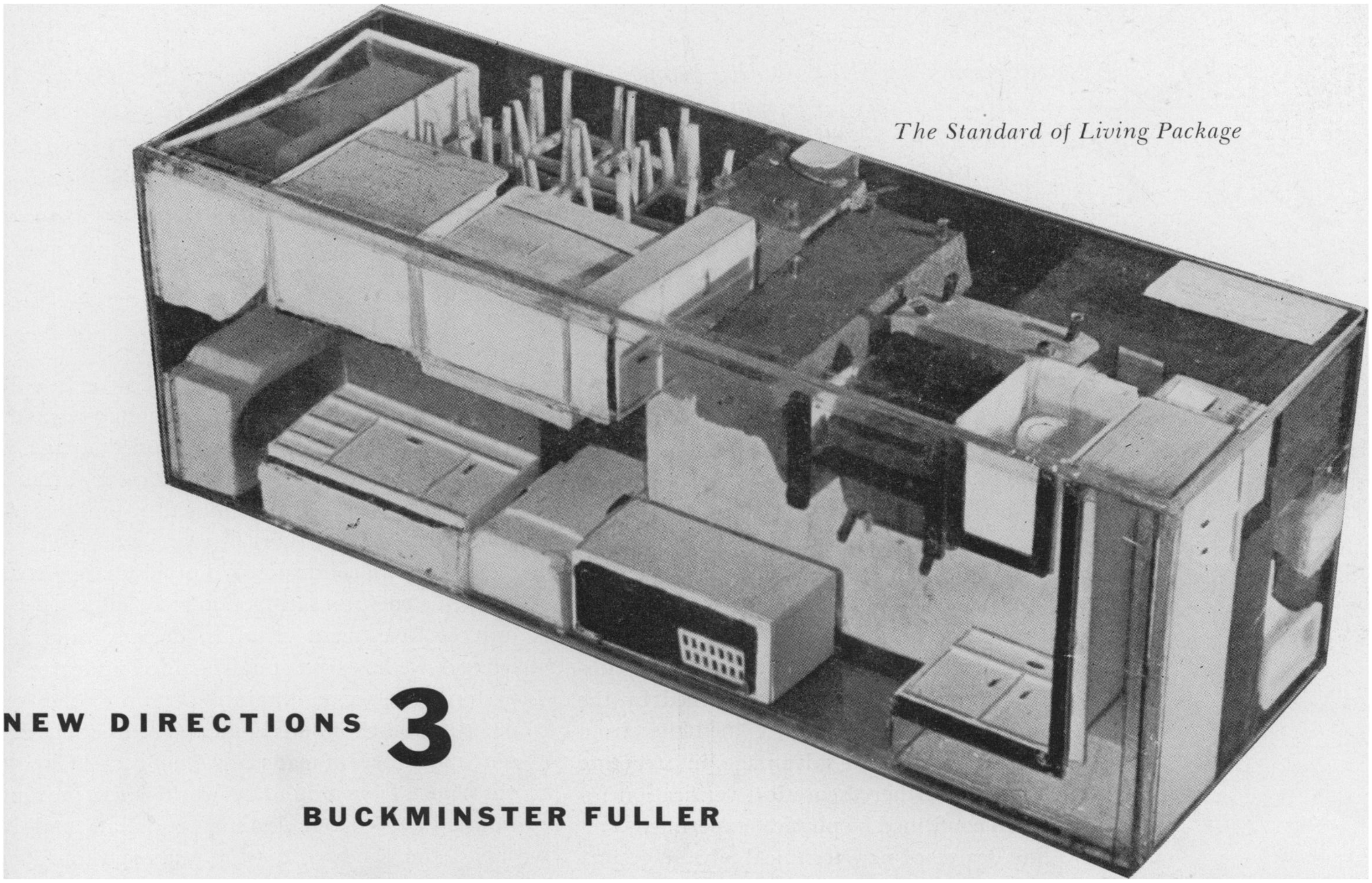


The Standard of Living Package

NEW DIRECTIONS 3

BUCKMINSTER FULLER

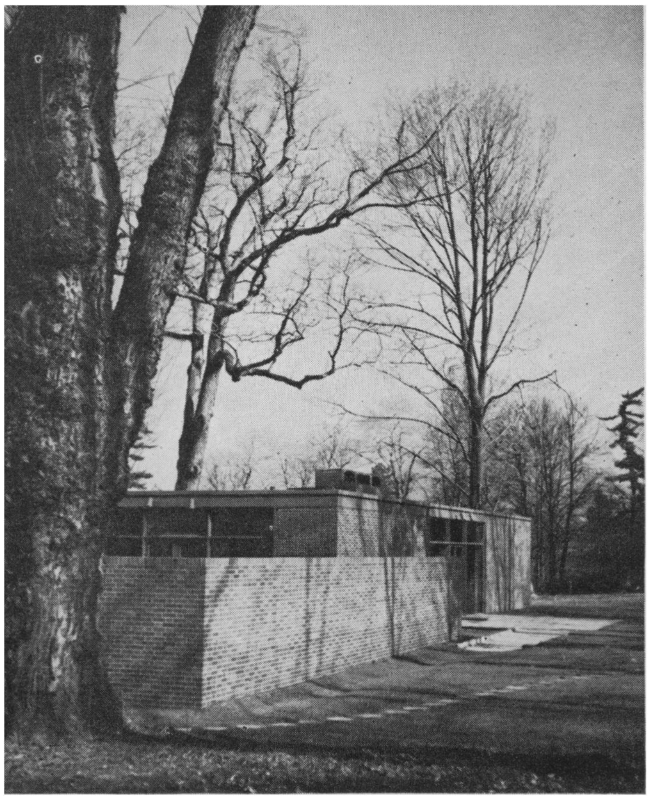
Today Buckminster Fuller and Dymaxion are nearly synonymous, for almost everyone is familiar with one of his many projects, the Dymaxion Map, Dymaxion houses, the portable unit bathroom, and the three wheel Dymaxion cars. His Dymaxion theory, which forms the basis of all his projects, is to effect the "maximum net performance output per gross energy input" in all elements related to living.

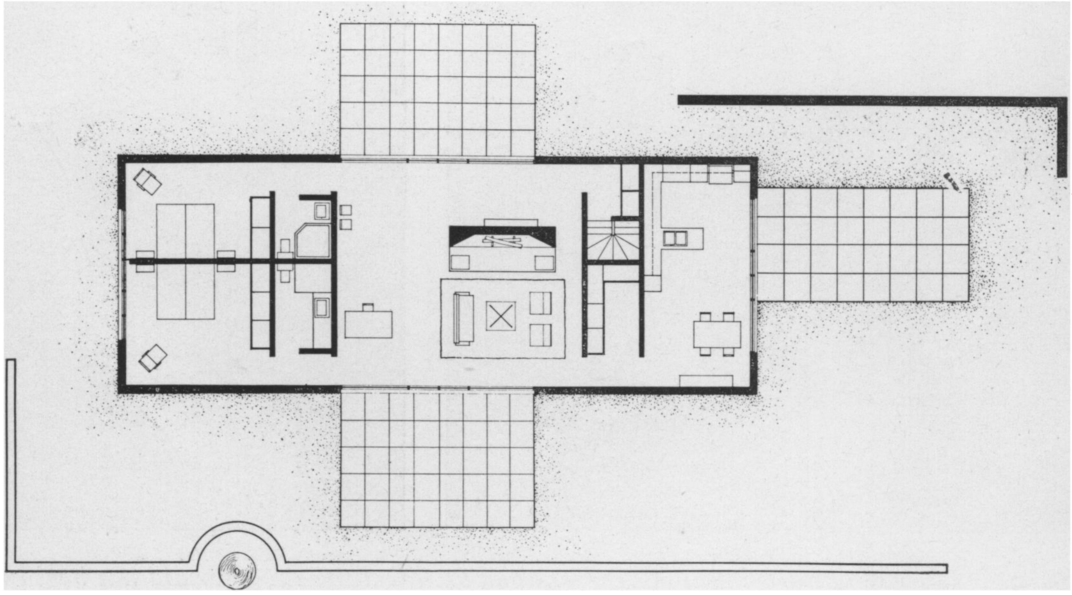
There are probably three experiences most influential in shaping his present directions. In the Fuller family tradition he entered Harvard in 1913 but abruptly ended his stay during his second year when, in a rebellion against exams, he went instead to New York to entertain the entire cast of a Broadway musical. His family, subsequently, apprenticed him to a machine installer in a Canadian cotton mill, his introduction to machinery. His enthusiasm enabled him to rapidly become an adept machinist.

His work with naval sea and air craft required a cognizance of navigation, map projection, the mathematics of ballistics. And he was impressed with the required mobility with minimum weight of seagoing machinery. In more serious pursuit of engineering he studied at Annapolis.

The tragic death of his daughter in 1922 and the failure of his business, the Stockade Building System, forced him into a voluntary exile in Chicago. There, with the abandonment of his carefree past, he completely reevaluated his ambitions. His decision was to set aside the desire for success and profit and henceforth devote his energies toward making the maximum technological resources serve the maximum number of people.

Since that time Fuller's projects have encompassed the fields of engineering, architecture, mathematics, geography, and mechanics. To his credit he has a new kind of map projection, a system of geometry (Energetic Geometry), the authorship of several books, the editorship of Shelter *in the '30's, and his Dymaxion cars and houses. For the most part the projects have never reached the public market for lack of commercial sponsors. However, in 1946 Beech Aircraft of Witchita planned to begin manufacture of the circular Dymaxion house. Although 37,000 letters had been received from prospective buyers it had to be abandoned for the lack of ten million dollars needed to tool-up for production.*





HOUSE ON THE HUDSON

ALEXANDER GEORGES

In recent years Mr. Fuller has incorporated himself into the Fuller Research Foundation; he is consulting engineer for several firms, lecturer, visiting critic at such schools as Black Mountain, M.I.T., and Yale.

Two of the latest products of his ever active mind are the Geodesic Dome and the Standard of Living Package, further examples of his applied Dymaxion principles. Their value, as in his other projects, lies not in their immediate popular acceptance but rather in their service as guide-posts and goals for future comprehensive designers.

The Autonomous Dwelling Facility

THE GEODESIC DOME

Throughout the last two years I have been preoccupied with developing what appears to be dynamic principles of structure inherent in the atom and its nucleus. While my efforts are entirely outside the work of formally recognized authority on atomic phenomena and the significance which I am inclined to assign to my discoveries may never be formally verified by the academy, I have, nonetheless, gained therefrom knowledge of technical advantage in structure that needs no further theoretical verification for it has been confirmed by physical experiment.

The degree of new technical advantage provided by the discovered principles may be appreciated by the fact that one pound of structure can hereby accomplish space enclosure heretofore requiring one ton of structure (when complying with the scantiest of U.S. city codes) while at the same time arriving at predictably stable conditions under extreme stress of earthquake, typhoon, arctic cold, tropic heat in the presence of which, the behavior of the contemporary city dwelling structure referred to is dubiuos. This 2000/1 ratio of comparative advantage is made regarding structures of approximately 8,000 square feet of ground coverage. The new structure has been named GEODESIC STRUCTURE because of its employment of great circle geometry.

We have witnessed a half-century's continuous shrinking of dwelling structures produced at increasing costs per pound and per cubic foot. During the same half century we have seen all the historical outdoor living controls, such as ice house, washing shed, root cellar, water supply and waste disposal mechanized and brought indoors. To a gradually improving mechanics of solution of these facilities have been added an increasing host of controls and mechanical devices. Cold that required winter's harvesting and degrees of cold not to be harvested are arrived at in minutes and precisely maintained within increasingly economical dimension. Functions of the past which required months, weeks, days, and hours have been reduced to minutes and seconds while new degrees of precision of maintenance of desired conditions previously undreamed of are now routine. As over-all result life expectancy at birth has been approximately doubled in this remarkable yet exquisitely short fifty-year era.

While we continuously lost advantage in degrees of structural satisfaction to be obtained per unit of investment (pounds, dollars, time and energy), we have continually gained in degrees of performance to be obtained per unit of investment in household mechanics. For fractions of a cent and ounces of material we can get instantaneous reports from around the world where the same would have cost thousands of dollars and involved thousands of tons 50 years ago to obtain the same personal home facility.

In view of these trends and looking to their further extension in the next 50 years I propose that we eliminate the shrinking and ever-less economic house altogether and concentrate entirely on amplification of the mechanics. Let's go camping with paraphernalia competent to make us masters of our environment and time as man has never dared to dream.

Briefly, I propose a super-camping structure consisting of a 600 pound, 50 foot diameter hemisphere. It consists of a triangular network of aircraft tubing, laced together internally by aircraft cable. Its airframe structure rises into a rigid truss in seconds as its steel sinews are hydraulically tensed, somewhat as a tinker-toy is drawn taut. A transparent plastic skin of double wall construction is inflated to withstand hail, or other similar impact loads. An interior shuttering device provides 100% variable optical control.

You may say, "What is new about a dome?" The answer is that while there is nothing new about a dome, the way that it is accomplished represents first a new advantage taken of the most recent increases of tensile ability and, secondly, entirely new structural geometry.

In our GEODESIC STRUCTURE the surface of a sphere is interlaced by unique numbers of great circles properties of which are that they intercept one another in such a manner that all the surface areas described by the intersections are triangular. As triangles are non-distortable this intersecting, if substantially structured, represents a rigid trussing of the spherical surface. If, between each of the vertexes or intersections of the great circles occurring in the surface of the sphere, we will construct chords or straight lines which lines must fall below the surface between their surface terminals, the lines converging at any one vertex all leading away below the point on the surface, must form a convex intersection or a pyramidal point. As we press against any convex vertex, and if the other ends of the line are elastically restrained, the vertex will subside and the lines will tend to form a flat plane.

As each of the chordal ends between vertexes of our GEODESIC STRUCTURE are rigidly restrained by the comprehensive trussing of the sphere, it is seen that when pressure is exerted inwardly against any vertex it will thrust outwardly against each of the chords leading radially from it. It will be seen that, inasmuch as each vertex represents a pyramid of triangular planes, the bases of the planes opposite the vertex constitute a closed linkage or ring. Because the linkage is of *great circle chords* and because sections of the great circle always represent the shortest distance between any two points on a sphere and the chords of the great circle represent the shortest distance between the two points in space through the sphere, therefore, the ring of chords tensionally opposing the compression thrust of the pyramidal lines from any one vertex may not be elongated.

Thus it is seen that the GEODESIC STRUCTURE employs the principle of compound curvature as the stress is radially distributed from a single point. All the vertexes surrounding any one vertex are secondarily actuated and each in turn thrusts outwardly to adjacent vertexes; rings of triangles of *geodesic* lines are successively activated from the original thrust against one vertex until six rings have been activated and the equator is reached. All the thrusting outwardly against equator symmetrically, their outward thrust is compoundingly restrained by the opposite hemisphere.

In the case of a GEODESIC STRUCTURE representing a portion of a sphere the functions of the balance of the sphere are rendered by the earth which tends to complete the spherical structure by stress extension within the earth. Thus in compound curvature structures of nature, emulated in principle by our GEODESIC STRUCTURE, working stresses are ultimately translated into an omni-directional outward thrust from the system center and are ultimately satisfied throughout all the cohesiveness of all the inclosing tension. In contra-distinction to simple curvature which is ultimately satisfied in polar focus upon two compression points, compound curvature invokes ultimate activation of comprehensive tension.

There are many ways of rendering GEODESIC STRUCTURES but all represent closed systems in which compression is comprehensively encompassed by tension. In principle this emulates the structuring of universe.

It is to be noted that men have employed GEODESIC STRUCTURES before in the form of the octahedron. While useful in small structure, the relative sizes of spans or chords of this well-known continuity of great circle triangulation becomes so great in unsupported length when applied to structures appropriate to men's buildings that its virtues were unavailable for practical purposes.

The surprise factor in my introduction of GEODESIC STRUCTURES to you is the surprise provided by nature. We have discovered and not invented all-triangular interaction of 25 great circles and 31 great circles whose relative chordal lengths make them appropriate for structures up to 100 feet in diameter.

There are further occurrences in greater numbers of great circles embodying the all-triangular interaction. Because of the shortness of the chords, which make possible the application of compression members between vertexes of a practical length-width ratio—while the system of short compression members may be comprehensively cohered by ground to ground tension lines—it is now theoretically possible to conceive of structures of spans approximating the great suspension bridges. A dome one mile in diameter appropriately skinned in may, in the future, economically encompass the activity of a city. Such a city would require no weather walls for its individual parts and could be entirely air conditioned.

There is special advantage of the hemisphere over other geometrical forms. For instance, the upper or enclosing surface of a hemisphere ("geodesic") or of a half cylinder (quonsette) is always *twice* the area of its base (floor). The upper surface of a half-cube structure (typical of a one-story box house) is always *three* times its base. The upper surface of a cube is always *five* times its base. The above ratios indicate clearly the initial advantages of curved enclosure over rectilinear. The advantage is spelled out in weight of material per unit of function and in surface cooling areas, etc. The peak-roofed box is at greater disadvantage than the flat-roofed box. The dome sheds its snow and rain in a superior fashion to a peak or a cylinder.

While it is customary to identify office and manufacturing space in terms of square feet of floor area, the actual fact is that—because man and his goods are not two dimensional—the space *is volumetrically employed.* For this reason, the unique advantages displayed by the sphere (as dimension is amplified) in the rate of volumetric increase as of the third power over surface increase at the rate of the second power has direct bearing on *use.*

It may be argued that the hemisphere provides unusual heights of volume and, therefore, the floor area is a better means of appraising the value of the space, but this aspect is only true under special forms of use which emphasize only the ground need. In the case of our GEODESIC housing where a fifty-foot hemisphere is employed, we find it appropriate to create a *second deck.*

Further uses are made of the hemispherical volume which take advantage of the unique geometry of the hemisphere; that is, atmospheric circulation takes advantage of the natural fountainwise flow of heated air, i.e., air heated at the center tends to expand and rise as the heavier air is pulled down by gravity. As it rises it further expands, it cools and flows outward and downward to floor level and then centers for reheating and recirculation.

This *natural fountain* motion of *heated* air may be observed as an isolated phenomena in the case of explosion and in great fires. Notably, the Bikini bomb may be remembered as demonstrating the upward-outward-downward and center rolling doughnut hemispherical shape. Inasmuch as this is the natural atmospheric circuit of energy as heat, it is seen that—*if the hemisphere is designed of the right size to accommodate the natural dimensions of a given heat fountain*—there is no tendency for heat to be lost or additional energy expended to impel atmospheric flows through unnatural chambering in order to distribute "comfort" atmosphere.

The hemisphere has further advantages relative to the phenomena energy-as-heat-in-the-form-of-radiation (in contra-distinction to energy-as-heat-as-articulation-by-molecular-acceleration in gases, which latter is commonly identified by the combined behaviors known as *conduction* and *convection*). We demonstrate our familiarity with heat radiation's spherical limits as we back into and walk away from the glowing fireplace. The spherical surfaces of *relative* heat "fronts" are well identified. Again, as in the case of *convection* fountain enclosure, it is seen that, if a structural hemisphere is of *adequate size,* heat losses by *radiation* (where the origin of heat is near the center of the hemisphere) may be scaled down to negligible amounts, and that such heat radiation as does reach the surface may be turned around by reflection and thrown directly back toward the point of origin.

There is a third aspect of unique advantage in the matter of *hemispherical volume,* gained at the third power; against surface growth of the second power, to wit, that advantage accruing to "Relative Size." In reverse, the principle of relative size effect may be noted in the relatively slow velocity at which a large cake of ice melts as against the accelerating velocity at which a small cake of ice melts.

Because the amount of volume that can encompass a given center for a given amount of pounds of structure is larger in the case of the sphere versus any other kind of geometrical form, and because our particular type of tube-and-cable "necklace" structure (which takes advantage of triangulation of geodesic lines) entitles us to the encompassment of relatively large volumes with relatively low logistic investment, optimum conditions may be economically obtained in consideration of these various "special" aspects of interior energy behavior.

There is a further advantage unique to this geometrical form not at first anticipated, that is the exterior aeronautical advantage. The hemisphere provides the least resistant form (to the sum total of omni-directional air motions about it) of any of the geometrical forms. The wind tunnel discloses that interior heat losses of permeable wall structures are proportional to drag. This is to say that the exterior low pressures created by the passage of air about a structure are satisfied by interiorly generated energy expenditure to pass the high pressure gases through the permeable passages of the walls of the structure.

Other experiments have disclosed this principle to be in operation. Cubical houses heated by return circuit hot water systems have been mistakenly supposed to be cool in the windward rooms in the wintertime because the wind was blowing on that side and was, therefore, supposedly chilling the radiators in the windward rooms. Experiments disclose that no heat rises from the boiler to the windward rooms because the total B.T.U.'s being generated are required to process the transfer of the heated atmosphere in the lee side of the building and that the whole heat flow is to the lee side.

It can be seen that the four factors noted above—(a) heat convection fountain, (b) radiation reflection to spherical shape, (c) Relative Size, (d) aeronautical properties—combine to provide unique energy economies, but with no further expenditure in physical structure in the way of conduits, partitioning impellers thus displaying surprise advantage in new magnitudes of available controlled environment.

Employing components now manufactured by American industry one of our engineering research teams has now completed a tentative flow sheet of the sewage disposal and water supply system—the latter for 600 gallon a day of chemically pure, sterilized, sweet water. This apparatus serves as a general energy exchanger, taking heat from the refrigerating system to satisfy the pressure distillation processes. It heats the water for general cleansing purposes while shunting a fraction to refrigeration for chilling. This total energy-sanitation-refrigeration system weighs approximately one ton.

THE STANDARD OF LIVING PACKAGE

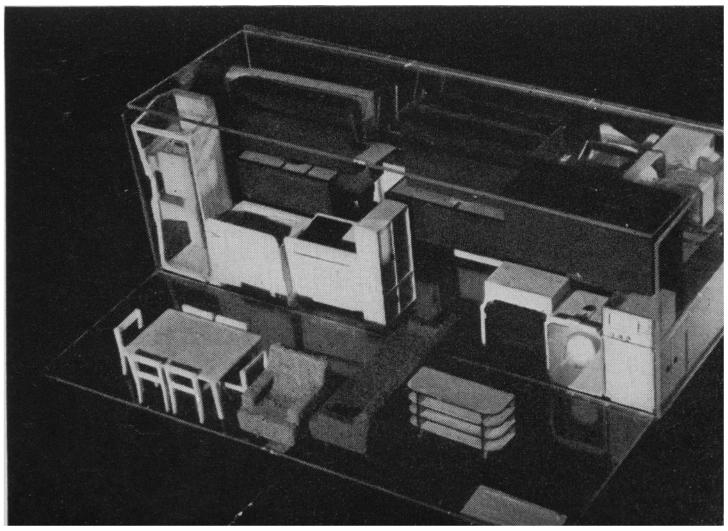
Fuller assigned the following problem to forty students of architecture and product design at the Institute of Design in Chicago:

Emergency situation is the lever that overcomes man's inertia. The city is to be evacuated. All residential and industrial concentrations of 50,000 persons or more are in immediate danger of annihilation. Consumable goods now directed toward these areas will be diverted to smaller, decentralized communities. You have seven days in which to gather all living mechanics necessary to maintain a high standard of living for a family of six, two adults, two children, and two guests. Everything not decentralized from big cities will be destroyed; therefore, there will be no purchase restrictions or limitations. You will be given prime-mover and transport to a decentralized area of low concentration. There a shelter will be provided that offers complete control over external destructive forces. Once on the spot, the prime-mover will be equipped to provide all of the power necessary to operate the mechanics of your selection. Personal transport—either air or ground—will be provided in order that consumable goods, repair and replacement parts for the mechanics can be obtained with reasonable ease. What are you going to do? What size van do you want? What size check do you need to cover your purchases? How heavy is the load? Etc.?

The assignment further stipulated that advanced scientific and industrial methods complement *intuitive initiations* and *assumptions* and that the whole be systematically reported. To gain the widest possible coverage of individual items, each student started to wade through the galaxy of stores in the greater Chicago area shopping for pertinent mechanics. Individual lists were then to be superimposed to minimize personal error. The greater the number of individualists, the smaller the end error. The data thus obtained was to be recorded on file cards as follows:

Name of item
Rating (performance characteristics, especially those unique degrees of characteristic performance which determined the preferential selection)
Manufacturer's identification (model and year)
Manufacturer's name
Retail outlet name
Gross weight per item (without package)
Net weight per item (without package)
Gross over-all dimensions (without package)
Net over-all dimensions (without package)
Cost per family package
Weight per family package
Volume per family package

It quickly became apparent that the scope and magnitude of the problem as assigned made it impossible to complete on an individual basis in the time allotted. At this point, teams were organized in systematic coverage of the above as checked against the "Universal Requirements" check list, evolved and periodically revised by Mr. Fuller as the scientific control for development of dwelling advantage.



The completed inventory was a comprehensive picture of the standards of living as advanced to 1951. The Package weighed 12,910 pounds, bulked 1547.78 cubic feet, cost $18,877.63, and could be loaded into a twenty-four foot trailer. Mobility of domicile was possible in spite of the fact that the Package contained every facility that man might possibly desire for personal or family home use, recreation or development. Elements ranged from highest quality of kitchen, laundry and cleaning mechanics to equipment for comprehensive machine and woodworking shops; still, motion, and talkie cameras and darkroom equipped for same. The Package contained all furniture for six people (Eames, Knoll, Beautyrest, etc.), much sporting equipment (summer and winter), and a selection of musical instruments including a $2500 Steinway concert grand piano.

It was improbable that any single family would want to include everything in this Package list since leisure time would not be available to participate in or utilize all of the equipment listed. Interchangeability of function according to preference was a conception inherent in this Package. Thirty individuals tested consistently used but one-third of the total items. Investigations by the group covered a variety of subjects such as traffic flow studies to develop the most efficient arrangement of facilities in relation to use, natural light control, independent space-sound controls, pneumatic floor components, redesign of elements in compact packages to reduce waste space, weight, solution of folding, moving and unfolding house components for greater mobility.

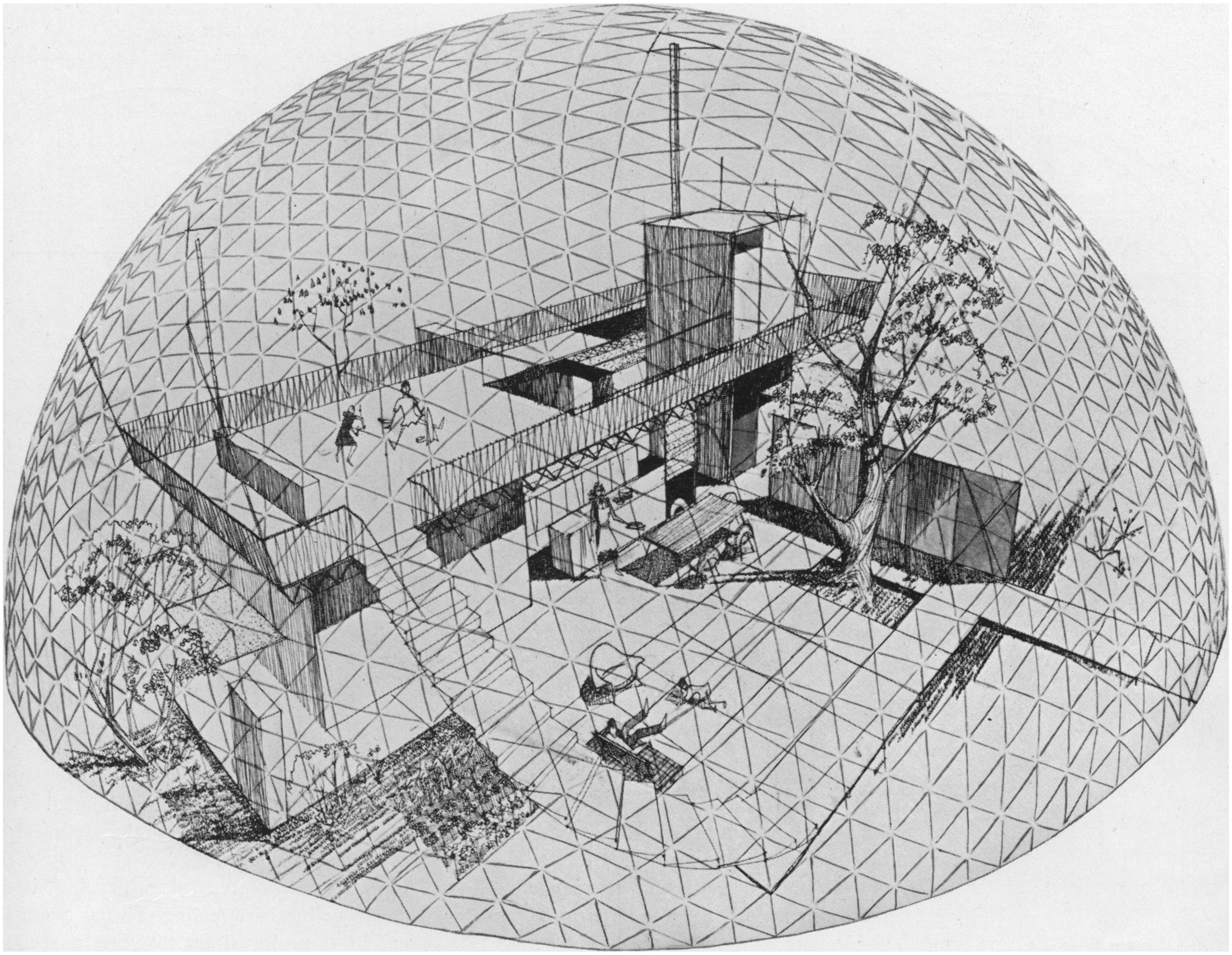
On second phase review of the mechanical facility inventory it became obvious that, inasmuch as all the items were inventoried at retail store figures and had been appropriately packaged for an indefinite succession of handlings and seasonal lags, the resultant succession of price mark-ups represented of necessity fundamental all-over inefficiency of distribution procedure. If the ultimate comprehensive mechanical Package to be acquired by the family over a period of years could be purchased en masse in advance, not only could individual mark-ups be eliminated, but also much costly protective packaging and independent stands, consoles and cabinets, appropriate to *separate* marketing. The traditional "have not" psychology would be replaced with spontaneous creative conservation.

As a result of these observations, designs and models were developed. Each of the six sides of a 25′ x 8′ x 8′ container (equivalent to the body of a medium transport trailer) locked together by hinges, served as mounting platforms for all items of the mechanical package. The contents were sorted and adhered to the six panels—the sides, top, bottom, ends—in relation to their use categories. Mounted with geometrical ingenuity, the panels, when hinged together, held the respective items mounted on them in reciprocal proximity, thus avoiding all loose shipping conditions. Hinged "open" the panels provided a floor space of 928 square feet completely furnished ready for use. This arrangement also makes logical the movement of the separate panels along the producers mass production line and the affixing thereto of the mass purchased component mechanics, and the hook-up of their respective and appropriate wire and plumbing harnesses and manifolds as in auto production.

The over-all economic significance is that: (a) it assures the original component producers of mass outlet and annual stability and (b) that the comprehensive package may be mass marketed on a long-term chattel mortage, thus enormously increasing manufacturing outlet and simplifying distribution to the consumer.

The mechanical package could thus be made available to the consumer at a cost per pound within the price range afforded by equivalent complex assemblies as now provided by the automobile manufacturing techniques. The automobile package was sold to the consumer within the price range of 25¢ to 50¢ per pound. The top figure of this range, 50¢ per pound, was to be compared with a net cost of $2.00 per pound at present retail for the respective items of the package, as they were now distributed and marked up. This meant that the same items with which we furnished our dwellings might be made available en masse at 50¢ per pound instead of piecemeal at $2.00 per pound. The mechanical facilities project demonstrated that a super-mechanical standard of living could now be made available in mass production at $4500 per family or $750 per capita, instead of as at present for $18,000 per family or $3000 per capita.

Because the super package just had "too-much" unusable luxury (there would not be time to use all the included items), there was a methodical review by each student and the optimum fraction chosen by any one student on behalf of his family was only ⅓ of the super package—the described standard of living package if mass assembled could thus be made available at $1500 per family of six. This could be amortized at present official permitted time banking of 3 years, i.e., with insurance and finance charges, at $50.00 per family per month, all paid up in 3 years.



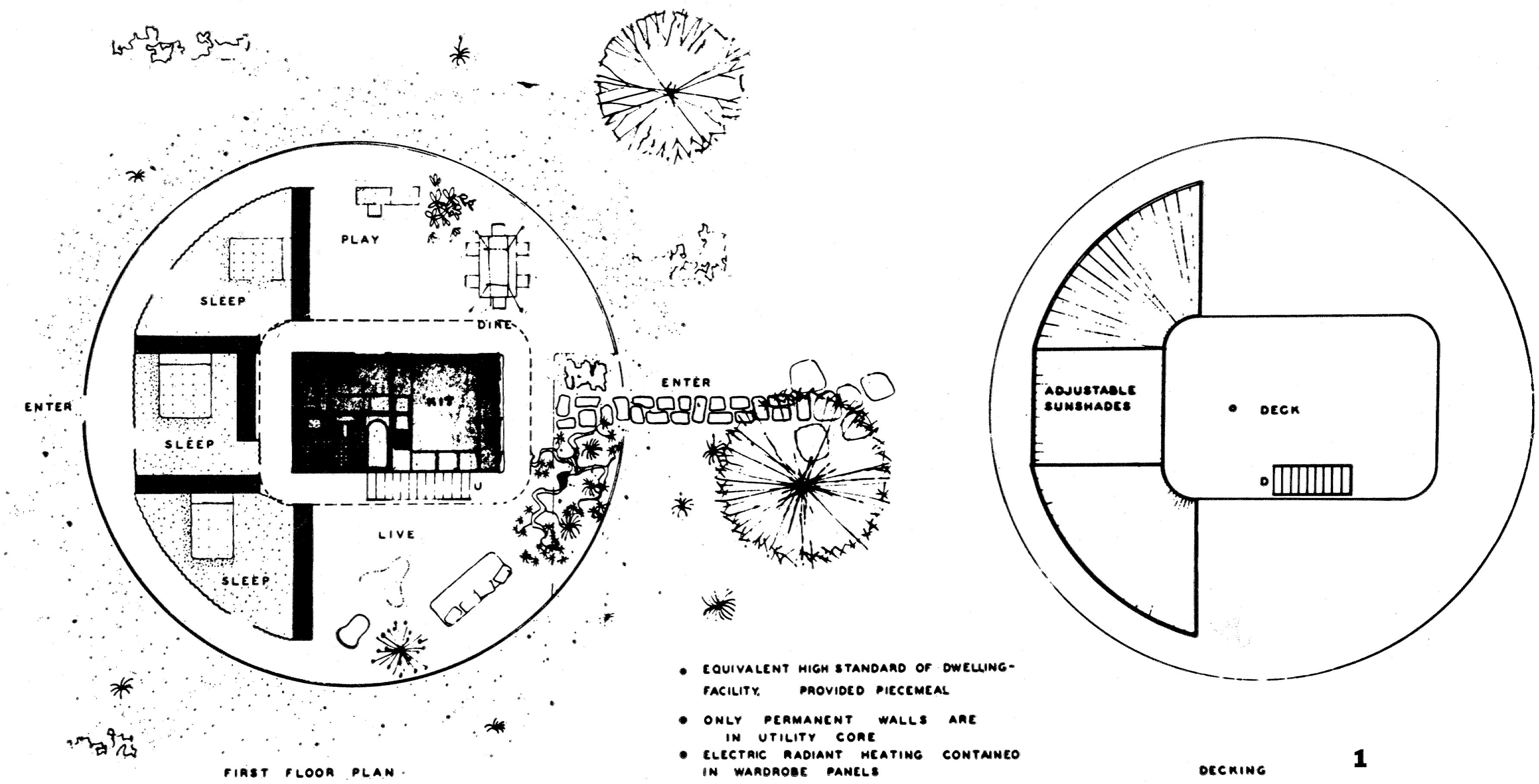
THE INDUSTRIALIZED HOUSE

Incorporating Fuller's Geodesic Dome & Standard of Living Package

The Bemis Foundation and the Department of Architecture at Massachusetts Institute of Technology have endeavored, through special courses, endowed research, and periodic conferences, to stimulate and encourage the study of the industrialized house. For the 1952 Housing Conference, held at M.I.T. during January, groups of graduate students prepared plans for the development of a 275-acre site in Wayland, Massachusetts. One team, composed of Thomas Marshall, Walter Roth, Harry Goleman, Robert Fowble, Vernon Shogren, John Rauma, and Alfred Moffett, worked with Buckminster Fuller on new concepts of design incorporating Fuller's Geodesic Dome. The following explanation is an excerpt from the presentation of their designs before the Conference.

. . . The design concept does not include such criteria as public acceptence or profit but rather we have tried to carry on a scientific prototyping activity to show how the house product can be designed for performance. We are interested in making a better house rather than realizing an immediate profit. This might be compared to the airplane—a considerable period elapsed before the airplane became a sound financial proposition.

. . . We envision three prototypes of this structure. The FIRST could be accomplished today. We could go out and purchase the inventory needed to construct the structure shown in drawings 1, 2. As you can see we are still tied to the standard type of mechanics. But we have



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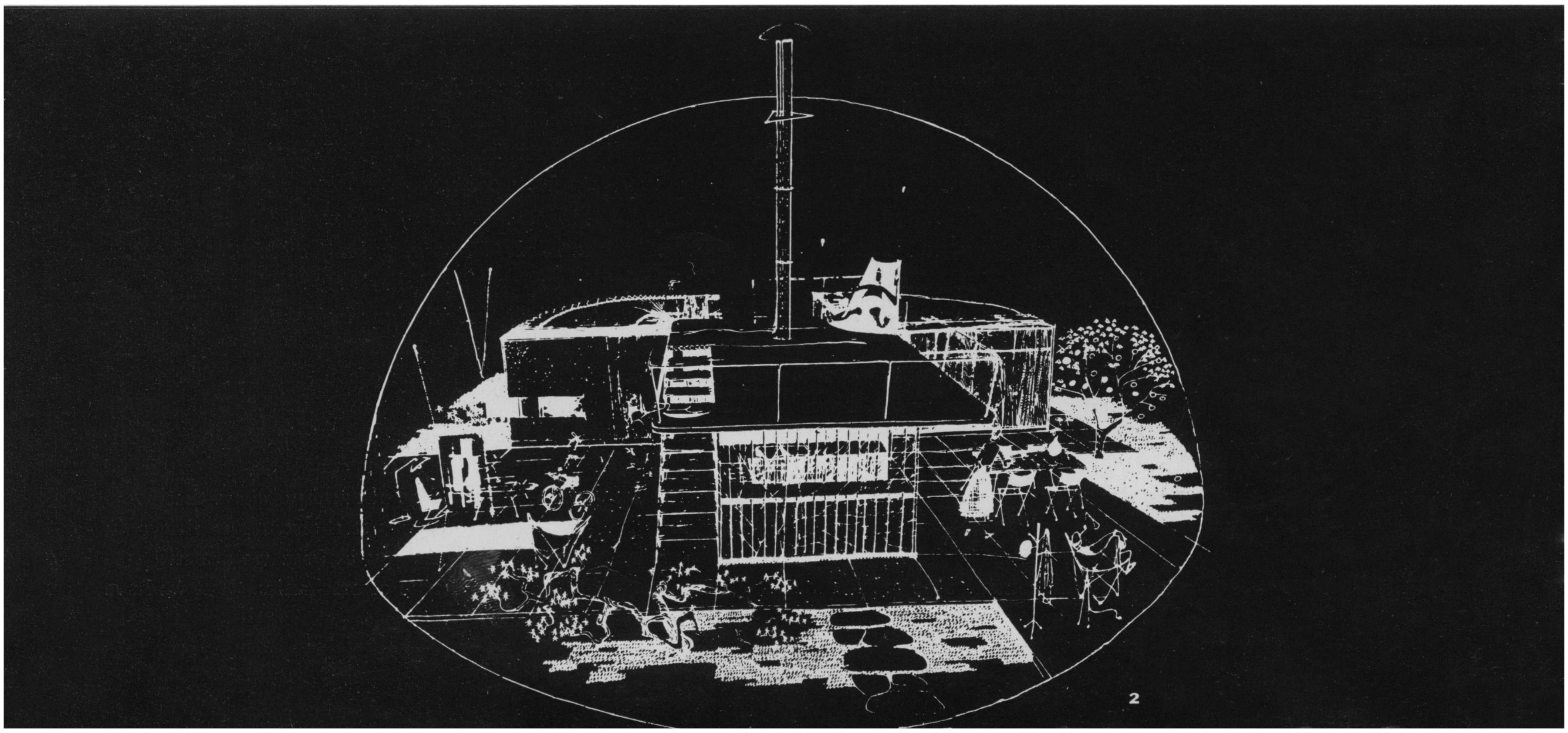
arranged them in a core unit on the center of the dome and around it are the other dwelling facilities.

The SECOND prototype, drawings pg. 35, 3, would be possible a few years hence. It would not involve any prolonged research or development—we would merely attempt to reduce the cost of the mechanics by packaging them. In this scheme we have taken the Standard-of-Living-Package and combined it with a Utility-Energy-Package which contains all of the necessary mechanics. The packages unfold and the walls of the package drop down and become floors.

The THIRD prototype, drawings 4, 5, is the result of our intuitive feeling of what might develop. It is projected for 20 years hence and



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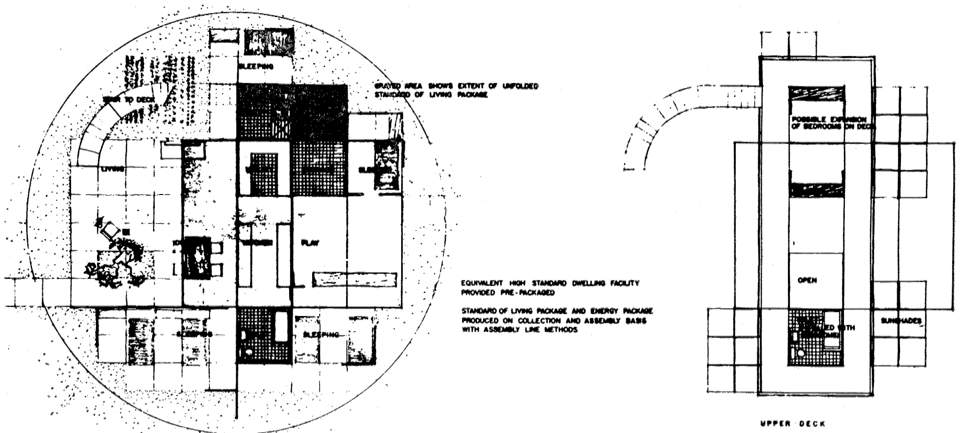
therefore difficult to describe because you almost require a new language. The water source is rainfall. We had information which led us to believe that this might be possible. A place which has an annual rainfall of five inches would have a water source which would provide five gallons of water per person per day. So the dome would be a water shed, deflecting the water to the perimeter, where it would be collected for treatment and storage under pressure. There would be no pipes —we are merely using a hose, possibly of plastic, designed with a facility for heating the water at point of use. For bathing and washing we would have an atomized pressure spray of detergent and water. It would require only a very small amount of water. When one of these was designed at Chicago, it was found that a whole bath might be taken without leaving a drop of water on the floor. The spray is carried off in the air.

For the floor of the house, panel tetrahedrons would be made of three way laminated fibre glass and plastic. We used aluminum tubular supports with a rigid connection at the edge, forming a series of triangular tables. These tables can be adjusted so that a man starting to build a house would merely erect one, and depending on his site and the proposed disposition of his living facilities, would be able to add the tables required.

The dome might be built in various ways. First a tubular structure of aluminum with universal connections at each vertex. A Saran tent would be hung from the structure. The second system would be a construction of diamond-shaped panels made of fibre-glass laminated plastic.



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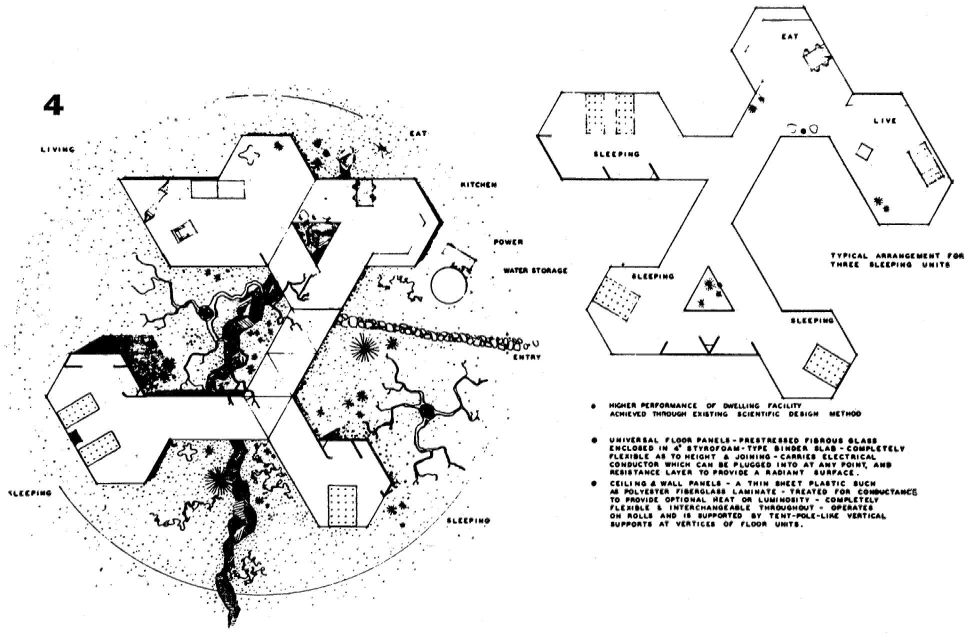

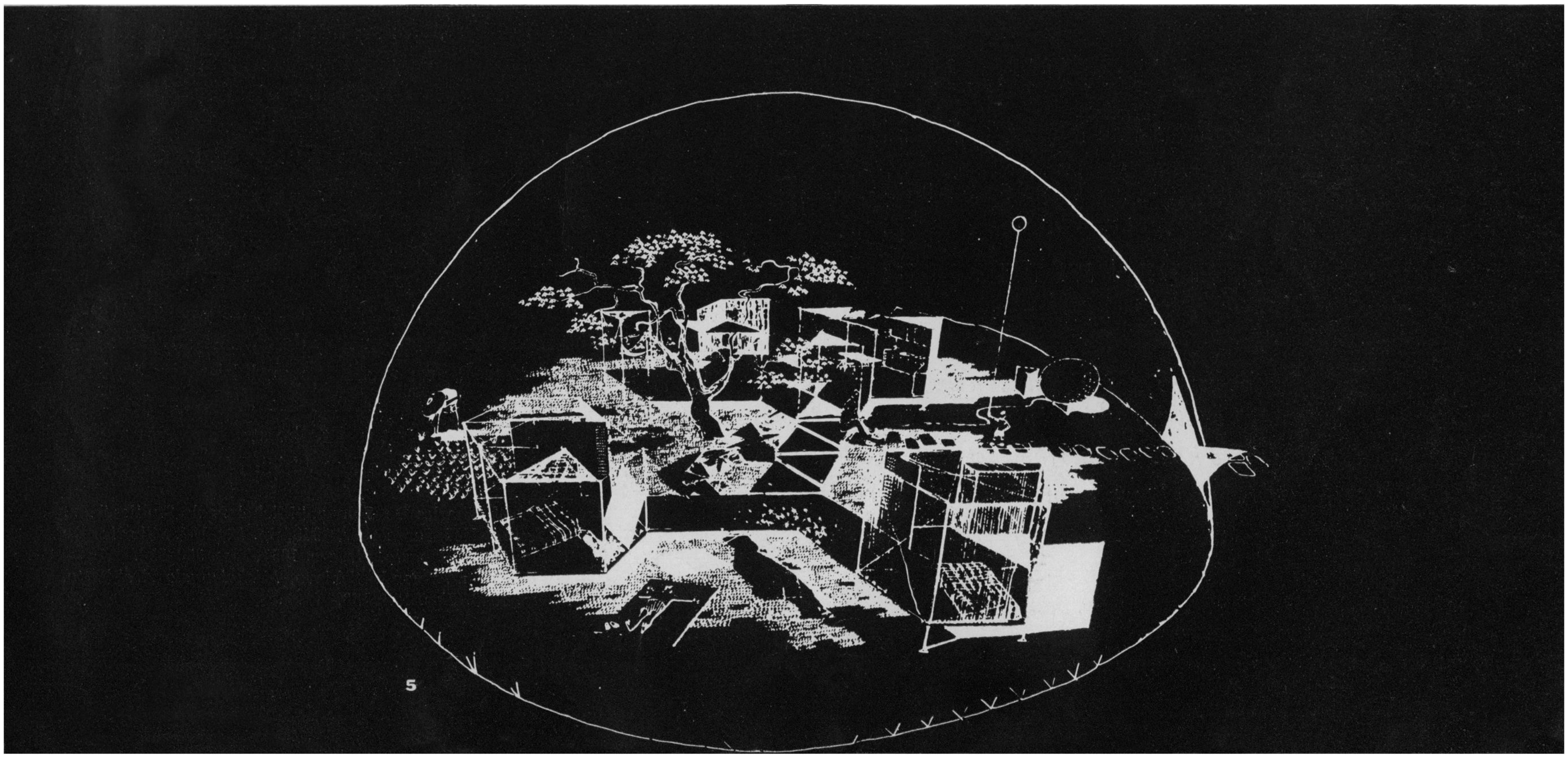

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