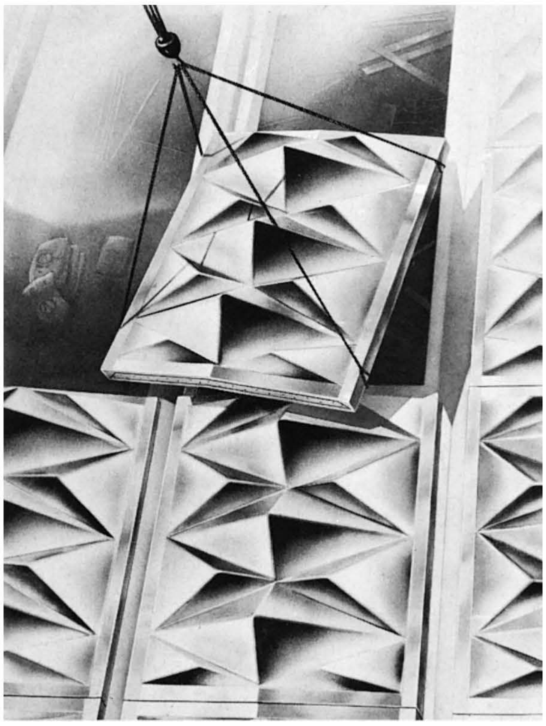
25. A model of the building in Northern Ireland covered with the prefabricated G.R.P. roof units.

27/28. Trial erection of reinforced plastics prefabricated building ("Clamp" system).

29. The English Electric Company's all-plastics geodesic radome.

30. An English Electric Company's "Unidome" erected in 1962 in Coventry, England.

31. All-plastics dome covering a planetarium for the South Shields Marine and Technical College, England.



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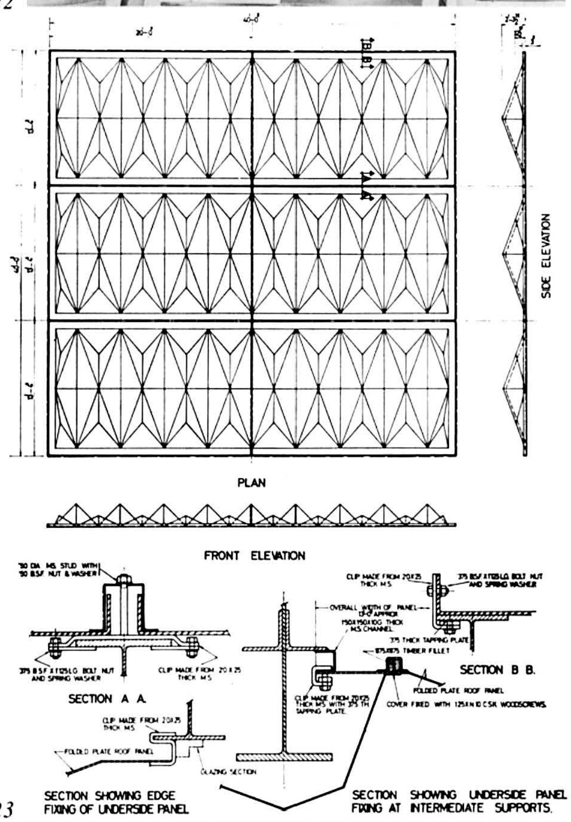

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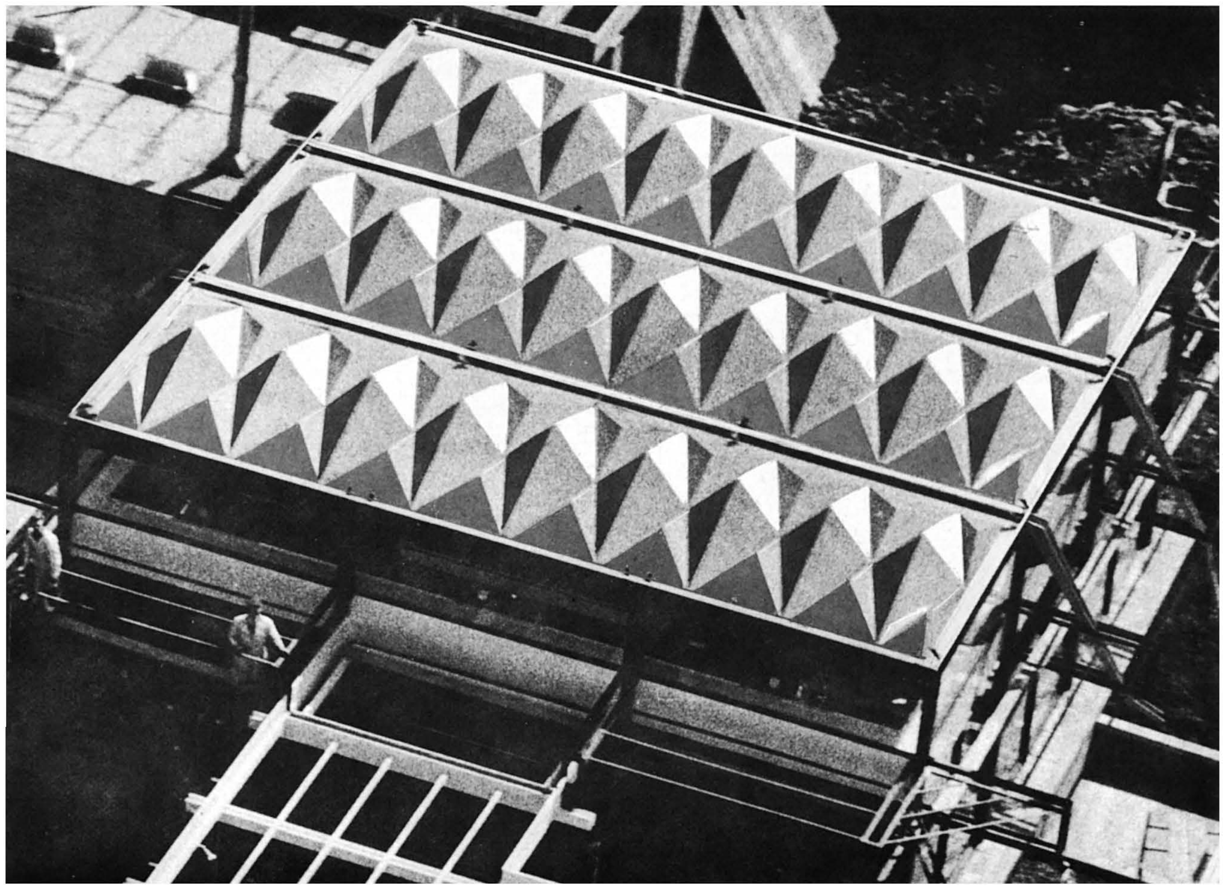

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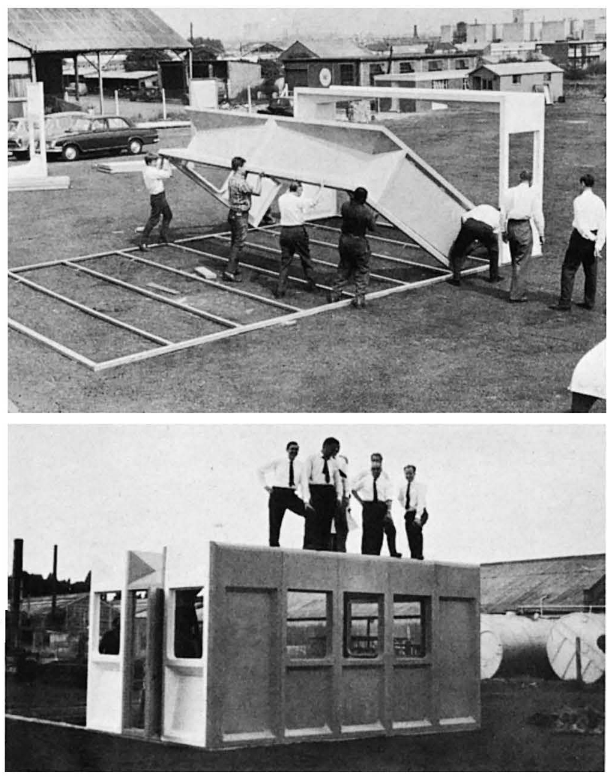

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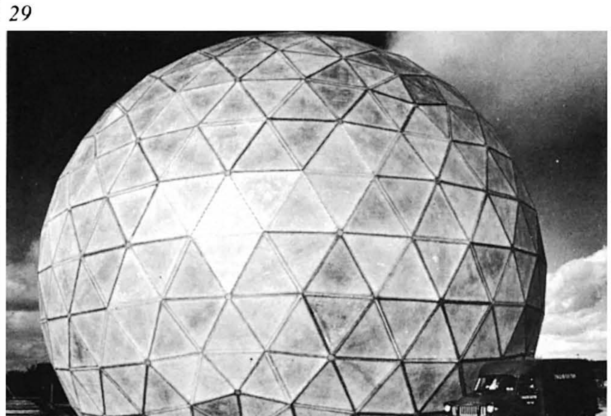

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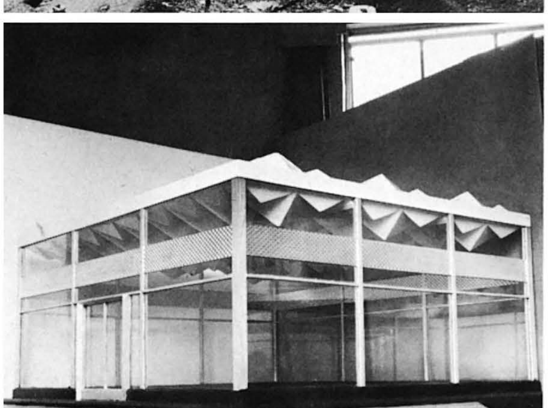

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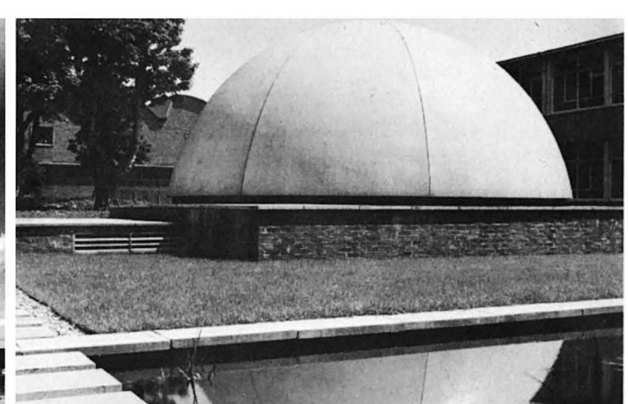

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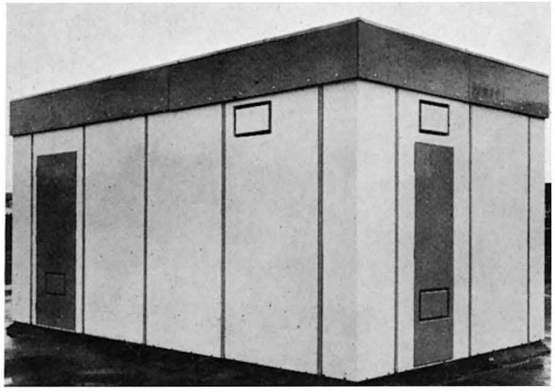

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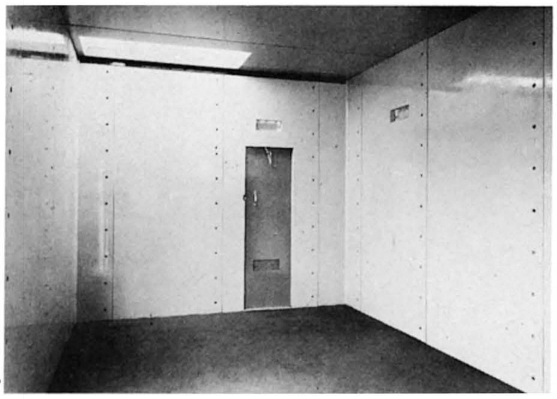

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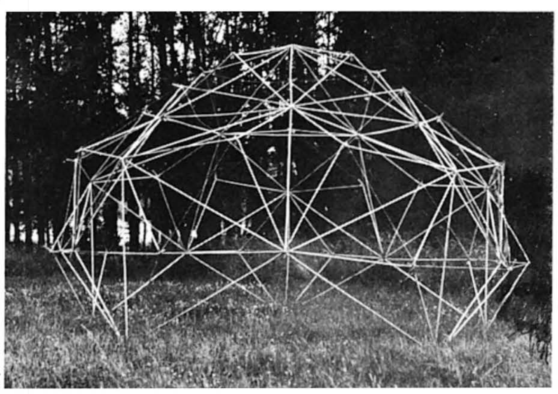

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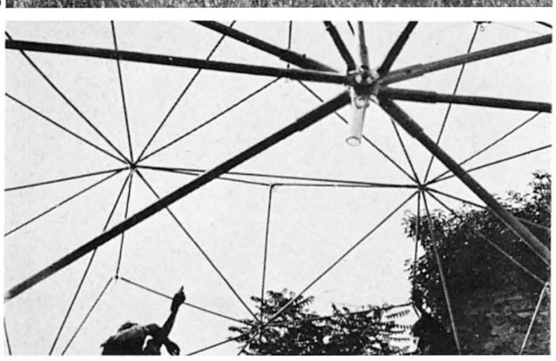

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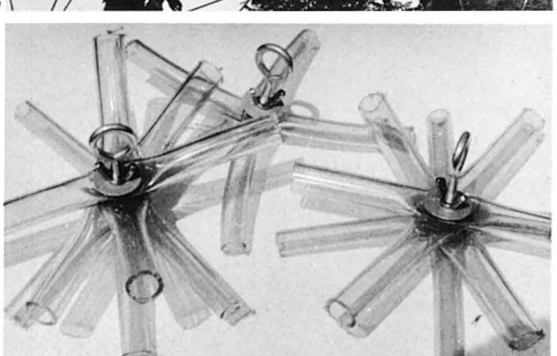

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61′9″ long x 18′8″ wide x 13′ high, it weighs only 2¼ tons—a great advantage on the site where poor ground has prevented the use of conventional materials much heavier than plastics.

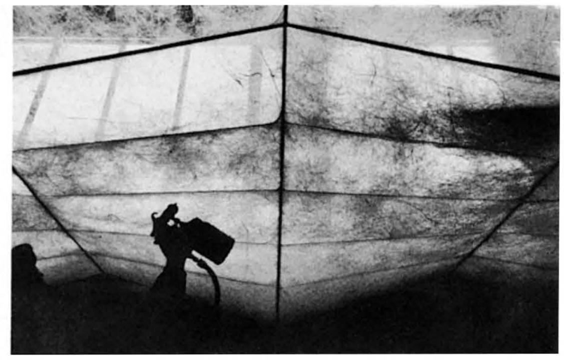
Fig. 22 shows the roofing of a large gymnasium with prefabricated glass-reinforced plastics units. For this job in the Middle East an interesting stressed-skin roof unit in plastics has been developed by Mickleover Transport Ltd. to meet the specification of the consulting engineers. Structural details are indicated in Fig. 23. Roof units rest on reinforced concrete beams 28m. long, which also act as rainwater collectors and carriers. The prefabricated glass-reinforced plastics roof units are merely dropped into position and clipped to the beams. The external laminate of the roof contains a light reflective pigment; the units weigh only 350 kg. each and they are arranged for stacking during transit. Each packing-case contains seven units as well as the necessary fixing bolts and sealers.

Fig. 23 also illustrates how the basic design of the gymnasium building has been adapted to provide a roof and "mirror image" suspended ceiling for another building erected in Northern Ireland at the beginning of 1966 (Figs. 24-26).

The same firm have also collaborated with an architect, James Dartford, in the development of a prefabricated all-plastics building system known as the Clamp system. It is based on the use of rectilinear semi-span portal units which combine the structural advantages of the arch with those of a stressed-skin folded-plate shell. The plastics units can be fabricated as an insulating sandwich or as a single-skin construction opaque or translucent, as required (Figs. 27, 28).

A standard sandwich construction has a ¾″-thick layer of phenolic foam as the central core, with inner and outer skins of glass-reinforced polyester resin. Units are connected by bolting the flanges, which incorporate weather seals to provide water-tight joints. Using the standard units, it is possible to obtain clear spans up to 30 ft. This system is an example of a prefabricated portable building construction which is light in weight, occupies the minimum shipping space, resists corrosion, decay and termite attack and offers excellent thermal insulation. It is easy to handle without mechanical aid and to erect without skilled labor. Several all-plastics buildings of this design have been erected in 1965 and are under trial in the Middle East. The structural use of plastics in radomes is already well-known. These installations house delicate radar equipment and the fundamental requirement for the material forming the cover is that it must be transparent to radio waves. Plastics are ideal for this purpose. Several British firms have gained a considerable amount of practical experience in the production of plastics domes. The English Electric Co. Ltd. is well known in this field (Fig. 29). This firm produces also a plastics summer house consisting of G.R.P. triangular sections bolted together (Fig. 30).

Another progressive British firm taking keen interest in plastics domes is C. F. Taylor (Plastics) Ltd. Plastics domes have also been produced by Mickleover Transport Ltd. as covers over large water tanks. It is interesting to note that the firm secured the contract in an open competition proving that all-plastics domes can



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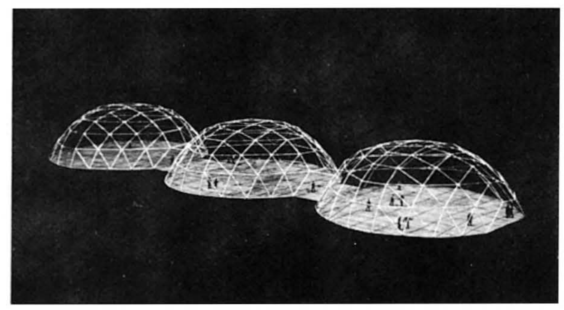

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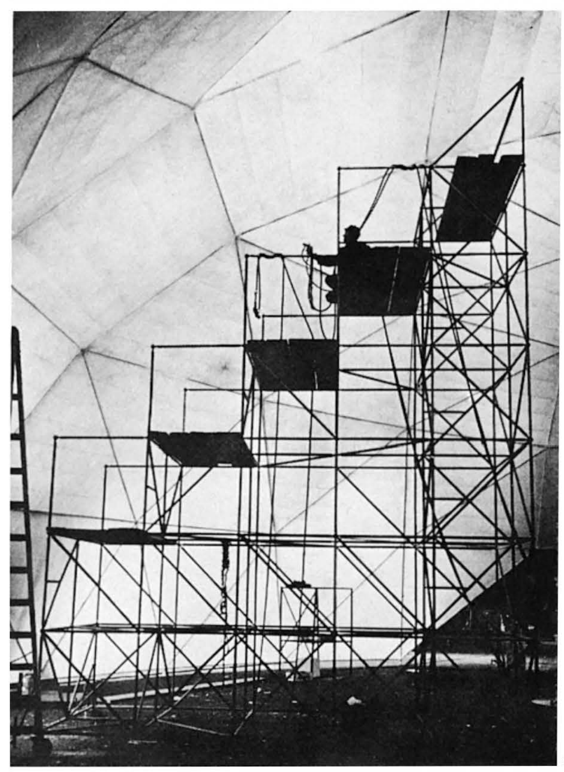

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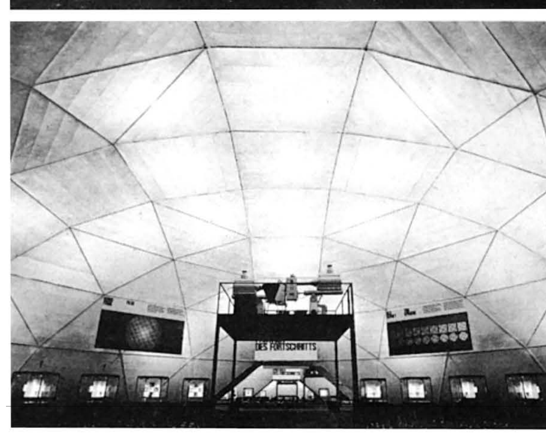

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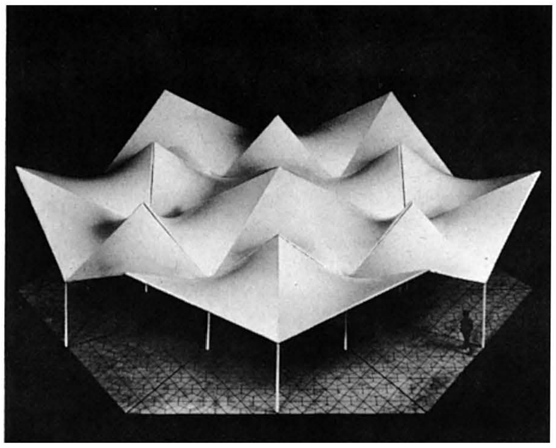
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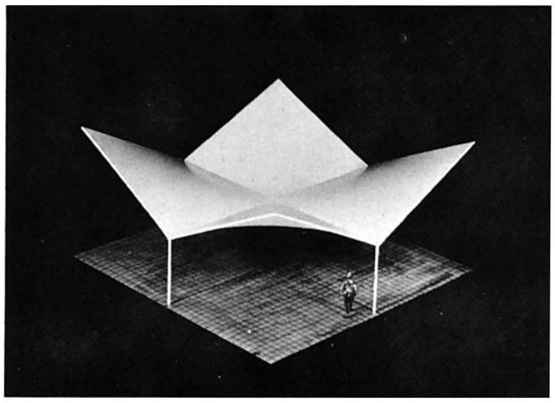
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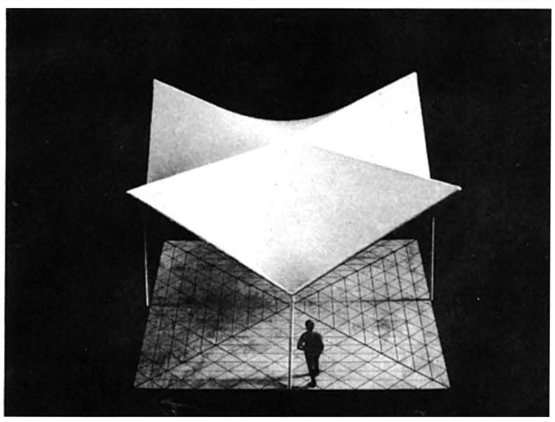
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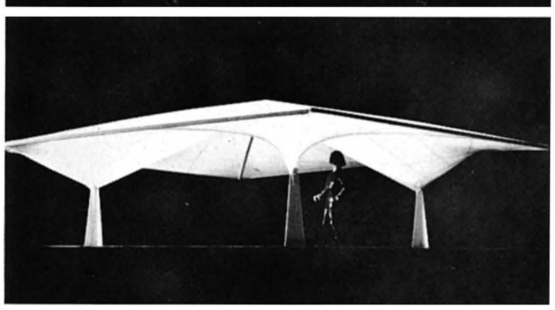
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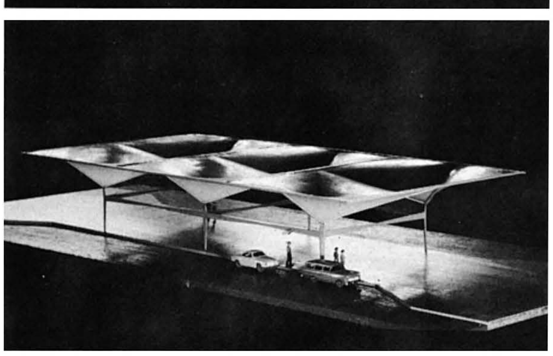
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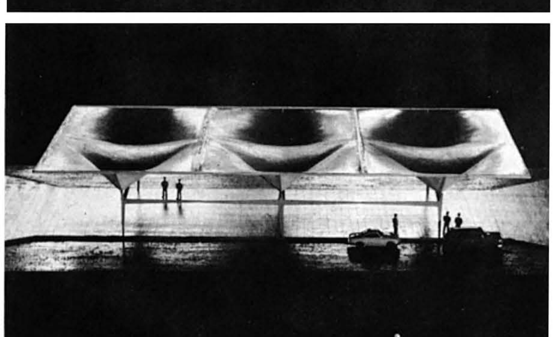
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compete with those built in conventional materials.

Several planetarium roof domes have been built during recent years in Holland, Germany and U.K. Fig. 31 is a typical example of such a G.R.P. single-skin dome over a planetarium for the South Shields Marine and Technical College built by a British firm, Hadrian Plastics Ltd. The dome has a diameter of 27′6″ and weighs only 1800 lbs. It has been designed to withstand snow load of 20 lbs. per sq. ft. and wind loads for a maximum wind speed of 72 m.p.h. The same firm is also producing sectional G.R.P. buildings. They have been designed specifically for British Railways' requirements and are very robust. Figs. 32 and 33 show the exterior of these frameless, self-supporting rectilinear structures erected from standard 4′-wide panels.

An all-plastics dome designed by the author for the University of Cambridge can be erected without any scaffolding and consists of prefabricated sandwich panels, having P.V.C. skins as well as P.V.C. core. The tests carried out on full-size elements proved a surprising high load-carrying capacity of these modular units (Fig. 34).

The spans obtained using all-plastics domes can be very considerable. Three very large all-plastics radomes which have recently been erected in England, give an idea of the sizes which can now be obtained in plastics. The domes have a diameter of 140′ and have been built at the Ballistic Missile Early Warning System station on Fylingdales Moor in Yorkshire.

One should mention also some interesting experiments carried out at the Hochschule fur Gestaltung in Ulm, West Germany, on skeleton plastics. Large-scale experimental structures have been built using P.V.C. tubular members and tested under various loadings.

In France, D. G. Emmerich, who is well-known on account of his most interesting studies of topological properties of three-dimensional systems, is also experimenting with plastics tubular space structures. Figs. 35-37 show some of his plastics braced domes and illustrate the simplicity of connections obtainable in plastics tubes.

In Germany, the work of John Zerning is attracting a great deal of attention. This young architect is experimenting with hyperbolic paraboloids, domes, double-layer membranal structures obtained by spraying quick-drying vinyl

32/33. Sectional G.R.P. buildings developed by the Hadrian Plastics Limited for the British Railway.

34. A test of a plastics sandwich panel for the dome designed for the University of Cambridge.

35/36/37. Experimental plastics structures built in P.V.C. tubes by a group of students at the Ecole Nationale Superieure des beaux-arts, Paris, under the supervision of Monsieur D. G. Emmerich.

38. Application of the plastics film over wires fixed to a lightweight steel framework—A technique of "cocooning" developed by John Zerning.

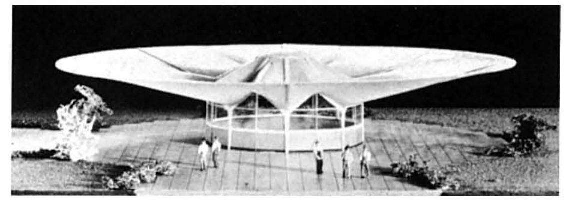
39. An exhibition stand designed by the architect H. E. Blaser and built in the "cocooning" technique of J. Zerning.

40. A model of the three domes built for the German Industrial Exhibition held in Berlin in 1963.

41. Spraying of P.V.C. film onto wires fixed to the lightweight steel framework of the dome.

42. Interior of one of the domes housing the German Industrial Exhibition, held in Berlin in 1963. Architect—W. Kuhn; consultation and supervision of the plastics "cocooning"—J.Zerning.

43-56. Models of structures on which John Zerning is studying his plastics spraying technique.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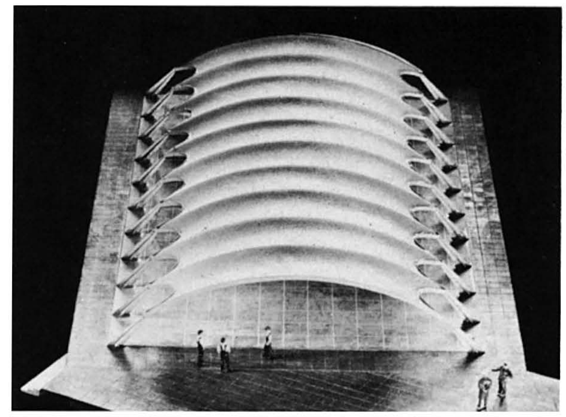
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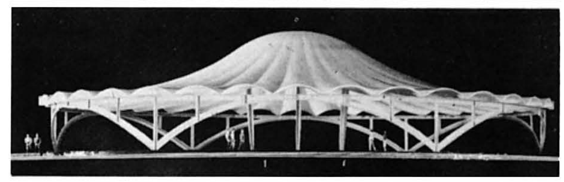
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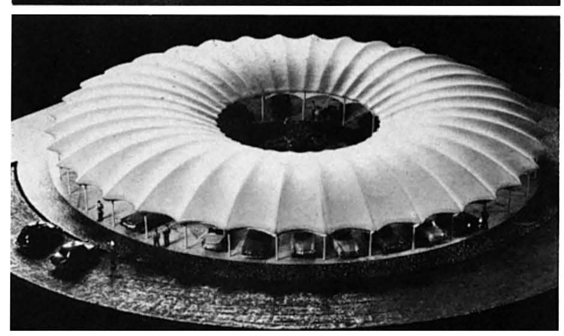
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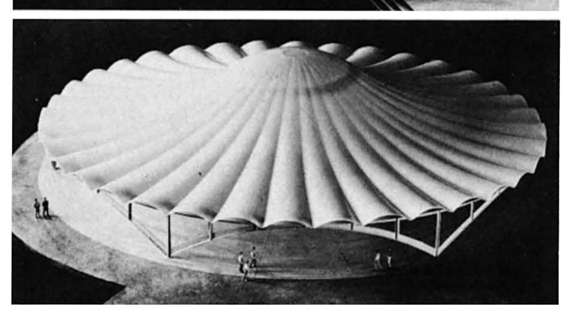
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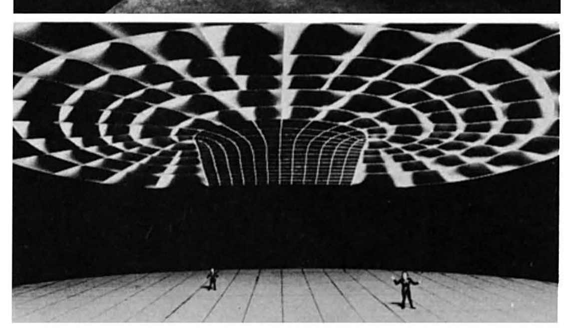
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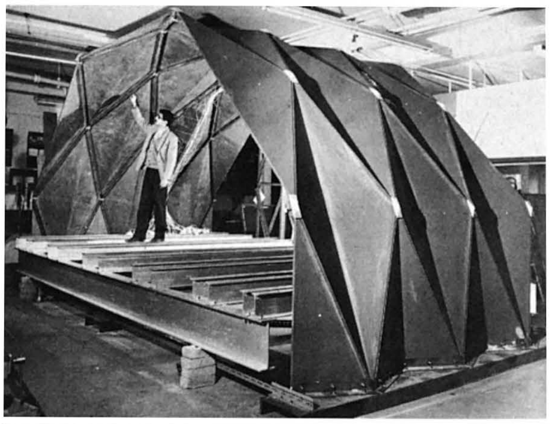
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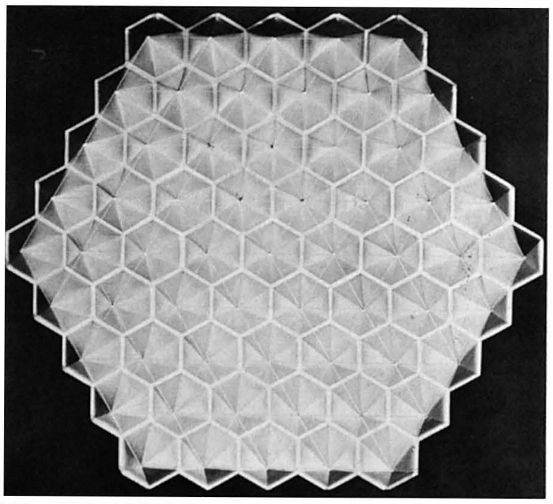
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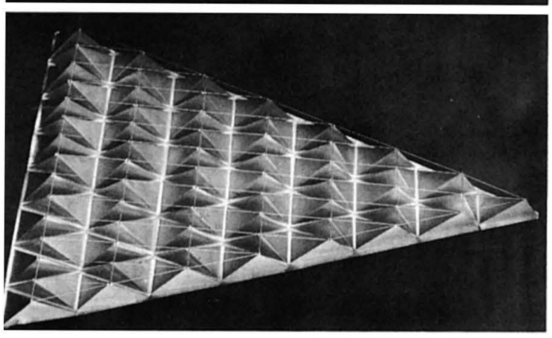
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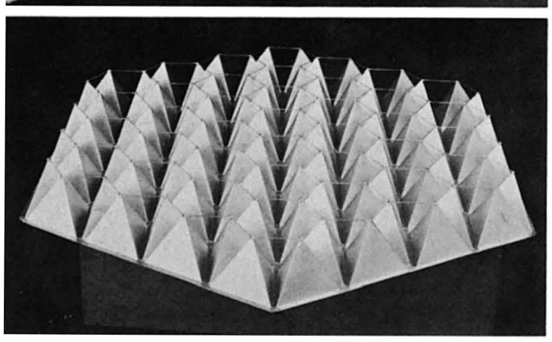
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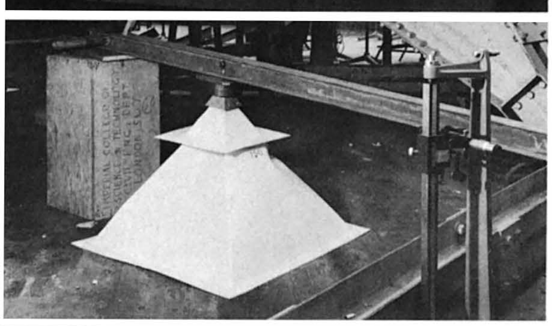
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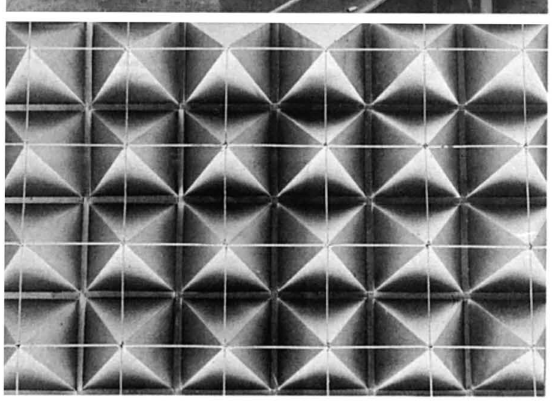
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onto a tubular steel frame. The main framework of his structures is covered with a network of thin wires meshed at about 2-3′ intervals and the vinyl coating is then applied by means of a hand sprayer. Several large-span structures have already been built by Zerning for exhibitions held in Germany during recent years. As the applied plastics coat hardens to the consistency of rubber, it shrinks thus producing a prestressing effect on the suspended net.

His architectural studies on structures obtained using his "cocooning" technique show the great possibilities, so far only touched upon in practical applications, of economic methods of construction feasible for very large spans. Only a very light tubular framework is required to support the plastics coating.

Fig. 38 illustrates the method of application of the plastics film. Fig. 39 shows an exhibition stand built using this technique. Three large plastics domes have been built for the German Industrial Exhibition held in Berlin 1963. The diameter of the domes is 80′ (Figs. 40-42).

Figs. 43-56 illustrate various models of hyperbolic paraboloids for which the "cocooning" technique of Zerning is especially suitable. Zerning's structures are an interesting example of "prestressed" plastics membranal system—the "prestressing" being obtained by the gradual shrinkage of the plastics coat taking place during the hardening period.

A different approach of post-tensioning plastics membranal structures has been used, with great success, by H. Hossdorf in his pavilion erected for the 1964 Swiss National Exhibition in Lausanne, where an area of 360′ x 240′ was covered by 24 identical mushroom-shaped plastics units. Each unit is made up of eight prefabricated hyperbolic paraboloids composed of a 3mm. thickness of glass fibre-reinforced polyester resin strengthened along the edges by steel angle sections. The inter-connection of the component elements produces a stressed-skin pyramidal truss. In order to increase the rigidity the trusses have been post-tensioned. The structure is still standing and has provided an opportunity for some tests to be performed and a record of the creep behaviour of such units to be obtained.

The engineers and architects realise a growing need for the formulation of design requirements and recommendations for the use of plastics materials in building structures. Whereas the research work done 10 or 15 years ago was carried out almost exclusively by architects, the situation is now changing rapidly. Structural engineers are now taking a serious interest in structural applications of plastics. Many universities and government research establishments have included during recent years structural plastics in their research program.

A new period of active research and development is now with us. It is characterized by a serious scientific approach to the problem of determining the limitation of plastics and of the appraisal of all the technological possibilities which may be offered by plastics, used alone or in conjunction with various other materials.

In the U.K. important research work on structural plastics is being carried out at Battersea College of Technology, where the Department of Civil Engineering established in 1963 the Structural Plastics Research Unit. At Battersea College the research on structural plastics includes the investigation of stressed-skin pyra-

57. An experimental all-plastics barrel vault at the Structural Plastics Research Unit at Battersea College, London.

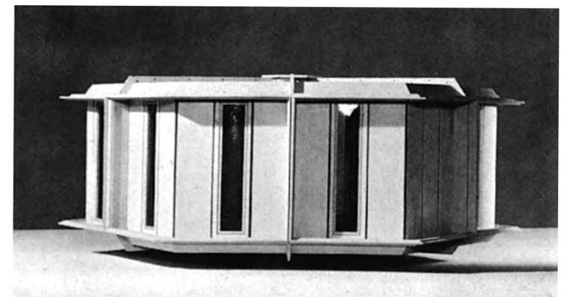
58/59/60. Models of pyramidal structures developed by Professor Z. S. Makowski.

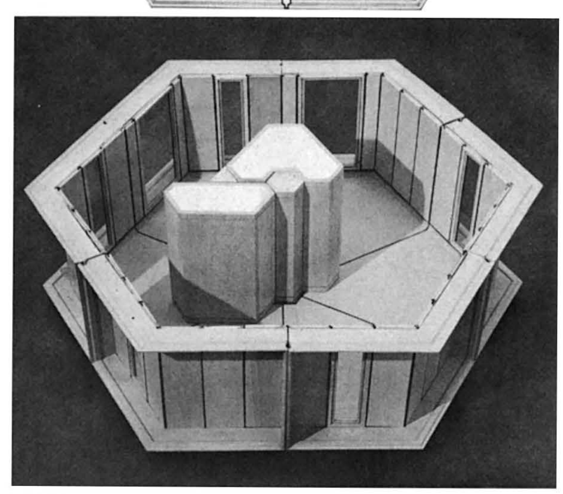
61. A P.V.C. pyramidal unit under maximum buckling load.

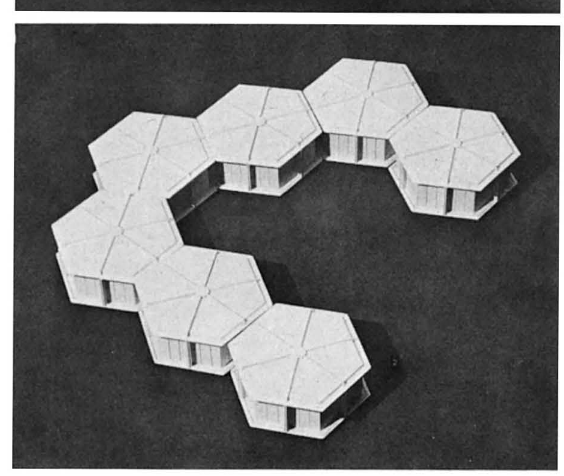
62. An underside view of a plastics roof constructed with G.R.P. pyramidal units built according to a design of Professor Z. S. Makowski.

63-66. G.R.P. hexagonal house developed by Professor Giordano Forti and his research team at Milan Polytechnic.

67-70. G.R.P. Pyramidal roof structures built in Italy by a young Italian architect Renzo Piano in collaboration with Foni, Garbuglia, Tirelli and Filocco.







midal roofs and plastics folded-plate barrel vaults as well as plastics sandwich panels. The recent tests carried out at Battersea College on a full-size barrel vault consisting of prefabricated plastics units of diamond shape have proved the remarkable strength and rigidity of this form of construction under various types of loading and have verified the mathematical analysis developed for plastics structures of this type.

Fig. 57 shows the experimental all-plastic vault erected in the Structural Plastics Research Unit at Battersea. Tests carried out by B. S. Benjamin, the author's research student, revealed a high degree of rigidity of the truly all-plastics structure, consisting of prefabricated plastics sandwich units of diamond shape. Plastics structures of this type can be built for spans up to 200′ if the modular units are of sandwich construction. Single skin barrel vaults can be built without any difficulty up to 120′ and in fact several structures of this type have been already manufactured by an Italian firm of Piano —Genova.

Some eight years ago, the author of this article started research into the pyramidal stressed-skin double-layer roof structures in which thin-walled modular pyramids are employed as load-bearing elements (Figs. 58-60). A number of large-span structures have been built during the last few years using aluminum sheet pyramids. Having realised the inherent rigidity of this form of construction, it became obvious that pyramidal roof structures can be built in plastics. The tests carried out at the Structural Plastics Research Unit at Battersea College show conclusively that it is possible to use thin-walled plastics pyramids as structural components for flat roofs of up to 60′ span; larger spans are possible in barrel-vault form. The pyramids, which are either square or hexagonal in plan, can be made of rigid PVC or glass-fibre-reinforced polyester resin (Fig. 61). Several structures have already been built using such prefabricated plastics pyramids for both temporary and permanent roofs, in England by C. F. Taylor (Plastics) Ltd.

A most interesting design, using prefabricated hexagonal G.R.P. pyramids, has recently been carried out for a swimming pool at Mill Hill, near London. The units are interconnected forming a cylindrical barrel vault 48′ long and 250′ wide. The light transmission of the plastics pyramidal units is over 80%; the plastics modules are bolted together along their mating flanges and tied together by light aluminum tubes, forming on the outer surface a three-way grid.

This plastics barrel vault has been built as a permanent structure, but if the need arose it could be easily dismantled and re-erected elsewhere.

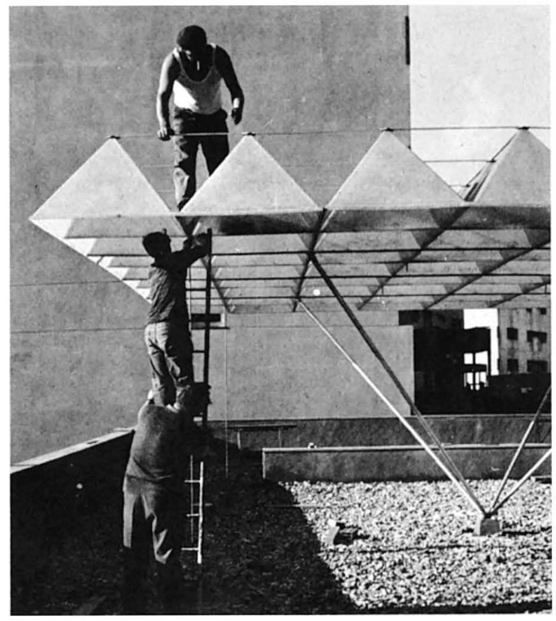
At the moment an investigation is being carried out by R. Gilkie at Battersea College on the behaviour of barrel vaults consisting of prefabricated G.R.P. shallow pyramids of hexagonal shape. A full-size roof structure has been built and tested. These experiments are providing the basis for a simplified method of analysis of these highly redundant structures.

Another research student, D. Robak, is working at Battersea College on flat roof structures consisting of G.R.P. pyramidal units of square base (Fig. 62). Clear spans up to 100′ can be covered with such systems. Robak proved through his tests that the remarkable degree of rigidity shown by the pyramidal sheet modules can be further increased by introducing radial corrugations running from the apex downwards. He also designed a double-tier plastics roof consisting of two tiers of plastics pyramids joined along a horizontal plane. The upper spaces are then filled with low-density cellular plastics and covered with a thin layer of reinforced structural screed. It is encouraging to note that these studies are not only of purely academic character—various British firms are taking a keen interest in the practical exploitation of these ideas.

The same situation exists in other countries. From Italy come reports about the research activities of the Technological University of Milan (Politecnico di Milano) in the field of structural applications of plastics. It was Professor Giordani Forti with his research team consisting of R. Piano, R. Foni, B. Huet and C. Ruggeri who produced the all-plastics hexagonal house, shown during the first International Exhibition of Prefabrication held in Milan in 1962 (Figs. 63-66). The house, which had been manufactured by the firm of Manifattura Ceramic Pozzi, consists of prefabricated panels made in G.R.P. with a sandwich insulation layer. It is based on identical interchangeable components for walls and roof.

Renzo Piano, one of the collaborators of Forti on this design, quickly realised the potential of plastics in structural applications and within the last few years produced, in association with other young Italian engineers and architects several most interesting all-plastics structures which are now being produced commercially by a firm Piano di Genova. Figs. 67-70 show the erection of some of his pyramidal roof structures, built in prefabricated G.R.P. square based pyramids. The pyramidal units can be connected together forming circular barrel vaults suitable for very large spans.

Piano, together with Foni, Garbuglia, Tirelli and Filocco, turned his attention to large size single-skin units of diamond shape. Several structures have been built in 1965 by his firm as roofs over industrial buildings and ware-



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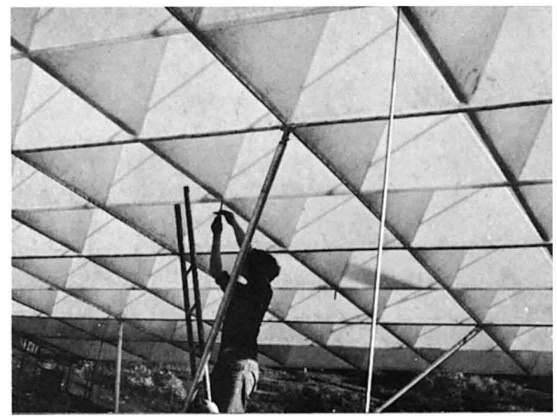

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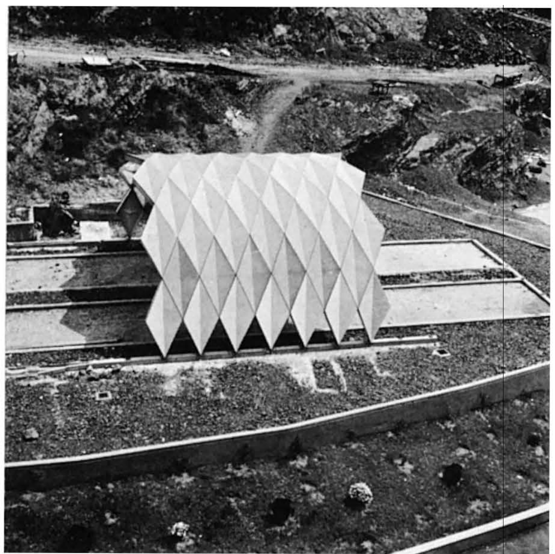

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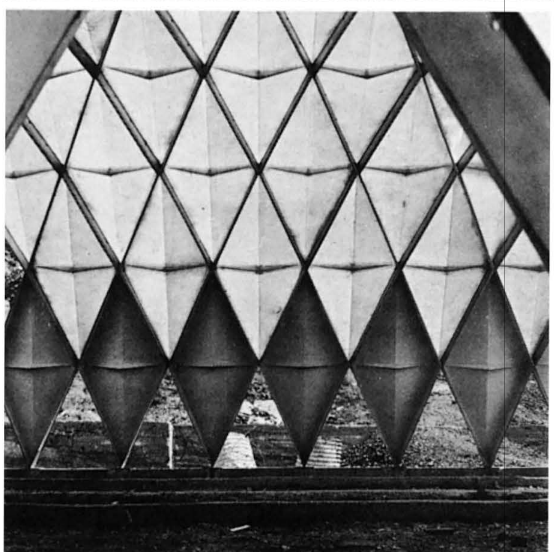

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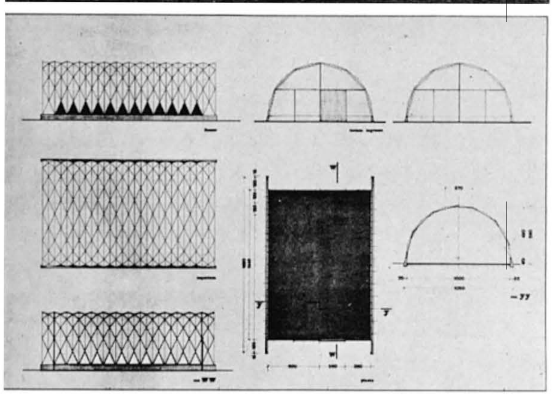

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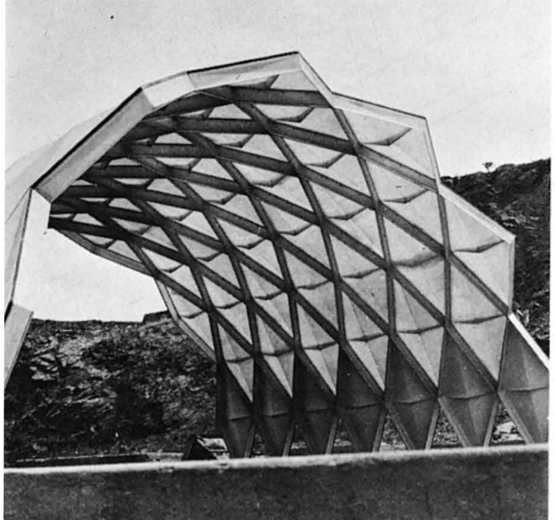
71-74. Erection of single skin barrel vaults consisting of prefabricated G.R.P. modules of diamond shape developed by Renzo Piano and manufactured by Piano Company, Genova.

75/76. Model of a G.R.P. prefabricated summer house developed by Renzo Piano.



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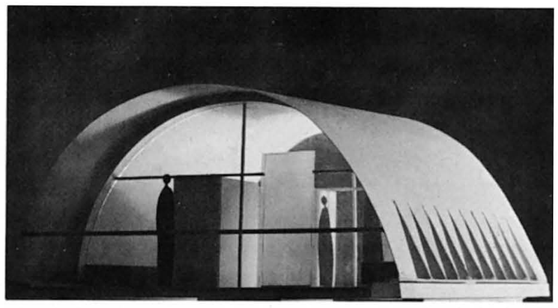

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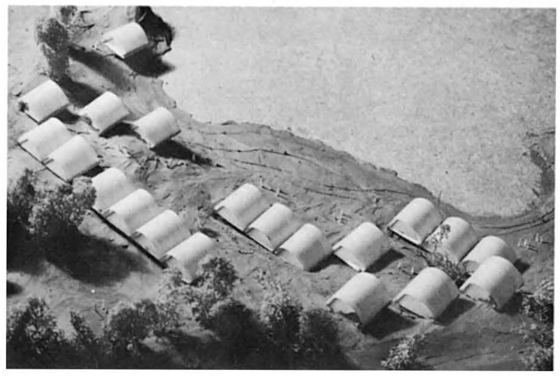

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houses combining an attractive appearance with a completely satisfactory structural behavior under real loading conditions (Figs. 71-74).

Piano's group designed recently a most ingenious all-plastics summer house which is now in the phase of prototype testing. The main structure of the house consists of two large G.R.P. sheets, which are delivered flat to the building site. They are bent during the erection into a cylindrical shape and interconnected together forming a very rigid double-layer barrel vault. The space between the top and bottom sheets provides the circulation area for the air, keeping the inside of the house cool during the summer. Figs. 75 and 76 show various stages of erection of this house which will be in commercial production towards the end of 1966.

Because of lack of space, it is not possible to describe fully all the recent developments in plastics structures—only some of the most interesting examples built recently in Europe could be touched upon in this review.

The great interest expressed now not only by architects but also by engineers and civil engineering builders and contractors in structural applications of plastics indicates clearly an appreciation of the advantages of this versatile material.

Whatever will be the structural shapes in which plastics will be used, however unconventional they may look, one thing is certain: plastics will influence our structures to a much greater extent than any other building material has done in the past.

The author wishes to express his sincere thanks to many firms and individuals who provided him with detailed information and photographs of plastics structures.

In particular, he wishes to thank Mr. J. A. Taylor of Mickleover Transport Ltd, London, Monsanto Chemicals Co. Ltd., Shell Chemical Co. Ltd., I.C.I. (Plastics Division) Ltd., Societe des Chantiers Reunis Loire-Normandie, Indulex Engineering Co. Ltd., C. F. Taylor (Plastics) Ltd., English Electric Co. Ltd., William Old (Resiform) Ltd., Hadrian Plastics Ltd., Trigon-Kunststoffhaus A.G., Architect Mario Scheichenbauer, Milan, Architect John Zerning, Frankfurt a/M., Architect-engineer D. G. Emmerich, Paris, Architect Renzo Piano, Genova, Architect Rudolf Doernach, Stuttgart.

A PHENOMENOLOGY OF RESEARCH

BY IONEL SCHEIN

(This paper came to us in highly eliptical and hyperbolic French. We have done our best to retain the flavor of the original while rendering it into more prosaic English. Ed.)

Coarse paper; rebellion; grease pencil; imagination; sketch; weird perspectives; publication; exhibition; model; the great architectural critic inventing cinemascopic epigrams; worldwide recognition, lectures, disappearance of rebellion; integration into the system; publicity; books on architecture and urbanism; publicity; radio, television; USA, USSR; FAIA, Bel-Air: la gloire!

That is how ARCHITECTURAL RESEARCH nowadays is born, lives and dies!

Launched the wrong way; misunderstood; pursued incorrectly; non-existant; worse: some sympathetic ones but not always very smart, persuaded that it is successful research by a pseudo-philosophical, half-mathematic and half-literary (but always shocking) jargon; with accents of simplicity or intellectual supremacy; with a good stock of sophisticated, barbaric and suggestive drawings . . . calling themselves "searchers" or "researchers"; forcing their way into the world of worlds; believing they will improve it by the effect of their abstractions; far from the people, far from themselves . . . showing a frozen future in a few booklets and publicity meetings to which they invite some big wheels . . . who happen also to be purchasing agents . . . making their visions highly commercial.

Hoopla! let's stop the charlatans of research! STOP THE FLOW OF SHINY PHOTOS TO THE ARCHITECTURAL MAGAZINES!

Urbanistic and architectural research must not, cannot be separated from experimentation and evolutive reality, whether social, political or economic; it must not rely only on technical progress or aesthetic criteria.

Research is an amalgam, depending on team work and no longer on a masochist cogitation in an ivory tower! It addresses itself to a constantly changing society, of which the researcher is himself a part. It is nonsense to believe that society will automatically adapt itself to progress; research must not forget this truth; one must not believe that it is enough to invent to progress, without considering the human material that is concerned.

No invention, no matter how promising, has any value whatsoever if it is without a social, economic and technical basis; to ignore one of these factors is just as bad as ignoring all of them.

Formal reasoning is a false approach, even if one invokes learned parameters and genuflects to science in a way that gives to the "visionary" the finest visual expression.

It must be a simultaneous operation; one must imagine the change in the tempos of the ways of life; catch and express the development of the implementing of men's activities, that of machines and their applications; think in new terms with regard to transportation and cultures, etc.

Can you tell me of what benefit it is to use intelligently the most advanced materials and to create with them the most harmonious, the most appropriate shapes, made in the most accurate technical manner (let's take housing as an example), if there is no reference whatsoever to the evolution of the family? Is the family going to coalesce or, on the contrary, is it going to break up and dissolve to be replaced by other basic cellular elements? Get acquainted with any one of the "prospective" projects and you will realize that not one of their authors can say in good faith that they have faced just one of the possible evolutions of the HUMAN BEING.

Yes, I know . . . They will tell you, and they will produce figures to support their words, that highway intersections and pedestrian-car confrontations have decreased in number, or even maybe that they have disappeared; they will even tell you that cows will come between the pilotis for grazing . . . but has anyone raised a question about the new forms of transport? All the "geniuses" think in terms of cars. That is a completely wrong approach! Cars will be superseded by other means of transportation and the rhythm will change. To make a reference to one helicopter in the sky above a city is not quite enough to make it reflect the future.

It is a flagrant lie and an intolerable manifestation of self-conceit and egomania for an urbanist or an architect to envision his own kingdom, without projecting the same prospective vision to all the other fields of men's activity.

The urbanist and the architect who are integrated in a multi-discipline team, have the exalted task of imagining a pattern of life that implies and requires a *simultaneous* evolution of all branches of activity of human groups. But it is the perfect expression of the current Malthusianism of most urbanists and architects, whether progressive or backward, to believe and make believe that a progressive container will always and automatically produce progressive contents.

The very meaning of prospective involves all the evolutions and the evolutions of all, not through fits and starts, the way-out, the unreal, but concomitantly and with strict simultaneity. Social, economic and technical evolution must no longer be considered apart from new urbanistic and architectural realities. This is the point where "visionaries" and reactionaries meet; both leave aside human evolution and activities.

We reach the point of our statement where it should be explained how deeply research should be politically involved.

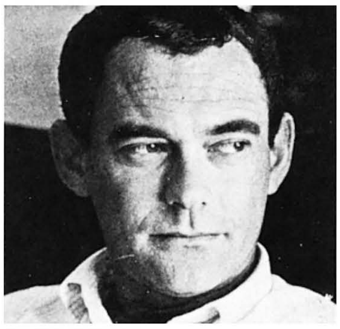
Today no activity concerned with the evolution of society can be effective without complete involvement, whatever its nature is; and such an engagement is a political one when it is within the frame of life. Urbanistic and architectural research lead to a complete change of this framework which reflects all men's political direction.

Urbanistic and architectural research must be conducted, as we said, apart from the designer's personalized universe. It must find thus its real and realized projection. It concerns all men and all activities; it must therefore be conducted within a "totalizing" framework, not secondhand from various disciplines. In short, architecture is a society's handwriting; it is inconceivable that such handwriting be static, separated from men who write it. But it must not as in the past play the role of merely clothing the mannerisms, and words of the people. Architecture must issue from research and no longer from improvisation, spontaneous imagination or mercenary obedience to the client, an architecture having completely different productive, distributive and consuming characteristics. For such an architecture to exist, *research must be permanent;* it must no longer be looked upon as the individual work of an isolated nut, but must be done at the level of a public institution . . . as is the case now for most branches of industry (rubber, textile, petroleum, aluminum, etc.)

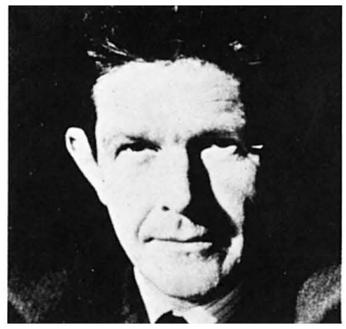
I would like to clarify my view of research as I have just characterized it with respect to the family of new materials that have appeared; then as applied to new production technologies; let us take the example of synthetic materials (incorrectly referred to as "plastic materials"). Today if a research project is undertaken, it must deal with synthetic materials, regardless of its approach or scope; for the very simple reason that these materials, in view of their technological qualities, meet perfectly well the very first need of contemporary architecture: industrialization. Industrialization in construction must no longer be conceived of as an isolated need; it is an economic necessity which can be achieved through technological potentials and social needs—it is demanded by society! In its present form, building industry does not exist. Small, incorrectly oriented, scattered attempts do nothing but confirm our point of view: architecture, almost entirely industrialized, can derive only from research that has a technical orientation and is politically and socially engaged. If we look at the characteristics of the family of synthetic materials, we find that they require an industrial application; industrial in the true meaning of the word; raw material of a small size, easy to store, keeping its basic qualities; typical and standardized elements, assembly lines, which are the real aspects of industrial production; marketing of products which, in view of their free, adaptable shapes, necessarily have the marks of evolution in themselves, therefore a consumption brought to consciousness by the specific properties of the consumed product.

Urbanistic research must be real, and on a large scale. There will be surprises. To bring out reality and "flash" the Past in order to reach a better conception of the Future, a truth will come to life; a truth always young, having intrinsic possibilities that increase and multiply in order to keep young. To discover the steps which are necessary for man to move around with the help of new dynamics . . . outside of pendular time! The framework of life will come with action; with the drive to find out that a rhythm needs evocative surroundings, temporarily precise, but transformable afterward—transition from one rhythm to another—beyond a wall, beyond static and final ideas. To bleed and coagulate; such is the theme of research; life; different, always different! I am still fascinated by Le Notre, who set out like a "visionary"; creator of "artlessly casual" spaces: architecture of trees and wind; urbanism totalizing man and his environment. Oneness, simultaneity; the notion of simultaneity in urbanism imposes a socialization of space; segregation, zoning become out of question! Oneness is actually a new plurality for it concerns the majority; man remains man, such as he is; with society, within or without. To express, to control and to make all this possible, such is the admirable, immediate, gigantic task of RESEARCH IN URBANISM AND ARCHITECTURE.

REYNER BANHAM
Architectural Critic, Historian



JULIAN BEINART
Architect, Educator



JOHN CAGE
Composer, Educator

HENRY DREYFUSS
Industrial Designer, Author, Educator

EDGAR KAUFMANN, JR.
Educator, Author, Lecturer

REPORT FROM ASPEN BY JUDITH RANSOM MILLER

Here is the part of the 16th IDCA that rubbed off on me. It was a good conference, peaceable, but good. The old dazzler, Reyner Banham was as dazzling as ever. The impact man was Cage who had, of course, thought about the problem long enough to have weeded out the peripheral. Beinert (who is too young to be true) is a quiet mountain mover—what he means, more than the volume of words, is what comes through.
As for the visual support at the conference: Aspen is no place for visual support—too much natural visual competition there, too much daylight at night so that films start when head nodding has already set in. Art Center was a success. Indiana University, with a lovely, quiet, disciplined graphics exhibit got little attention—too little light in the Paepke lobby. The films themselves were interesting (especially "The Hotdogger") but not recent (especially the motorcycle documentary—I've forgotten the title). Whitney's film was great—not to be complained of in any way, but that is always true. More than one speaker used night time for talking that could have been more wisely used for showing visual materials. Lionni's slide presentation and reading of his book about the mouse who was a poet and knew it was more than merely droll—full of love and implication. Kaufmann was singularly clear and succinct. Kaufmann stressed the need for disposability, particularly as a part of the concept of the design process, or, more accurately, as a design consideration.
Back to films: UCLA has a number of considerably more recent and extremely good films—why were they not sent?

J.R.M.

If size is a measure of success, and in America we tend to believe that it is, then the 16th annual International Design Conference at Aspen was a success with nearly 1200 persons in attendance. There were representatives from every major design society, 28 design institutions, many government agencies, and 9 foreign countries. An IBM grant made possible the attendance of 10 students from England and 10 distinguished guests, representing varied disciplines: architecture, industrial design, film making, graphics, teaching, urban planning, journalism — even representation from the Harvard School of Business! A Graham Foundation grant brought 10 representatives from a geographic range that included Princeton, IIT and the UC Berkeley. Then there were the 19 IDCA scholars and their 5 teachers. Greeting this galaxy of talkers as they approached Herbert Bayer's still crisp new orange tent down a path bordered by neat young aspen trees was an exhibit presented by the students from the Art Center School—an exhibit which made a pleasant mountainy noise, withstood weather nicely, and whirled and changed color as the wind changed velocity or direction.

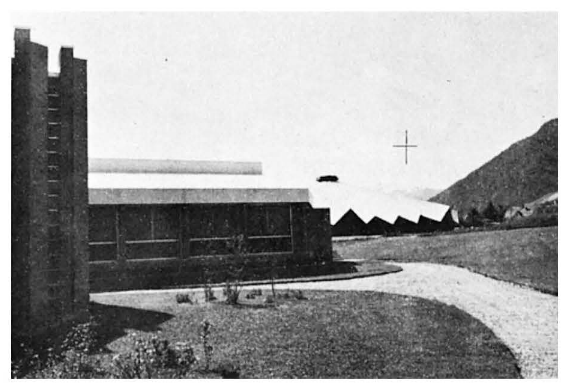
The idea of this the 16th conference, "Sources and Resources of 20th Century Design," was not, said program chairman Allen Hurlburt, to present a definitive review of the past or a precise projection of the future, but instead to assess the state of design and design education today. "If form does follow function, there has been no clear definition of terms and a reassessment of the relation between form and function is needed. . . . This conference, like those of the past, does not mean to show you how to do better work or solve problems better; its purpose is to increase awareness of the complexities of the environment and to help in the understanding of the nature of the question."

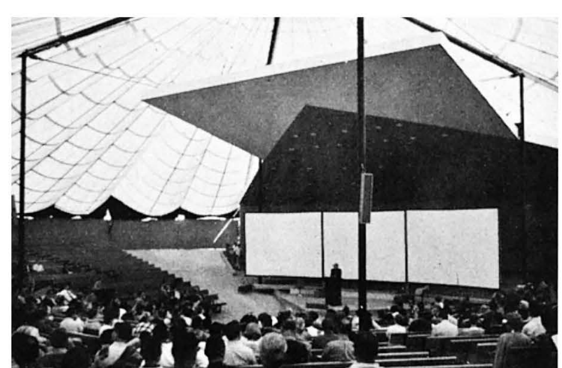
It was to be assumed that the 1200 conferees, even though they had declared common interests and interdependent professions, would bring with them widely varying understandings and responses. The presentation of *prepared* talks such as those of Reyner Banham and Henry Dreyfuss brought this variance sharply into focus. It almost seemed that the same social-industrial-technological forces had not shaped these two men. In fact, had Reyner Banham's talk not preceded that of Dreyfuss it might have appeared as a rebuttal. Dreyfuss proposed that the responsibility of the industrial designer is to establish a bridge between technology and people, to do something about the common man and the machine. He called for honesty, integrity, and "intelligent leadership to raise the level of public taste." (In 1936 Edgardo Contini, speaking of design when the dollar had a higher value than at present, said, "What this country needs is a *good* five dollar chair—produce it and you'll have an overnight revolution in taste!") Said Reyner Banham, (1966) "Plastics are the great democritizers of glitter . . . The love of glitter is not just a *vulgar* dream! Wright, Gropius, Leger, Read loved the city at night, the crystal buildings, the vessels of stainless steel. There is a hypnotic effect of glitter and shine. . . . They symbolize a fresh start, the clean, the new."

Reyner Banham identified two principal sources of contemporary design: (1) the plastics industry whose effects have been "vast and pervasive" and (2) worry about the state of the arts, in the tradition of Ruskin, Morris, Greenough and Cole—especially Cole who pinpointed his worry of new materials. The performance of these new materials can be specified by design and controlled by manufacture, but not necessarily recognized by the observer. Further, it develops that the imitative does not necessarily do a worse job than the "natural."

Dreyfuss, while worrying about the burdens of waste, mistakes that multiply *"even when we're careful,"* our consumeristic society, and expansive, cumbersome ornament in conflict with design, still maintained stoutly that designers, as the representatives of the consumer at the court of technology, have the "privilege of giving more people more things." Reyner Banham suggested, however, that designers and manufacturers are or soon will be turning their talents to the provision of services rather than goods to be owned; that is to say, society is moving toward a reduction in the quantity of things owned, not a loss of respect for design or for things, but a loss of respect for ownership.

In speaking of the character of design teaching today as compared to the old Bauhaus approach (which he said was in part to disabuse the student of ingrained visual prejudice, to bring the sophisticate low, to make him as a child again) Banham said, "Today's student has seen everything!" (In-





LEO LIONNI
Artist, Designer, Writer

TOMÁS MALDONADO
Educator, Writer, Lecturer

BEN SHAHN
Painter and Graphic Artist

BENJAMIN THOMPSON
Architect and Educator

HENRY WOLF
Designer and Art Director

cidentally, so has everyone else.) This student is sophisticated, not well educated, perhaps, but not visually innocent either and less visually prejudiced than in the past. He can tell stainless steel from plastic that masquerades as stainless steel at fifty paces—may even prefer the plastic on the grounds that it does a better job. This visual sophistication is not confined to students. "There are households today," says Reyner Banham, "in which every object is addressed by its surname: 'Pull up the Eames chair.' 'Toss a salad in the Prestini bowl.' 'Let's have coffee in the Rosenthal.' There *are* people who *believe* in industrial design!"

The complicated equation of health: morality :: design standards: moral improvement is a snare and the designer's need for moral reassurance and public examination of their moral scruples results, said Reyner Banham, in annual synanons such as IDCA. He asks, "Do dentists have conferences like this?" "No," said advertising art director Henry Wolf, "because the dentist is not trying to change the world . . . he is just fixing uppers for money." Wolf replied indirectly to Reyner Banham's charges that designers (1) enjoy a 19th century misunderstood genius martyrdom and the claim—however erroneous—that design is a thankless task and (2) a great concern with the public good, and have strong opinions as to the kind of good they would like to impose on the public. They do, says Reyner Banham, take themselves and design too seriously, "leaving no time for dancing—no time for the Watusi and the Pavanne!" Said Wolf, The artist is a very responsible person who worries about hurting other people's feelings. The artist who works for others within the promised land, but separated from it. "One day I realized I just wasn't folks!" The artist has too much love to give and is shy about it, so he gives work instead, not as a substitute, however. Like other shy persons, the artist gives to those who least understand the gift. His dilemma is one of equality versus excellence, the latter being achieved by tantrums, insistence, luck, diplomacy, and paying for it himself. Excellence, when achieved, is of course innovation and the logical result is "adaptation" (polite word) on the part of others. What recourse has the innovator? None. He cannot even use his own invention because imitators crowd him off his own tennis court. All he can do is duck because it's his own stuff that's killing him. He is drowned by the importance of his own innovations. Worse is the problem of misadaptation; the AVIS type face works for AVIS, but not for perfume—it might work for Hertz. The problem as Wolf sees it is that the innovator is left no time in this era of accelerating change to refine and perfect his ideas.

Wolf came across the conference table to the listeners with an immediacy not possible for those who either spoke from prepared papers or were unable to participate to any extent in the small conference exchange.

Reyner Banham in many follow-up exchanges proved less vulnerable than Dreyfuss, for example, who was unable to stay for the full time. Clarification and re-iteration tend almost always either to reduce differences or the appearance of differences. Speaking as a designer who heads a signally important company with identifiable products and clients, Dreyfuss was open to pot-shots and got them. Reyner Banham may have spoken vehemently and anecdotally, but always from the umbra of history and theory. Ironically, Dreyfuss who works in California chose as his demonstration a reference to his company's newest designs for poles and high tension towers for its client, the Edison Company. California had the greatest number of persons present at the conference — more than 140—and Californians in general react hotly to the subject of poles and wires. In fact whole counties (e.g., Orange) and cities (e.g., Los Angeles) no longer permit the installation of new overhead services. Other cities are systematically removing existing poles and wires. There were persons present who felt that perhaps Mr. Dreyfuss' client had not played altogether fair with him.

And thus we are brought to Wolf's identification of the real worry—as opposed to the "baroque" worry, "The real obstacle, royally neglected in speeches so far: *money!* Art and money! Your art and someone else's money! He suggested a box cornered by the terms art, love, money, time.

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The artist, he says, works for love. If he works for money, he has a profession and enters the field of diplomacy and compromise. If there is a marriage of time and love, the result is nostalgia. Art and time equal style. If love and money get together? That question is to be pondered later.

Wolf spoke mockingly of "baroque worries" such as the *New York Post's* concern over Greenwich Village and LSD or the art critic's assessment of Cezanne's dependency on geometry and "real worries," that is, health, love, age, applause. Others spoke positively (Shahn and Farson), optimistically, (Dreyfuss), humbly (Beinart), telegraphically (Cage).

In Tomas Maldonado's able hands the tangle of social problems, design problems, teaching problems, sources and resources seemed to thread into a discernable skein. In substance he said that in our society of the "planner," the "planned" and the "planned-for," benefactors become malefactors. Designers set themselves up as arbiters. Protectors end up making life unbearable for the protected. The designer's functional position to society needs assessing. Serviceability has become confused with servility until we have a network of servilities and an ethical neutralization. The authoritarian personality gains power; management becomes mismanagement. Environmental design becomes contradictory and confusing; the new name for comprehensive design is *total* design. The designer becomes the great inquisitor.

Ecology, he says, demands an open system, a habitat that doesn't erode our environment, that does not set up things in conflict with persons. As it is, we have violence, sadism, ostentation, aggression, *and* the bettering of our minds independent of living.

The new family of teaching concerns is the relationship between design and the behaviorial sciences. Until now there has been a confusion between predictive and observed data; the relation between design and research has not yet been assessed. There must be a confrontation of design education and other fields of progress. It is a human problem. We have a new reality, a world of incredible visual intensity. When all is said and done man is not only the subject but also the object of all design pursuits.

In his summation of the conference, Edgar Kaufmann, Jr., defined design as "an area bounded by other areas," just as geographical areas appear on the map. The areas surrounding design, he said, are usage, salesmanship, architecture, engineering, fashion and fine art. "The boundaries are in dispute," he said, "and there is a lot of smuggling across the borders."

Kaufmann discounted the importance of the philosophical bases and sources of modern design. "We often use inherited ideas and values," he said, "which actually are a drag on what we're trying to do." He suggested that in the future, designers will be guided by such values as numbers, personalism and disposability of objects.

Noting that much had been said throughout the conference about "human scale," Kaufmann argued that there no longer is a single human scale, but many scales, depending on circumstances. "The standing human figure," he said, "is not very much of a human anymore." He observed that in all phases of human activity, the middle scale is dwindling, with the very large and the very small gaining in importance. "The loss of the middle scale can be one of our greatest victories," he said, "because it can make way for intense personalism."

Kaufmann indicated that there is great significance to designers in the trend toward disposability of products. "It means," he said, "that the value of the object is no longer in the object itself, but in how people think about it and use it. This is giving rise to new ideas of quality, new ideas of change and improvement."

The future of design lies in "situation design, not in product design," Kaufmann concluded. When this develops, he said, "smuggling across the boundaries" between design and the areas surrounding it "will be a very good and positive thing."

Others on the IDCA program included Leo Lionni, former advertising and magazine art director in the U.S., now an artist, designer and writer residing in Italy; Julian Beinart, architect and professor of urban and regional planning at the University of Cape Town, South Africa; Henry Wolf, designer and art director; John Peter, architectural commentator, editor and designer; Douglas MacAgy, director of the Dallas Museum of Contemporary Arts; John Cage, composer and Fellow of the Center for Advanced Studies at Wesleyan University; John D. Entenza, director of the Graham Foundation for Advanced Studies in the Fine Arts; Willard Van Dyke, director of the film library of the Museum of Modern Art; Yaacov Agam, painter.

Program chairman for the conference was Allen Hurlburt, art director of Look. Mildred Constantine, associate curator of design of the Museum of Modern Art, was co-chairman.

theater

BYRON PUMPHREY

Had James Saunders' play, *Next Time I'll Sing to You,* been presented by a less prestigious organization than UCLA's Theater Group, it would in all likelihood have been dismissed by the brief, scathing reviews it so well deserved. But Saunders, a British playwright, has impressive credentials, impressive enough, at any rate, to influence the Theater Group to do his play. I feel bound, therefore, to comment upon this pretentious trifle at some length, especially in view of Leonard Cabell Pronko's provocative (to me) note on Saunders in the theater program.

The play is supposed to be a kind of inquiry by a playwright and a group of actors into the life of a real character, an English hermit by the name of Alexander James Mason, who lived very nearly in total isolation from 1906 until his death on January 17, 1942. As indicated by this description, Saunders attempts to employ Pirandello's technique. He combines this approach with an effort to color his work by patter he takes to resemble the kind of dialogue one gets by such masters of the theater of the absurd as Beckett and Ionesco. He is not able to make either of these sources of influence, or inspiration, work for him, but he succeeds admirably in becoming his own best critic in some of the lines he gives to his characters. Act I contains long stretches of tedious dialogue in which the actors wonder who they are supposed to be. "For the love of God," one finally exclaims, "we'll have the intermission on us before we know who we are." "Yeah," responds another.

How Saunders' accomplished exercise in unmitigated dullness can be seen as profound passeth my understanding, but Mr. Pronko, a professor at Pomona College and the author of two books on contemporary theater, writes that *Next Time I'll Sing to You* is a "joyous celebration of the mystery of human existence, revealing man in his complexity and contradiction, and doing it with humor and poetry which strikes deeper than logical discourse."

Here are a couple of samples of what passes for Saunders' humor: "I didn't come here to be insulted." The rejoinder: "I love that trite turn of phrase." An allusion is made to St. Francis feeding the birds. "Was it a color photo or a snapshot?"

Of profundity: "Behind that mechanism (the brain) is something else. It's name is grief and signifies nothing."

But if Saunders has deluded himself, believing that his play is something rather special, what is one to say of the critical judgment of Mr. Pronko: ". . . Saunders creates a Pascalian image if Man caught between the two infinities, the infinitely sublime and the infinitely vulgar: 'Praying to Almighty God and farting into the bedclothes.' "

Elsewhere Mr. Pronko says that Saunders "is quite clearly a post-absurdist playwright," whatever that may mean. He finds, too, "that the little drama that is being built before our eyes is the drama of our own existence in all its vulgarity and all its aspirations, seen not only as we see it, but as others view it too."

I doubt that the occasional nervous laughter of the audience on the opening night at Schoenberg Hall signified that they saw anything of the sort.

One might reasonably suppose it would be hard to top Mr. Pronko in the art of cultural intimidation, but Malcolm Black, who directed the play, manages to do so with astonishing ease: "James Saunders is a master of the art of using comedy to make his philosophical points. He breaks every serious moment by pulling the rug from under our feet with a zaniness that makes *Beyond the Fringe* look square."

It was the talented cast which had the rug pulled out from under it. Robert Casper played the hermit; Christopher Cary, Meff; Patrick Horgan, Dust; Carol Booth, Lizzie; and James Douglas, Rudge. The abstract scene design was by Sydney Rushakoff, the lighting by Myles Harmon.

In the revival of Tennessee Williams' *The Glass Menagerie,* James Doolittle's second independent production at the Huntington Hartford, the dream-like quality of the play was not altogether achieved, but both the choice of the play and the staging of it encourages one to hope that Mr. Doolittle is on his way to establishing the Huntington Hartford as a significant theater for independent productions as well as for imported ones.

This Williams' drama is so perfect of its kind, at once so fragile, so penetrating, and so clear-eyed concerning the memories of its poet-protagonist about his family that it would take exceptional actors and plenty of rehearsal time to compose the acting, the movement, and the speech into that marvellous unity that Williams has realized in the work itself.

James Olson and Piper Laurie very nearly managed it in their scene together, the scene between the Gentleman Caller and Laura, keeper of the glass menagerie. Olson himself played the scene to perfection; it was a high point in Miss Laurie's performance.

In his stage directions on lighting, Williams refers to El Greco, but ideally, I believe, the effect should be that of a vivid, haunting dream in color, along with both the realism and translucence of a good impressionist painting dealing with every day life.

Ann Sothern portrayed Amanda who was a one-time southern belle, a woman conscious of her beauty and her charm as well as a gentlewoman versed in the art of conversation. Toward her son, Tom, her attitude is that of a mother-sweetheart, an Amanda expressing unconscious Oedipal impulses as well as that cultural conditioning of the southern lady which leads her to expect from all male members of the family somewhat the kind of courtly love knights and troubadours were wont to bestow—platonic, that is, but with unmistakable sexual overtones. To distinguish between these two similiar, but nonetheless different qualities, and get it into one's performance is no mean feat of acting. Miss Sothern did it beautifully. One lost a good many of her lines, and this was not because of her southern accent, which was good. It was simply that her voice sometimes failed to carry in the theater.

As Tom, the poet-narrator of the play, Ben Piazza's most effective moments were in delivering the narration. These had a sensitivity and feeling for the character that he never quite managed to carry over into his scenes.

Although the narrative passages in the play are casual and brief, it is through them that Williams establishes the enormous pressure of the world on the shabby Wingfield apartment. Through allusions to Guernica, labor troubles, Berchtesgaden, and Chamberlain, one sees that the blindness of Laura and Amanda to their situation corresponded to America's blindness to the international scene.

This fragile structure, this memory play of Williams, in deftly touching our minds at these points, calls up the world stage as it existed in the thirties. We say good-bye to this bereft southern family, as Tom says good-bye to it, but with the knowledge that there is some sort of connection between Laura and Amanda and ourselves. Perhaps it is the crippling, haunting influence of the past.

MUSIC

(Continued from page 8)

technical guide and challenge for inspiration; they are a mine of technical knowledge for the instrumental composer.

Virgil Thomson is an indigenous American composer, who trims his work with the French idiom of Paris in the 1920s, disdains what he calls, to underline its foreignness, *"Mitteleuropa,"* dislikes formalistic theory though he relies on it and seldom fails to know exactly what his music should do next. Widely renowned for his long leadership as a music critic with a style as sharp and aphoristic as his talk, informed, prejudiced, his tone as sweetly acerbic as his voice, liking to praise but intemperately witty in condemnation, he rejected the tone-row and its consequences and failed to recognize the authority of Ives. But he was a composer long before he was a critic and has remained a composer foremost during and since his commitment to the *New York Herald-Tribune.* He is now writing his autobiography, meditating a barbed discretion, like

Amor poising his arrow above the recumbent St. Teresa. If some of the concise talk Thomson has brought to recent lectures has come out of or is going into his book, we shall all turn to it many times for guidance. I shall be interested to read his mature appraisal of American music as it is at present and how it got there, and what he has to say about the younger American composers of the two succeeding generations who owe much to his discerning, sceptical encouragement.

Virgil Thomson has composed a large quantity of music, of which only a small part has come to recognition and appraisal. His operatic cantata, *Four Saints in Three Acts,* has had a number of performances and, improved in my opinion by cutting, has been available in recorded performance for two decades. His true opera, *The Mother of Us All,* has had few performances, has never been recorded, though it is the best native opera, with due respect for Marc Blitzstein, and one of the very few first-rate operas in English. We heard it last year at UCLA in a delectable performance. Orchestral performance of his music has been restricted to the suites made from motion picture scores; his chamber music, keyboard music, and songs are seldom heard.

Thomson is now working on full-scale grand opera for the Metropolitan Opera of New York, whose spokesman cautiously announces that they have not quite promised to perform it. Be it never so awful, there's no place to develop native opera except at home. Russians, Germans, French know this; Italians take it for granted; the British have conspicuously learned it from Benjamin Britten.

The American approach to American music has been to decry as "chauvinism" any praise of it; therefore we have the peculiar condition that, while many works by many American composers have been performed, relatively few of these have been repeated often enough to enable the public, or the critic who believes that score-reading is no substitute for hearing, to make their acquaintance. Score-reading is no substitute for hearing, because the eye too often misinterprets the individual or idiosyncratic moment as "mistake."

Thus a large part of our academic education in music is aimed at learning not to risk "mistakes," or at finding theoretically correct ways of doing a new thing, without questioning whether in too many instances "correctness" may not be the real mistake and the presumed divagation into error a true guide to unique talent. The professional answer to this argues that a real composer will know better than his professors and go his own way, taking his lumps, trusting that eventually a few musicians will explore his music, expose it to the public and eventually bring another generation of professors up to date—a date which may be, as now with Schoenberg and Ives, still fifty years behind. If maltreatment flattens the composer or destroys him, it is presumed that he lacks genius, which is, so interpreted, an infinite capacity for taking pain.

The defence is, of course, that for one potential genius flattened to conformity a thousand or more pretentious non-geniuses have been routined to grammatical and syntactical correctness. But we have lost the one genius. And the thousand flattened conformists unite to ensure flatness. The academic argument claims that discovering the exceptional genius among a horde of students who must be pushed to their degrees regardless of talent is not an educational responsibility. The teacher teaches by presumption of the creative skills he cannot recognize.

I apologize for the foregoing to the many teachers at all levels who make a constant effort to recognize the difference. Many a creative student owes his life to them. They know as well as I that what I have been saying has been often said and cannot be said too often. It is because of our conformity at all levels that the whole work of such a composer as Virgil Thomson remains unknown and unexplored. The radical conformists are as much against him as the conservative.

In New York this spring I stayed one night at the Chelsea Hotel, had supper and enjoyable gossip with composer Milton Babbitt, and then went to the ninth floor of the hotel, where Virgil Thomson has long had his apartment. During our talk I asked him whether his Requiem Mass had been recorded and was delighted to receive from him both a copy of the score and a record of the first performance, by the Crane chorus and an orchestra under the composer's direction, at the State College of Education, Potsdam, New York, which commissioned the Mass.

The record is privately issued and needs no criticism, except to explain that, probably because of imperfect microphone placement and, I would guess, stage drapes, much of the sound was lost and the balances were unbalanced. The performance, so far as I can judge, was satisfactory.

Thomson's *Missa pro Defunctis,* composed 1959-1960 and first performed in May, 1960, is in nine parts plus a *Praeludium* and a *Postludium* for orchestra. That it is a Requiem for soldiers is made evident by the trumpets playing *Reveille* at the start of the *Tuba mirum*: what sound more natural to awake dead soldiers!

The opening prelude is in simple, unemotional counterpoint, but when the chorus enters with the *"Requiem aeternam"* to commence the *Introitus,* the opening theme is transformed into a 12-note tone-row with repetition of the tonic note. The harmony refuses to have any part in this excursion but persists in a mild chromaticism as safely remote from Vienna as Berlioz from Wagner. I have no idea what the composer meant by this, unless to temper the absolute by the relative.

Thomson believes in simplicity, and his Mass is at no point complex, yet I cannot pin it to a style or, with raised eyebrows, speak of it as eclectic. The melodic line is never melodious, as in his operas, and except the one instance of the *Reveille* there is no introduction of familiar tune or song. It is a work of quiet dignity and unforced emotion, with no great rhythmic surges to drive it along; but it moves, and in every part an emotional equivalent of the liturgical meaning is presented. The pace is subtle; one appreciates the alternation of flow between pleading and the hope of rest.

One can guess that this later style, like the earlier style of Thomson's operas, derives from the work of Erik Satie, certainly as good a source as Webern. There are fashions in sources; the ostentatious fashion of the last decade stems from the discovery of Webern, after Robert Craft had made the complete works available in a single record album. One thinks of Satie as, by comparison, a small composer, but there is more music by Satie than by Webern. Thomson's operas expand on the "public" Satie of *Parade,* the artificial entertainer. But Satie's entire life was a performance, and it is this life, more than his idiomatic tricks, which has entered deeply into the imagination of Virgil Thomson, John Cage, and other American composers who share their discipleship. Anyone who has studied the work of Satie is aware of his profound seriousness, that his public habit covered a privacy at once reverent and tormented. The notion used to be that because Satie could not be a serious big composer he chose to be a comic little one; this is untrue. The composer who began the *Mass of the Poor* and completed *Socrate* has absolute stature, no less than the master who concentrated a lifetime of technical wisdom in the series of small piano pieces, *Sports et Divertissements.*

It is this technical wisdom Virgil emulates; he shares nobody's fashion. Listen to the opening phrase of the *Kyrie eleison,* the undramatic but expressive overlapping entrances. John Cage, after analyzing Thomson's complete works to the length of half a book, dismissed his art as "entertainment." The *Missa pro Defunctis* does not entertain, moralize or decorate; it is not operatic; it strives for no great climaxes; it does not shed tears for the audience. But at the opening of the *Agnus Dei* and in the great cry at the end of it one hears all that has been held back, the mingled hope and grief. So too with the *Sanctus,* beginning in its long, measured, divided, instrumental tread and the gathering repetition of the word, one meets again the composer who could create in full seriousness amid comedy the figure of Susan B. Anthony and release the culminating emotion of a long life with its reality into the final aria of *The Mother of Us All.*

Let us give thorough attention to the work of Thomson, who may be a composer of far more weight and stature than we yet admit.

LETTERS TO THE EDITOR

Dear Sir:

Congratulations on having elicited that top-notch piece by Mrs. Moholy-Nagy. May I elaborate on one point in it?

First Mrs. Moholy cheers us with the "memorable and highly symbolic visual stimulus of public buildings, expressing shared ideals of power, hope and success." Then, only a bit later, we read of "the race for urban grandeur between Mr. Chase Manhattan and Mr. Seagram . . ." Isn't it time to say that one of the saddest confusions of our time (and this place) is that the whiskey building has been given a dignity and monumentality that any reasonable culture would have pre-empted for a public symbol? Mies cannot say (as Gropius once did about the flabby Pan-Am), "I always wanted to build a skyscraper"—he has had them. And his aquiescence in using the finest rhetoric for anyone who pays, instead of having appropriate modulations of expression ready at hand, is another weakness of the art in our times.

Dore Ashton, too has given us a good phrase over a good thought: "a condition of intellectual stammering that is becoming more evident for each day that passes." This, and the Stella that evoked it both reminded me of the works so well presented in the May issue of Progressive Architecture.

Edgar Kaufmann, Jr.
New York

Dear Sir:

I was enormously pleased by the June 66 issue of ARTS & ARCHITECTURE.

The cover is magnificent because the concentric lines give an almost uncanny dynamism to the movement inherent in this sector of the "Lightmachine."

As for the contents: I don't think Mr. Parr's reply says much. I guess it is the ancient insoluble and at present so very acute conflict between the sociologist's and the artist's view of man-made environment.

The Moholy-Malevitch is, I hope, very rich fare for the eye and the mind. I never thought it would be possible to put so many illustrations in so small a space and still have them come out so legible. Thank you very much.

Sibyl Moholy-Nagy
New York

Dear Sir:

Your editorial about Mayor Yorty and the short-sighted (Los Angeles) city council's lack of vision (A & A June 66) concerning urban renewal is certainly to the heart of the matter. It seems all city planners are married to some sort of urban renewal. When questioned, however, about the meaning, one always hears about the mall in Pomona, or some sort of stop-gap means that have been adopted.

The enormous energy that Los Angeles has shown in the past 4-6 years has been uncontrolled and almost totally without architectural discipline. Witness: The Music Center, the County Museum, most of the new buildings at UCLA and countless others. The first two named, I seem to remember were covered by your magazine, but no one took the hint.

I am eagerly awaiting a critical article about the buildings, the landscaping and the general misuse of the land at UC Irvine. I must presume you've not taken the 60-mile drive down this way to see this campus.

The buildings are disfuctional, ugly and quite out of keeping with the natural rhythm of the land. The structures squat upon the gentle heights of the low rolling hills, and others bury themselves in the sides of the same hills. At the tops, these structures are entirely without silhouettes. . . . They look as if they had been driven into the ground.

The landscaping is just as bad. No. It's ghastly. There's almost a total profusion of eucalyptus and pine trees. The first named is generally used as a windbreak hearabouts and the Silver Dollar, certainly one of the ugliest members of the family, is freely used. The choice of the pine family is almost as bad. Until several weeks ago, I saw no shade tree on the entire campus.

Take a trip down and see what "planning" has done at Irvine. More, see what a selection of a first-rate, third-rate architect has yielded.

Bill Ching
Santa Ana, Calif.

Dear Sir:

A propos Esther McCoy's excellent article on Young Architects (A & A, Feb-March 66) I should like to suggest that when you write about the topic again, you bear in mind that the struggle for a creative and economic survival is by no means limited to the young architect. I have a feeling that for most U.S. architect-artists this is a life-long problem, and that only a few get their work in national magazines (not to mention the textbooks of architecture) and really get rich!

Another thing which you may want to remember is that the publicly acclaimed architects (young or old) are the seasoned social mixers and political joiners who know how to get the really big jobs. These men are usually the least creative artists. They are mostly shrewd operators even though their names may appear high on the local AIA roster and in the social columns of local newspapers.

Finally, there are areas—Florida is one of them—where the cultural level is so low and the speculative overtones so obvious, that almost any kind of architect—young, old, good, poor—has a hard time in competing with package dealers or with giant out-of-state architectural firms.

But perhaps Mrs. McCoy has covered all this and more in her other writings.

Jan Reiner, Architect
St. Petersburg, Fla.

Dear Sir:

I have just read your editorial in the May issue of Arts & Architecture. Congratulations on a fine and pertinent article.

The Los Angeles problem seems to be a parallel of problems in business and (I dare say) our city (?) of Phoenix is headed for the same fate.

Several cliches come to mind:
Trying to do too much with too little.
Don't send a boy to do a man's job.
Rome burns while Nero fiddles.

Henry H. Bluhm
Consultant-Industrial Design
General Electric
Phoenix, Ariz.

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