This magazine was originated by students of the School of Design and is maintained as an independent student project.

Editor: Forrest W. Cole, Jr.; Business Manager: Paul S. Shimamoto; Associate Editors: Ralph L. Knowles; Layout and Typography: Roger Montgomery; Photography: William Campbell, Jr.; Subscription Manager: Harry Mosier; The Staff: Betty Ann Easter, Harry Ellenberger, Irvine E. Jones, K. Vernon H. Smith, Jr., Charles Winfield. All material in this issue is copyrighted by Student Publications of the School of Design—1954, and no portions may be reproduced without written permission. Published three times a year. Postage subscriptions—$10.00 for one year; Regular subscriptions—$6.00 for one year; Student subscriptions—$4.00 for one year; Individual copies—$1.00. Editorial and business offices: Box 5973, Raleigh, North Carolina.

THE COVER of this issue is a photograph of a faceted model of a hyperboloid of one sheet. This model was developed for aerodynamic wind tunnel test in conjunction with the investigation of double curved surfaces now being conducted by the fifth-year class of architecture. (Photograph by Ralph Mills.)

VOLUME 4  NUMBER 2  WINTER 1954

3 Pier Luigi Nervi  CONSIDERATIONS FOR A CURRICULUM

7 Atilio Gallo  INTRODUCTION TO THIN SHELLS

20 Roy Gussow  1 BEFORE 2

82 Margaret Lemle  SKY-EYE

34 Irwin Jones  ESTHETICS AND SURVIVAL

41 Buckminster Fuller  FLUID GEOGRAPHY

plus the Dymaxian Airaccean World map

STUDENT PUBLICATIONS OF THE SCHOOL OF DESIGN
CONSIDERATIONS FOR A CURRICULUM

Recently when the School of Design decided to make some curriculum changes they formed a committee to present various questions to selected educators, scientists, philosophers, engineers, etc. in an effort to obtain broad opinions as to what one should consider before establishing these changes. Of the answers received, we particularly felt that the following paper by Italian engineer Nervi was constructive as well as interesting.

A program for a graduate School of Architecture should depend upon the answers to the following three questions:

1. What ideas and ends will building construction be directed toward in the future?
2. What "forma mentis" (mental attitude) is necessary to understand such ideals and ends?
3. What is the best educational system to develop this "forma mentis"?

In order to understand the laws of the physical world, humanity is unquestionably being directed toward a scientific-technical attitude, both for the idealistic wish of knowledge and for the knowing use of energy, materials, and production. Each scientific development represents an established truth taken out of our hands.

Each technical improvement is a step forward toward the integration of the type-solution (prototype) with existing physical laws which are valid and constant in their time and place. Large bridges, airplanes, vehicles, fast boats, and mechanical solutions clearly show the type-solutions toward which they are definitely directed, or those they will reach after some period of time.

It is interesting to see that in the social fields we are also leaning toward a more truthful humanity that is based upon people with equal rights and equivalent standards of living. The false, unnatural caste systems and the hereditary supremacy of only a few families can now be considered as ended forever. With them also disappear the impressive estates and the great palaces that were typical expressions of the architecture of the past.

We also have to consider the type-solutions, as parts of an increasing number of formal bases into which the most free technical solutions are being assimilated. This is clearly shown if we observe the influence that the streamlined forms of airplanes and fast vehicles have had over slow vehicles and even objects for domestic and common use.

It is very difficult to explain why the most technically perfect forms, closely conforming to physical laws, are, with few exceptions, satisfactory to our aesthetic taste. It is undeniable that a well designed machine, a large bridge, a perfect static structure.

Translated from the Italian
that it prevents the designer from producing comparative solutions. Besides, each statically complex structure has to be solved through calculation for verification.

The heart of the matter is developing an educational system which will give the student a mental awareness of statics and the mechanics of an approximate method of calculation. The problem is very difficult and depends upon the answer to this question: Is it possible to acquire intuition of statics and the control of an approximate method of calculation without going through the complex study of the building construction has taken stride—a stride which will be increased in the future.

These brief premises show that the architecture of a town would need to be re-defined on a new basis, on a more technical one, with the progressive diffusion of the scientific-technical ability, the social, economic, and structural problems and their relationships to the character of type-solutions. With this spirit architecture will find its place in the combination of structures and its possible its quantitative evaluation, without completely developing the entire theory of elastic systems and its relation to higher mathematics?

It is clear that if we accept this as a fact, it will be necessary to introduce into the architectural school such subjects as higher mathematics, physics, rational mechanics, and construction sciences as a level at least equal to the ones existing in the very best engineering schools. If this happened, the amplitude and difficulties of the study of architecture would be practically insuperable, added to the impossibility of relating mental approaches so different as the analytic-mathematical of the deep theoretical research and the synthetic-intuitive one characteristic of architectural creations.

I believe that an effort should be made to organize a program where the structural and spatial field is directed toward the conceptual understanding of the phenomena of statics and the use of an entirely new approach, with the approximate formulae sufficient to give the static aspect of the resistant elements of a structure. I think that if starting from a solid base of elementary statics (composition and decomposition of forces, general equilibrium of a system, behavior of materials affected by loads, indeterminate static system) it would be possible, through the use of models, analysis and critical interpretations of complex structures and examples of practical exercises, to arrive at an intimate understanding of a complex hyperstatic structure, and to ultimately be able to determine in advance the hyperstatic unknowns of its division determined static systems.

The final step in calculating a fixed-end arch can be reduced to the elementary principle, the hyperstatic arch if based upon intuitive considerations can approximately determine the points of the curve of pressure in the key and bases. Every hyperstatic structure, when understood and interpreted in its fundamental way of resistance, allows a preliminary evaluation of the unknowns that can later be solved by a system of known equations. In more complex cases it is also possible to decompose a hyperstatic system into a determined static system with the intuitive evaluation of the residual unknowns in mind.

I particularly consider the use and study of graphic statics as being important in the understanding and analysis of resistant systems. Graphic statics shows the play of forces, inflexion, and decomposition much better than the analytical method. I am glad to have been able to check the practicality of this approach for structural
problems through several decades of constant work, and the extensive exact calculations carried out by me and my collaborators have never fundamentally changed from the initial hypotheses.

We can have the same approach for the other related fields of architecture, such as heating and ventilation, air conditioning, hydraulic engineering, mechanics, lighting, etc. Subjects of primary importance are those related to the profession such as the History of Architecture, Freehand Drawing, and Architectural Composition which are, more or less, considered from an aesthetic point of view.

What aspects of the architecture of tomorrow (without formal ties with that of the past) will have to be studied? The past has also had very pure, truthful solutions related to subjects and materials of their times such as the Greek Temples or the Gothic Cathedrals. Truth is lost when the architectural substance is lost in pursuit of formal aspects; it reduces the style of a period to a few decorative elements applied to completely different organisms.

I believe that the study of the History of Architecture should be directed so as to emphasize only the art of building construction which although common in essence, is sometimes different in form, as is found in the stone structure of a Gothic Cathedral or in a well balanced reinforced concrete structure. The beauty of a work is obtained by the harmonic composition of the equilibrium of action and reaction, the relationship of columns to spaces, and the number of schemes all determined by the distributive and static characteristics of the individual architectural problems and not related to predetermined methods or forces.

It is possible to see that the expressiveness of an artistic manifestation is directly influenced by the unconscious mood of the author through whom it reflects the atmosphere in which he lives.

In summarizing, I believe that a good solution to the difficult problem of teaching in schools of architecture is to make evident a creativity which is based on the limitations and potentials of the various disciplines, I would say that it is worthwhile, after developing some of these disciplines, to devote a year to a comprehensive design, assisted by the Professors of the coexistent fields such as Architectural Composition, Techniques of Construction, Technical Installations, etc., in a way that will allow the student to acquire the ability of contemporaneous coordination, and the reciprocal subdivision of the essential elements of an architectural work.

I consider it also very important to limit the study of drawing to its truthful function as the indispensable representative medium of a reality which is completely independent of the qualities of the drawings themselves.

The main mistake of the architecture of the first decades of the twentieth century was that of confusing drawings with architecture. It was thought that an architectural event (reality of form, volume, equilibrium of forces, composition and distribution of spaces, accomplishment of economic and social laws, etc.) was only the happy and harmonious play of lines on a sheet of paper.

Attilio Gallo, from Buenos Aires, is a structural engineer who has calculated and built many long span thin shell structures in Argentina.

INTRODUCTION TO THIN SHELLS

In the structural field which deals with long span bridges we have found that reinforced concrete structures, because of their excessive weight, cannot efficiently compete with the relatively light, economical metallic structures. Some prestressed concrete bridges have reached the limit of development; but still they are unable to rival the ones constructed of metal.

In the structural field which deals with light shelters composed of long spans, the highly specialized field of reinforced concrete reached an unprecedented level when, in 1965, Dr. Ing. Diezinger introduced us to the thin shell concept and illustrated its maximum expression in the Leipzig Market. The great spans and the economy of material that was obtained with the Zeiss-Dwygwig system allowed thin shell concrete structures to advantageously compete with metallic structure; for certainly, some of these projects, such as Diezinger's span of 800 feet, tend to make this system one of the wonders of our time.

In order to appreciate the success of reinforced concrete in the field of light shelters, despite its inherent excessive weight, we must mention two things that Diezinger introduced into the science of construction: the membrane, and the new form we call the thin shell, whose properties have yet to be analyzed.

A new path has been open to architects and engineers with the application of membranes to such materials as

Translated from the Spanish
light metals, fabrics, and plastics; for the conditions of our time require us to cover huge areas with a minimum of supports. Although we now have a great deal of experience in the application of prestressed concrete to large span shelters and to certain other vertical barriers to prevent the application of the continuous membrane or lattice-skin concepts to other materials that are better suited toward solving the problem than reinforced concrete.

THE NETWORK

Let us consider a string which is two feet long. Can we stretch it so that it takes a perfectly straight line? Yes; there is no difficulty (figure 1). Now can we repeat the same test if the string is 1000 feet long? Certainly not; for the string's own weight, when stretched, introduces a transversal stress which leads to a known curve: the catenary.

If we increased the tension $F$, the deflection $f$ decreases until the string reaches its maximum resistance. It fails before reaching a deflection of zero. If we want to maintain our string in equilibrium it will be necessary to join it to two fixed points and to keep our stress constant.

Application: a. Now let us rotate a flexible cable around a central column and fixing it in sixteen different positions as in figure 2. The column will take all of the load and the ring will maintain all the horizontal stresses in equilibrium. The cables will take a catenary curve which will be connected by concentric rings composed of cables of a smaller resistance. We now have a surface as a reticular structure which can be covered with a very light skin. It can only absorb tensile stresses. Its equilibrium is obtained by securing its reinforced edge to certain very well defined points. Study will show that there are an infinite number of shapes that this type of structure can adapt itself to.

THE MEMBRANE

If we take a network and successively increase the number of meshes per unit of surface area while simultaneously decreasing the weight of each string, we will have a web with the same structural features of a net work; and, if the meshes of the web are infinitely small, we will have a structure which is called a membrane, a skin, or a film.

Membranes are structures with a very small thickness relative to their surface areas. They are extremely flexible and can only resist tensile stresses. In nature we find an infinite number of membranes such as a drop of water or the skin of an apple. Examples of artificial ones can be found in a sheet of paper, the silk of a parachute, the envelope of a dirigible, a plastic tablecloth, or a nylon stocking.

Application: a. If we cover a ring with a membrane and hold it tight against the rigid edge we will obtain a flat surface of limited dimensions. Suppose that a sailcloth covers a ring which measures 150 feet in diameter as in figure 3. If a simultaneous tensile stress is applied at the ring to every point of the membrane, we will be able to reduce the sailcloth's deflection to a minimum, which is compatible with its resistance. At its central part the surface will be a catenoid of revolution, while at the edge the surface will be undulated because of the perturbations that appear as a result of the concentrated stresses from the reactions of the ties. The rigid ring will be submitted to a series of radial stresses $H$ translated into annular compression. The vertical components $F$ will be balanced by the cloth's own weight and by possible live loads. Disproportioned live loads, however, will produce tensile failures in the membrane.

This structure is highly economical (its cost reduces as the deflection $f$ increases); but, having its concavity upwards, it presents the unavoidable problem of drainage. It is possible, however, to devise several solutions to overcome this problem by employing the appropriate surfaces.

In figure 4 a very simple idea is represented, that of keeping the circular plan and the rigid ring on a horizontal plane. The surface is originated by joining a corresponding point with straight lines from the horizontal ring $ab$ and from a convenient curve $C$ ab. The structure is thus formed by a cable $C$ whose stress can be regulated, and a membrane, as in the previous example. The rigid ring is now under different stresses than those indicated in figure 3; but we will not discuss the problem here. We will
leaving the reader the task of applying the same system to rectangular plans, 150 feet by 300 feet, with diagonal cables.

**THE LATTICE WORK**

Let us now compress a steel rod (figure 5) with a stress $P$ proportional to its section. If the rod is short, its axis will remain a straight line. If the rod is greater than a certain length, we have rod curving and producing the known buckling ratio of $l/r$. How is it possible to avoid such deformation while keeping the same compression $P$ and at the same time increasing its length $l$? Obviously, it can be done by employing lateral supports at convenient intervals. The axis will then keep its original features whether it is straight or curved (figure 6).

**Application:**

a. It is possible to build a column with three longitudinal rods (figure 7) with a helical wire welded to them at established distances. Despite the small section of the rods, the equilibrium is secured by the rational location of these elements. By analogy, we can build a lattice with longitudinal rods under compression with transversal rods to overcome the buckling. The equilibrium will be secured if the lattice is developed on a cylindrical surface which follows the directrices and generatrices (figure 8) when the section of the rods is proportional to the external stresses. The fact that the lattice is developed as a cylindrical surface gives stiffness to the element which is a quality that is not present in flat lattices or isolated rods.

If we compress the directrices of the cylindrical surface (figure 9) we again obtain a state of instability; thus a double curved surface is required to stand compressive stresses from both directions.

b. In figure 10 we have a structure with a circular plan developed on a spherical cap and subject to symmetrical stresses at the joints. If the lattice is spherical and the angle is less than $55^\circ$, all the lattice bars will be compressed. In this structure we are able to absorb all the

1. The number of bars will be large enough to allow the use of straight bars between the joints; although, for clarity, we have shown only a few bars in figure 10.

horizontal components from the support reactions by the use of a tension ring. At each support we will have vertical reactions. The section and the moment of inertia of each bar will have to be calculated proportional to the loads and diameter of the cap at its base; for too great an $l/r$ ratio it will be present if we go beyond certain limits. If we consider a non-symmetrical load, such as wind pressure, the lattice is subject to internal stresses which will tend to deform the lattice (figure 11) and thus the entire structure. By correcting this with diagonal tension bars we will form the structure which is known as the “Schwedler Dome.”

c. For practical reasons it is often necessary to cover spaces with rectangular plans. In this case we will form the structure which we have already discussed we obtain the structures shown in figures 12 and 13. The surface of figure 15 is generated by a curved line $c$ that moves parallel to itself on the curved line $b$. In both cases the structures have to be reinforced at their edges by other elements known as diaphragms or edge beams so as to transmit the loads to the supports. Despite their apparent simplicity, these structures are very complicated, however, they do allow us to obtain large spans with great economy of material. By analogy, we can build a lattice working at the maximum efficiency that the section and material employed allow without danger of buckling effects. The internal stresses are either all tension or compression, but never flexure, provided the loads are always applied at the joints.

d. The structure of a rigid dirigible is a lattice work of double curvature. The builders of the Zeppelin approached it as a surface to be developed by transversal rigid rings to which longitudinal beams could be connected. The rigidity of each joint was acquired by using many diagonal tie wires. If we regard that form as a space structure, we can build its surface as a triangulated lattice with its double curvature providing the required rigidity (figure 14).

A greater resistance to dynamic loads is given by using the longitudinal axis as a position from which radial wires evolve on planes acting as the diaphragms of the cylindrical surfaces (figure 15), which we have already discussed.

2. Their construction will be pursued as soon as the structural concept is simplified.
This is very clear if we see how a ring is deformable by two opposed radial forces (figure 16) but becomes more rigid by introducing radial tension wires.

**THE THIN SHELL.**

If we take a curved lattice surface and increase the number of nets per unit of surface and simultaneously reduce the section of the bars, we will obtained a continuous structure with the same static properties of the called "thin shells." This name is derived from the small thickness of the shell relative to its other dimensions, however, thin shells are never as thin as pure membranes. The difference between thin shells and membranes is that thin shells are able to resist tension and compression while the latter are only able to resist tension. Despite their small thickness, thin shells are often able to stand some concentrated loads on reduced surfaces that would otherwise cause failures in membrane structures.

Similar to lattice works, there is no rule of thumb to the design of thin shells. As an orientation we can say that a thin shell has a thickness $t$ in an almost constant ratio with its radius of curvature $R$ as the resistance increases with the increase of its curvature. Thus the ratio of $t/R$ will be within these limits:

$$\frac{1}{100} > \frac{t}{R} > \frac{1}{10000}$$

Greater thicknesses do not belong to this type of structure, and smaller thicknesses belong to membranes.

The materials that are available for thin shell construction lead us to select certain proportions as being the most convenient for the fulfillment of practical aims. Thus we can say for a thin shell of double curvature that its $t/R$ is:

- for reinforced concrete $\frac{1}{100} < \frac{t}{R} < \frac{1}{800}$
- for duraluminum $\frac{1}{500} < \frac{t}{R} < \frac{1}{800}$
- for steel $\frac{1}{500} < \frac{t}{R} < \frac{1}{10000}$

3. Lord Raleigh has obtained membranes of a thickness of one micron whose $t/R$ could reach 1/100,000,000.

The determination of thickness based upon the radius of curvature, dimensions, position of supports, and exterior stress is a problem that can be solved only by a specialist applying the proper mathematical theories for the interpretation of such phenomena as statics, elasticity, and strength of materials. In many cases the mathematical solution of the problem is impossible; therefore, the designer often has to be guided solely by empirical data. As an example of the influence of the form on the type of resistance developed by thin shells, we have compared a cylinder and a sphere of equal radius of curvature and thickness (figures 17 and 18) on the assumption that both are built with reinforced concrete and using a safety factor of three. In this example we see that the diaphragm allows the cylinder to stand a load five times greater than the cylinder without the diaphragm while the sphere is able to stand a load 800 times greater than the cylinder with the diaphragm. We can also see the enormous resistance of the cylinder as a column:

$$\frac{800 \text{ psi} \times 33^2}{\frac{2}{3} \times \pi \times 33} = 13,200 \text{ pounds per foot!}$$

Without its curvature, as a flat surface two inches thick and 100 feet high, the surface could stand only 300 pounds per foot which is only about one-fourth of its own weight.

These examples are very simple ones; in practice we frequently use sectors of cylinders or spheres which present edges, that when reinforced, often make the mathematical problem quite complex; however, this does not alter the major concept. Thin shells composed of a sector of a cylinder are well known in the field of long span structures (figure 19).

Frequently the question arises as to what is the largest span that a thin shell can reach with a given thickness. In a cylindrical structure similar to figure 19 there are other factors in addition to the span $L$ and the thickness $t$ that are pertinent to the design, such as the width $B$ and the radius of curvature $R$ and $H$; and, if we do not consider all of these, it is impossible to answer the question.

It is good to remember that when the desired span is so long that when applying ordinary rules the thickness $t$ becomes too great (the appreciation of "great" is based upon weight related to economy) it is possible to adopt methods
that are able to accommodate a higher moment of inertia, such as those shown in figure 20.

DOUBLE CURVATURE

Alexis Carrel said that "if Prometheus or Archimedes were to be resurrected at this moment, they undoubtedly would guess for what end such an unknown organism as an airplane had been created . . . as in the human organism it is necessary to find its aim in the structure."

We can say the same about all organisms; whether they are a product of nature or of man, their structure is exactly related to their aims. In a few words, "structure" means the organization of matter in view of a predetermined purpose. All structures possess a form as its external quality. Its image, we could say, has no relation with any aim beyond an abstract geometrical idea. Forms are products of the imagination, while structures are products of the study of the behavior of matter under impinging forces.

In this field the shells of double curvature are especially appropriate; for, if the resistance of very thin sheets depends upon its curvature, the double curvature becomes its maximum expression. We see in nature that shells are always of double curvature as a manifestation of nature's aim to always obtain the maximum efficiency with the minimum amount of material.

There are an infinite number of surfaces of double curvature, and we have to apply several rules and a little imagination to create them; however, four procedures are known:

1. Rotation of a plane curve (generatrix) around a straight line (axis) on the same plane. They are known as surfaces of revolution, and they include the sphere; the circular, elliptical, or parabolic torus (figure 21); the paraboloid (figure 28); etc.

2. Translation of a plane curve (generatrix) parallel to itself resting on a curve (directrix) in another plane. They are known as surfaces of translation (figure 18), and their numbers are vast and not yet named.

3. Transformation of a plane curve (generatrix) similar to itself when rotating or translating. They are known as surfaces of similar sections, and their numbers are even greater than those above, e.g., a cow's horn; a leaf of grass; or a groin vault without edge (figure 23) which is generated by a circumference of a variable radius resting on another of fixed radius while taking advantage of double symmetry; or the cloister vault without edge on a square plain (figure 24), where the directrix is a straight line, and the generatrix is a variable circumference.

4. Projective transformation of a surface onto another surface by using the methods of projective geometry. They are known as projected surfaces, e.g., the ellipsoid of three different axis as a projected surface from the ellipsoid of revolution. With this method it is possible to easily adopt a solution that has been studied under certain dimensions to others with differing dimensions while still maintaining the same criteria.

Note: We will refer to surfaces of double curvature which are generated by straight lines in our discussion of The Ruled Surfaces.

Application:

a. Figure 25 shows a continuous surface obtained by a diagonal elliptical directrix A and a variable elliptical generatrix B which is parallel to the other diagonal. The longitudinal and transversal sections are not actually elliptical; thus the surface can be referred to as an informal ellipsoid.

b. A circular arch of variable radius moving on a fixed parabola gives us a surface which we can rotate twelve times to obtain the structure shown in figure 26. If this were to be built in reinforced concrete with a uniform thickness of three inches, we could obtain a structure of 150 feet in diameter.

c. A double curved surface composed of a spherical cap and a wave surface whose sections with co-axial cylinders are analogous. By developing the cylindrical surfaces we obtain the sinusoids of equal wave length but varying amplitude. These

5. Mathematically speaking, projective transformation includes the transformation discussed in the third procedure, but it is better to keep this classification for practical reasons.
sinusoid lines (generatrices) move as a circular directrix as can be seen in figure 27.

One of the objections to the design of these structures is the apparent complicated calculations that are necessary to derive these relatively simple forms. It is convenient to remember that very few surfaces of double curvature can be mathematically analyzed and that approximate methods are generally used for most practical applications. We should not forget that the structural theory of the mushroom column and slab was non-existent at the time when construction was very common. It usually happens that man’s imagination poses problems that are only later analyzed by mathematicians. Their analysis, on the other hand, then allow new imaginative developments.

THE RULED SURFACE

All second degree surfaces have already been mathematically analyzed, while the analysis of surfaces of a higher degree, which we have designated as surfaces of double curvature, are almost unknown.

Among the second degree surfaces there are only two that can be generated by straight lines, and they are thus called ruled surfaces. They are the hyperboloid of one sheet and the hyperbolic paraboloid. Their geometrical properties are well known but their application as thin shells is extremely scarce. Special cases, such as the cone and cylinder, are often used because of their developable surfaces; but they are of simple curvature.

Below we are able to see four different ways of generating surfaces of double curvature by using straight line generatrices:

1. The straight line generatrix moves parallel to a plane and rests on any two curves or straight lines (directrices). If the directrices are two non-coplanar straight lines, a hyperbolic paraboloid is obtained; if the directrices are non-coplanar lines, one straight and the other curved, or if both directrices are different curves, conoids are generated. (A special case would be the helicoid that is generated when the generatrix is perpendicular to an axis and simultaneously rests on a twisted co-axial curve).

2. The straight line generatrix moves touching three dual non-coplanar curves or straight lines. If the three directrices are straight lines, we will have the hyperboloid of one sheet. Surfaces arising from other cases have yet to be named. (A special case would be when the straight line generatrix rotates around a non-coplanar axis, thus obtaining a hyperboloid of a sheet of revolution).

3. The straight line maintained perpendicular to a curve which moves while resting on another curve or straight line.

4. A projected transformation of a ruled surface always gives another ruled surface.

No ruled surface can be developed as a plane without some deformation, and, because of this, they fall into the class of anti-elastic surfaces.

Application:

a. In figure 28 we have a structure which is formed by conoids, cones, and cylinders arranged so as to form a solid of equal resistance. Here the edges are subject to tensile stresses while the shell is almost completely under compression. A similar thing happens in barrel vault structures (figure 19) where all the conoids are different but can be derived by a projection from the central one. The fact that it is a ruled surface makes its construction relatively simple.

b. We have not considered the cases of the hyperbolic paraboloid and hyperboloid of one sheet as being known structures.

CONCLUSION

Networks, membranes, and thin shells are three cases from the same family of three dimensional structures. The common feature between them is their curvature or, to be more precise, the relationship between their thickness and radius of curvature t/r. For a constant thickness, the ratio t/r = 0.065 would designate a shell; a t/r = 0.001 would designate a membrane; a t/r = 0 a plane; and a t/r = 1 a solid sphere with a radius t.

We have established the relationship 0.01 > t/r > 0.001 as being the practical limits for the structural application to thin shells. If the shell is of variable curvature, this condi-
tion must be verified at every point. By acquiring the proper thickness, any curved surface can become a shell; for this is the way that a geometric form becomes a structure. The surface may be of uniform continuity as in the egg shell, or corrugated as in the scallop shell (pecten maximus), or latticed as some radiolarians (malöön); but, in every case, the continuous internal stresses will exist.

The thin shell as used in construction was first introduced by specialized reinforced concrete engineers, however, the inherent properties of the thin shell do not necessarily confine its use exclusively to reinforced concrete. Shells can be built using almost any material, but one must remember that its thickness will be smaller the greater the resistance to tensile and compressive stresses. The particular advantage of reinforced concrete is its ability to be molded to take any form, while steel and aluminum are especially appropriate for curved lattices which use like bars and joints throughout. Timber allows us to build lattice skins using bars or lamellas, and, when it is laminated with glues or nails, it makes possible the construction of timber shells.

A barrel vault roof resting on two generatrices secured with tension bars is not a shell because it is not a three dimensional structure. Its internal stresses are parallel to a transverse plane, and, as such, it is considered a planar structure. A cylindrical vault, however, becomes a shell when diaphragms are added to each end so as to act as supporting elements and thereby avoiding the tension elements. Thus we find many shells that are combinations of various curved surfaces or curved and plane surfaces.

We have purposely omitted the three dimensional structures that are formed solely by planes; these are polyhedral forms (tetrahedron, cube, etc.), and they are very interesting and perhaps very useful; but they are not shells because of their lack of curvature. We can say, though, that they are to shells as a regular polygon is to its inscribed circumference; but each plane surface is a "plate," and it is statically different from a curved sheet.

We have said that it is the "form" that gives thin shells their characteristic rigidity; but how is this form determined? We can only answer that it is the task of the designer, for whom there is no rule. The form is created by the imagination in an effort to solve a certain architectural problem.

The designer's imagination is free; but it must be guided by his technical knowledge and the greater his knowledge, the greater his results. Imagination, which is the creation of mental images, should not be confused with fantasy, which is the creation of capricious fiction. Imagination flows logically and objectively as thoughts; fantasy is unreal and illusional.

When the form has been created by the designer it is the duty of the engineer to analyze it as a structure in order to determine its characteristics for adaptation to materials and methods of construction. The duality form-structure is no more than the consideration of one unified problem under two different, but complimentary, viewpoints—one synthetic (design) and the other analytic (structure).

But is an analysis always possible? No; for the analysis depends on the technical and scientific knowledge of the engineer, and occasionally it is insufficient to analyze some of the simplest forms created by the designer. In many cases, however, an estimation, although only approximated, can be highly sufficient. One must not forget that a calculation, regardless of the number of figures it contains, can be of no value if it is based on a hypothesis that is not related to reality. In the field of structural analysis, a mathematical background can be a very valuable tool if a correct estimation of the known coefficients is made before establishing the exact formulas for the calculation of the internal stresses and the external reactions.

In order to analyze a structure, it is necessary to have a clear and logical understanding of the static problem as a whole along with a correct estimation of all the participating forces and elements. A very sharp and highly refined stress analysis is of less importance! For each new architectural problem, the designer creates a new form which is subjected to his experiences and intuition. The selected form requires a physical structure to bring it into reality and this must be obtained by a close collaboration between the architect and the engineer. This collaboration is successful only if the imagination of the architect is guided by a broad, although not necessarily a thorough, understanding of the problems in the technical field and only if the reasoning process of the engineer has deep foundations in the field of mechanics and is guided . . . by the imagination.
The photographs on the following pages are samples of work done by first year design students. As the captions will disclose, these are studies—"problems"—involving specific elements with definite limitations. The choice of both elements and limitations have a purpose which is directly related to the general sequence of a developing creativity. They are not arbitrarily selected. An attempt is made to isolate certain elements in order to study their interaction with the whole, to learn something about them singly before combining them with the many complexities usually involved in composition. In other words, as much as possible, all elements in the arrangement are maintained as relative constants except one. An example of this would be the problem of studying planes in three dimensional space. The volume itself retains its size, shape (cube or rectangular solid) and proportion. The material of which the planes are made is kept uniform and usually anonymous (white, neutral gray, or beige). Sometimes the size of the planes is kept uniform or, if modulated, they are done so within a modular system. The only element that is really manipulated is position—the placement of these planes within the volume to produce a particular space quality and interesting, efficient articulation of that volume. This is a scientific approach but with enough of the intuitive decision included to make it a balanced experience—a intellectual and emotional exercise. This problem can develop by gradually increasing the variables—such as first varying the character of the planes by utilizing different materials—then transforming the planes into volumes which can be visualized as complex planar structures; then incorporating certain structural requirements which would involve tension and compression in a realistic manner. Each selection brings with it some demand for concession. What the concession is, and whether the element is worth the concession, are questions which must be answered by every designer.

Most of the work in the first year follows this pattern—from experimentation to control. Application is only suggested since premature specialization brings about narrow viewpoints and impoverished the experience of a developing personality. This is also the reason why the problems are treated objectively. It provides a broader background of experience to which the student can refer. A wall, floor, table, or garden pool, all become planes objectively and can, therefore, be more satisfactorily organized in relationship to its function.

Perhaps it is because of its objectivity that this work is regarded as an art form, but the naive which eliminates children's two and three dimensional communication from the category of aesthetic expression also prevents these problems from falling into the same category. The problems are not entities in themselves, but the manifestation of a process and a step in a series of elementary studies.

The progress of the student is evaluated neither in terms of quality nor of production, but what is considered of utmost importance are the attitudes developed. Techniques are fundamental, but creative stimulus and desire for expression form the incentive to learn techniques. They are a means to an end, not the end in itself. The student must learn for himself through his own efforts. He does not study tradition, but instead analyzes the principles and factors which affect tradition.

The purpose of this approach to design education (and it might well include education in general) is to train and develop a responsiveness to the world, an awareness of the quality of all things—ordinary and extraordinary, the structure of a pebble, the craters on the moon; to develop the courage to approach problems on one's own initiative; and find equilibrium within one's self and with society.
to discover and express the structural qualities of a sheet material—paper
not a direct application but a demonstration of those qualities
No glue or fasteners of any sort
ABOVE—limited to a plane relationship
BELOW and RIGHT—Form or enclosure of mass

Lite quality—articulate area
use of gravity and interaction between surface
and liquid paint—colors optional
LEFT—free
RIGHT—geometric organization

line quality
exploit ruling pen and drafting tools
LEFT—complete freedom in six equal areas
RIGHT TWO—planes in space, transparency, overlapping penetration

plastic use of texture and value
transparency, overlapping, dual image
LEFT—ink and various methods of handling
RIGHT—use light, even texture, change

light reception, corrugated cardboard
plastic use of texture and value
typography as texture
value (light and dark) affected by line
space—relationship within the characters as well as between the lines
LEFT—plane
RIGHT—warped plane

warp plane with
drawn lines —ink, pen or brush
articulate three basic shapes with one continuous line
the gradients and edges should reflect the shape that is being articulated

enlarge one shape vary line thickness to suggest depth

articulate area with planes—low relief
not more than three thicknesses of illumination borders—overlapping planes—positive and negative
RIGHT—exaggerate third dimension—on in planes to masses.

sequential composition each area composed separately and fit in as part of a series
LEFT—horizontal and vertical lines, touching each other face of sides

UPPER—lines parallel or perpendicular to each other, 90 degree angle
dividing each other and sides
LOWER—line tangent to planes but free of each other and sides

UPPER—planes touching each other, free of sides—parallel and perpendicular to sides, lines on angle and touching sides
LOWER—in above but lines are parallel or perpendicular to each other or sides both use texture and value

UPPER—curved lines and planes
LOWER—free combination of any or all limitations

ingenious combination of linear articulation of volume and above problems there are four separate linear structures—balanced separately or in combination with each other

Planes in space
plane articulation of volumes, from linear versions, 6-9

Masses in space
masses orthogonal planes, change to masses, maintain linearizable space quality and scale—12"—18"
value study
black, white and grey shades
used as negative space
certained to form
folded or warped plane
one enlarged and
expressed with three
halftone—match value

equilized shape from
above superimposed on
triangle—no color
limitation—achieve
maximum transparency

enlarge and explode
original form
no color limitation

value study
photograph or camouflaged
photograph—work
directly with light and
shadow—exploit black
white and extended
grey scale

use of value or
shades to create
simple forms—one
line, pencil and
typographical texture

equip to color value
vertical elements
arranged horizontally;
high value, accent
with low value

different views of
small simple object
involves text, then
ordered with
linear emphasis and
few large color areas

above, with solid
color areas—low
value, high intensity
accent with high
color
horizontal and vertical
elements arranged horizontally
and vertically—low
value, accent with high
color

above, with linear
accent replace
color variation

above, combine
high value, high intensity
low value, low intensity
achieve maximum pliability

color plasticity used
to oppose dimension of
low relief. Low
plane of relief advance
with color intensity;
high plane, repeat
RIGHT and LEFT
same problem

color plasticity used
to camouflage or
distort relief

shape relationships
color changes with
background positive and negative

value, intensity
gradations radial
development

transparent overlapping
planes
low value, high intensity
accent with high value
high intensity
shapes within shapes
worked colored paper
process allows
last change

work within grid
make use of inherent
order; rubber ink
mat

cut paper, color—shape study similar
to one on extreme left, after arrangement
is completed it is rearranged into
more or less regular interchangeable shapes.
shapes are lifted, a new order is formed

photomontage
natural elements placed in unnatural
surroundings also permits clearer
visual story telling and the use of
psychological implications

support a common
brick not less
than 14" away
from table.
see minimum
drinking straws
and through
economy tents
structural efficiency

examine the use of
the wrapped plant as
a structural element
in nature.
utilizing the qualities
of bent metal develop
a visual, structural, three
dimensional form which will
reflect some aspects of the
research, can involve willing,
reeling or saddling.

in nature.
Our knowledge of outer space is contingent upon
the development of instruments which can accur-
ately receive the faint signals which issue from it.
The most recently developed instrument for this
kind of work is the radio telescope which is used by
scientists today to conduct research on radio waves
from outer space which originate in the action of
hydrogen atoms. The waves, which make hissing
noises, are caught on an open-work curved-mesh
parabolic mirror and are amplified so they can be
heard by human ears.

Because of the necessary size of the mirror, 250
feet in diameter, and because of the importance of
its being aimed at the sky at all angles, a structure
built to house it must be very strong, precise and
light. Inasmuch as conventional types of mounting
have become too heavy, inflexible, and expensive.
Bucky Fuller and Jeffrey Lindsay, director of the
Fuller Research Foundation in Canada, have super-
vised the construction by Tulane University archi-
tecture students of a model of a new mounting sys-
tem. In Fuller’s solution, the mirror, the largest ever
built, would be housed in a ¼ sphere construction
300 feet in diameter, which would float in water as
lightly as a ping pong ball in a finger bowl. With
this floating suspension, the mirror could be turned
mechanically with great precision to track auto-
matically the changing position of any sky object.

The actual radio telescope based on the model
would be one-fourth lighter, (weighing 74 tons in-
cluding the mirror), and far more versatile than the
conventional steel radio telescopes now in use. In
addition, it would be approximately 50 per cent less
expensive to build. The spherical supporting struc-
ture would be made up of 1,100 cigar-shaped hollow
tubes, 88 feet in length, two feet in diameter and
weighing 110 pounds apiece. The tubes would be
made of glass-reinforced plastic and be joined by
specially patented joints of stainless steel. A relative-
ly small number of these tubes can displace enough
water to provide the buoyancy necessary to support
the whole structure.

If this solution proves successful, it will be a
mounting design as revolutionary in concept as the
instrument it supports.
Irwin Jones

ESTHETICS AND SURVIVAL

The author of this article, a resident of New York City, formerly attended Columbia College and is now a student of Architecture in the School of Design.

Laughter, that trait peculiar to human beings, can indicate at times, an attempt to exorcize the seriousness of an accusation, an unwillingness to face the obviosness which is occurring in a particular set of concepts or ideals. It is perhaps this kind of laughter which occurred recently when Bucky Fuller, when speaking to an audience, alluded to the insignificance and unimportance of the supposedly revolutionary ideals of esthetic refinement which we in this first half of the twentieth century have all been taught to accept. To challenge the idea that architects are distinguished from, and elevated above, the other workers in the building field by their intuitive knowledge of the refinements of form and proportion, and of the mysteries of 'space,' moreover, to insinuate that such a preoccupation on our part actually detracts from our social usefulness and well-being, is to step into our architectural ego. The self-conscious laugh that followed seems to reveal that we don't feel as secure in the value of our contributions as we might like.

Is it difficult to begin to understand why this insecurity is present in us once Bucky has given us glimpses of the full, psychological responsibility that is ours in assuming the task of design. We are shown that the field in which we must work has been expanded far beyond our normal areas of thought, both spatially and temporally. As designers, we can accept nothing less than the entire globe as the spatial complex in which our actions will have consequences. The near future will see this complex greatly expanded. We can accept nothing less than fifty years of the future as the practical temporal complex in which our actions bear consequences. Design in its most general conception becomes the distribution and apportionment of the energy available to us, the people of 'this' era. That what is said about esthetics is said in the forms of redefinition in design. Design becomes a basic social necessity whose problems are not those of day dreams, but of ultimate reality because it deals directly with survival, a survival no longer threatened by nature, but by the tremendous tensions created by the energy differentials between the peoples of the world, differentials made operative by our newly-born world society. When Bucky shows us what designing mean from now on, is it any wonder we laugh nervously and squirm a little as we think of our present preoccupation with developing a 'personal style' of worrying about someone stealing our clever ideas, or of being accused of having stolen someone else's.

Few of us can help being struck by the fundamental validity of this analysis and feel its power in the implications it holds for our future actions. But this problem of esthetics, so important in our present thought and seemingly neglected in this new thought, still holds us back. This was, after all, the noblest phase of the study and practice of architecture, the reason we were studying to be architects rather than engineers. What about esthetics?

To begin by comparing my (or anybody else's) subjective reactions to a Fuller dome and a house by Frank Lloyd Wright would defeat the purpose of this article. It would be accepting the widely held premise that esthetics is essentially a problem of refined subjective reactions which a few lucky people are blessed with while the rest of us suffer. The masses must forever remain incapable of real esthetic enjoyment. It is, on the contrary, the thesis of this article that esthetic experience is an inherent part of every activity, that esthetic value must be judged according to the same criteria as any scientific theory and practical action; that no one, above all the artist, can withdraw from social responsibility. A conception of subjective esthetic experience as closely woven with the whole of our life as any other experience.

In trying to discover the operation of the esthetic faculty, a very important phase of esthetic experience which we cannot overlook is that which many mathematicians and scientists claim they have. When a well worked out experiment, or a new, powerful mathematical deduction is made, it is very often called "beautiful." This leads us to suspect that that which is esthetic is not confined to fine arts, the arts of man, or even science, but is really a quite basic satisfaction which can be derived from almost any sort of experience. It is something which is a part of all actions, all thought and so very deeply important to all of us.

In order to talk about esthetic experience, it seems we have to first consider some of our fundamental conceptions of all experience. Any group of ideas about the world must eventually accept a basic value which determines the validity and worth of all subsidiary actions and thoughts. This value will determine the nature of reality for the people who accept it. Most systems of belief, for example, accept some notion of a god, or a deity, or a mystical principle as their starting point, and develop a concept of reality and of valid action and thought from that. Many people shall continue to do this in the future, and ultimately there is no way of proving this principle wrong. This is a vitally important and not subject to any rational discussion or judgment. However, the people who do accept a god as reality must live in "this world" and suffer with the rest of us; they must even accept the fact that the thoughts and actions valid in a god-reality are essentially irrelevant to the occurrences of "this world." The other basic value we can accept is one which includes as valid actions and thoughts none but those dealing entirely with "this world," namely, human survival. Reality becomes a series of problems the solution of which is necessary for survival. It is ultimately described purely in terms of sensation, of what we feel, see, hear, taste, and smell. There is a good deal of evidence gathered by psychologists, anthropologists to support the latter value. A person believing in a god-reality, however, would have no logical compulsion to accept these findings; neither would they have a logical right to use them. The ultimate difference in the two values is the eventual amount of physi-
cal and mental pain suffered by people in "this world." This fundamentalistic distinction in values would undoubtedly be attacked as a kind of extremism by those who wish to hang on to some apparent emotional comfort offered by the god-reality while taking advantage of the scientific developments of the survival-reality, but then they must forever face the cultural gap which yawns between the technical and socio-political improvements of the last four hundred years. They must give up any hope of closing this gap by other means than the catastrophic methods of totalism.

If we accept survival as the fundamental value and reality, then we must adopt ways of looking at the world which are going to enable us to deal with reality, to face it, and not allow our ways of thinking and acting to add to the problems we have to face. Unreal ways of thinking and acting are nothing less than fantasy of a potentially very dangerous kind. For example, many artists say that we can talk about esthetics as much as we like, but when it's all over, action is the only thing which accomplishes, which solves the problems. This type of sentiment contains the seeds of totalitarianism—too much talk, let's "do something." This is not to insist that anyone uttering such an idea is good material for the next S.S. troops or NKVD. But ways of thinking are transferred very rapidly from artistic activity to political activity and vice versa. The way we approach our problems is the real unity which exists between fields of endeavor, rather than any comparability of specific content.

If a particular approach to problems exists in a man's most important field of activity, it is bound to appear in others as well, albeit not in others too, and certainly not in the same way.

Action-thought is the tool of our survival. In order to work it must be able to gain control of our external circumstances through knowledge. Knowledge we have to come to think to be primarily associated with the mind or what we normally understand to be thought, in and of itself. Experience, however, occurs only through action, and without experience, we could never have any contents or substance to knowledge. What the mind does supply, we might call procedure. It is only after experience in the form of various sensations given to us by action is organized and ordered into various relationships supplied by thought that we have knowledge with a survival value, knowledge of reality. Action thought is not concerned with "things" with "units" or particular sensations, but with relationships existing between various sensations. Our perceptions of sensations are chaotic until organized. A familiar question in this respect is, "Is a penny round or is it elliptical?" When we look at the penny from the top it appears round, from an oblique angle, elliptical. What is the penny really like? This is a question we can't answer because there is no real penny in the sense of some absolute thing. "Penny" is a concept we use to describe a relationship of several sensations and sensations that is that is artistic, that is expressive, that is aesthetic, that is musical as something apart from the other arts. Music seems to be purer than the plastic arts or poetry. This difference can be explained on the basis that music organizes pure sensations of sounds, while poetry and plastic art have essentially dealt with secondary
activity is due to the sense of power and security created by the development of a series of relationships which aid in dealing with reality, with survival. Esthetic value cannot be an end in and of itself. It is a result of any activity which deals with reality. The esthetic satisfaction of a mathematician or an accountant need no longer surprise us. Mathematics, for instance, is the purest form of "science" in that it deals, not with the relationships of "things" but with all possible types of quantitative relationships. "Art" and "science" must be in quotes because we shall soon realize that they are capable of having the same knowledge value, and be subject to the same intellectual and emotional scrutiny. "Science," in particular, will include science, meaning "science," meaning that we will investigate the rigor of the scientist, those relationships in all relevant phases of experience which will make it possible to deal with reality, with survival. Once he is able to do this, beauty will be part and parcel of every joint as well as of the whole structure.

Because we become aware of structures through visual impressions, we cannot jump to the conclusion that architecture primarily concerns the organization of these visual impressions. Architecture deals with the relationship of stresses which occur in gravity-defying structures. Inasmuch as stresses are relationships between crystallized energy which exist in a given structure, they may be seen as a formal aspect. Ideally this aspect should correspond exactly with the pattern of stresses.

How can an architect presume to add value to a building by changing the visual proportions of structural members? The architect must not be a slave of structure, for it is said. This is similar to saying, "The architect must not be a slave to reality." Implicitle in these statements is the idea of a split between human personality and "material things." We, as people differ from structures and "material things" only in organization, in the types of relationships between our parts. We can try to escape reality, but we will succeed only in obscuring our knowledge and our ultimate chances of survival. Actually, the architect is a slave to structure only when he doesn't understand it or uses it inefficiently. He is free when he has found its most workable relationships. It is also said that the architect must "express" structure rather than explore it. It is hard to see what other visual relationships can better reveal the pattern of forces in a structure than those which result from the members of an accurately-designed structure itself. "To express" a structure in other than this way is to create an inefficient economic or structural relationship and a visual fantasy.

What is the only possible justification of these alterations of the proportions of various elements? The only reason offered by those who practice this kind of esthetic activity is that validity can this have? What can "modern" architecture mean? What is the architect who argues in this way say to a person who likes Grecian columns stuck on the outside of buildings? Is there really any difference between the classic columns around the government buildings in Washington, D. C., and the WF columns around...
FLUID GEOGRAPHY

A primer for the oceanic world

It is a sailorman's credo that there is a generic difference between himself and a landlubber. While admitting that sailor blood sometimes may be trapped in the veins of others, he believes that it never loses its dynamic procities. Though landlubbers may frequently oppose the course of the 'ship, course urge

in the same manner as a mechanical con

and perhaps of all spheres of activity it is peculiarly able to do so because of its necessity. Being the only one in our everyday lives. But what are our emotional needs? Emotionally, we have not been able to face the realities of the twentieth century. We feel in the same way our great-grandfathers did while having to deal with H-bombs and totalwarzania. Is architecture fulfilling emotional needs if it encourages fantasy and escape from reality; if in an age of urbanism and collective living, the ideal house is one deep in the woods overlooking a quiet lake; if in an age of light metals, plastics, and mass production, the ideal house is made of stone and wood; if in an age when people work in man-made surroundings and deal with man-made problems, travel greater distances more often, the ideal house "grows from the land" and "communes with nature." Our ideal house of today is an architecture devoid of any men of

Emotionally with today's reality but rather keeps them dependent on a set of ideals long since out of gear with reality.

Just as we can no longer think in terms of "things," we can no longer have emo
tional attachments to things, specific things such as texture and materials, particular places, particular items of art, music, furniture, clothing; specific ways of doing things; because particular must and shall change and they change more rapidly now than ever before. To remain emotionally dependent on particulars is to be sure of continued emo
tional insecurity. We must find new emotional security in people individually and

cooperatively. We can't impair the development in building of our knowledge for sur

vival by insisting on particular things to which we have emotional attachments, nor can

the architect continue to be the agent of such a process.

As a sailorman I have been inclined to suggest that the discovery of relationships among sense data is the process necessary for knowledge, that can aid our survival; that esthetic value and satisfaction is due to the sense of power and security resulting from such know

ledge; that it is only by accepting the ultimate value of survival, these conclusions as to esthetic value which follow from it, and the actions implicit in the whole, that the great gap between emotions and the results of thought can be bridged.

The images which I have been trying to give us, is, imagine, a little tinged with fantasy itself. The obstacles to be overcome by the plan of action implicit in this analysis are tremendous and so can constitute only a direction to follow, to my mind, the only logical direction.
sailor, what is really being demonstrated here is the principle transcending identity with either the sailor or the submarine.

One common observation of an effect of this principle is "necessary is the mother of invention." The sailor is thus forced to adapt to the changes that are made to the submarine. He has to come to terms with the submarine as he is. The submarine is not a new thing; it is the same thing, just differently adapted to the sailor. If he had no other reason than because land is now being explored on every work of art, he would be able to change the submarine, to adapt it to the sailor's needs. If the submarine is not designed for the sailor, it will not be used. If it is not designed for the sailor, it will not be used.

Unembellished by the peripheral sinuses necessary, first, to the point, the passing of the polar alternative of any solid, this projection is the joint result of a new mathematical theory and the development of the other of emancipation from the formal cartographic typology. With a new theory, the separate parts of a new theory are brought to the full light of reality. The particular assembly of isoic triangles accompanying this article is not the only arrangement. There are many other ways in which it can be developed for each. For, by 'picture psychology' focuses attention on the central portion of the mass. Yet residuals all other factors in appropriate contributory status. Each of the arrangements is as important as the other, depending on the geographical location with which the individual has habitually been identified.

The sailor may ascertain by inspection the most advantageous courses to his many world ports from the tactical centering in the ocean. He will make a point of reconnaissance. A quarter of whose uneven bottom crops up through the surface to peak and place in to the shore, he's coming in to the peak of a mountain range above four miles high, to our modern cosmic sailor, coming in to an airfield in Tibet over the Himalayas is approximately the same sensation as coming in to Puerto Rico over the Antilles range rising abruptly 2000 feet above the line.

There are also many rearrangements of the map to emphasize whole continental masses. By means of these elective arrangements, the maps are sometimes isolated within the special geographical environment of the peoples of any occupied upon their own set of conditions directions and proximity to all the rest of the world. A new world map is illustrated in a sort of a condition that we discover the dynamic leverage afforded our world approach to the spatial equilibrium. A variety of circumstances among other items, a theme of means for seeing the world from the dynamic, cosmic, and comprehensive viewpoint.

The Dymaxion Airscape World Map, Student Publication Bureau, University of Illinois, invented for this purpose, and while it is certainly to be benighted by subsequent inventions, it is for the moment the most reliable comprehensive projection, in that it describes the earth's surface with the minimum total score of distortions from the many well-known geometrical processes inherent in translation of the angle and scale information from a spherical to flat surface. This new projection makes possible the reassembly all on one plane of each and any of the continents in any of the arrangements in the composite of some of this one map makes to one another on the globe as one explores successively the infinite number of arrangements that can be visualized. The projection's division into East and West occurred as the offshoots drew into diametrically opposed positions in the course of their eventual encirclement of the earth. Growing out of its beginning in the eastbound, and westbound appearances progressively absorbed the lesser divisions of the areas. America, as well as the interweaving complex migrations.

The differences between the two spoor connections exist only in the effects of environment, blown upon their extreme diameters. The spoor developed at extraneous times in the period approximately like the Dark Ages.

The sailorman, alert to currents, can see the flows of history at the static historical view. A similar view to the one that has been described in the first quarter of whose uneven bottom crops up through the surface to peak and place in to the shore, he's coming in to the peak of a mountain range above four miles high, to our modern cosmic sailor, coming in to an airfield in Tibet over the Himalayas is approximately the same sensation as coming in to Puerto Rico over the Antilles range rising abruptly 2000 feet above the line. The next flow in the direction of least resistance, and because the earth was too great for the north, the least resistant direction was set to a direct north-south direction. The seas of the generations are directionally random extension. The central core of the world is assigned one-twentieth of the world's population to an insecticide, fragmented, and distorted Asiatic borderline position.

The sailorman's interest in world history relates only to the narrative, and where he is in the world, and how his component parts of his unit globe. All history 'pays off' to him in his relation to the Chinese and Tibetan coast, along the Aleutians and eventually down the coast to the Americas, with myths of subterranean spearmen, penetrating the world from the main trench. The newer to the main story, the larger and more plentiful were the feasts.

As offshore to this first major spearhead coasting northward from the Aleutian Islands, reaching the Bering Sea, then to the eastern half of America, then to the western half of America, then to Japan, then to China, then to the Ainu, as the Mongol, called Mongol, then to the southward, then to the northward, a genus of their secondary way of travel, of thousands and thousands of years of the many different races of the world, the species of the many races of the world, the species of the many races of the world. Varieties develop distinct and unique characteristics. Many of the variations are the result of su- stained changes in radiation conditions. Many of these tribes reappear to the westward all the way from the Mediterranean to the Arctic Sea. They arrive in successive waves, for instance, as the Hellenotes, in the Aegean, and along the Danube. Some of these tendrils doubt back toward the Pacific. Fragments of their more recent and vivid eastern manner have sometimes occurred from gazing on eastern shores of the western margin of the early Asiatic migrations.

Despite this impressive inland migration, the great- est migration of the peoples of the world has occurred near the sea and flooded and formed along the fertile shores of many of the many rivers, where their progeny still exist as a teeming marginal life. Reeling our continuity backward millennia to the ancient original pool of civilization in Indo-China, let us inspect the continuing major spearhead.

The second spearhead, which broke off from the first at the Malayan tip, drifted out of the myriad interflows between China, and Australia. Though part of this sward drifting was by accident,
part of it must have been attempted by choice and as such constituted a competence of the air and not of that demonstrated by the people who hopped the coast. The separation of the boats on the rear was only a first screening of psychological types. This psychological screening took place not only among the navigators but also among the navigated. The navigated are those who are not used to the open sea. The navigation problems in this case are not defects of the navigator, but a function of the navigator. For this reason sea history plays an important part in de velopments of the navigators' problems.

Substituting on the less fertile soil of the islands, and of necessity forced to wander from time to time, the navigators could not so easily control their course of direction between the islands, nor indeed so easily control their latitudes for sailing better than at home to the wind. From this they discovered that they could not control toward the direction from which the force came. They discovered that wind and sail were not as efficaciously controllable as they were at home. This is the reason, of course, why the Western Sphere was not as consistently navigated as the Eastern Sphere.

In design, building technique, and materials, the show follows the practices of Biblical and pre-Biblical times. It cannot be ignored that the history of the best of the America's Cup Defender sloops, though it can be thoroughly impossible to discern the amount of a sloop's spars is most crude and difficult by comparison.

The Red Sea and negotiating the Ara ban Desert in the Persian Gulf, the Arabian Sea by boat, the East Africa Channel by sail, the azimuth and the journey of ships in the Mediterranean, where they appear as the earliest vessels of the Northern Hemisphere or number one seafarer.

Developing its technology at a slower pace, the major northwestern sphere came naturally and not directly to displace the square-rigger out of its down wind sailing junct. The foresail of the north- western wheel surface was first used by the shift west by caravans. The Rebel period of the ocean was the eastward direction. The Suez Canal is now westward in the face of the prevailing winds, whereas, before the invention, it was the prevailing winds in the Northwest.

How can we so be sure of all this? Because in mark ed contrast to the fragmentary character of man's land and sea travel records, the development of the boats and sailing types evolved throughout these centuries into a complete body of data. Only, the evidence may be found in operation today under the same rules that caused them to appear. The navigators were chartered by their own slow invention in the very same environment and paid in the same prices. These navigators did not have to guess how the ships operated before them. They demonstrated diatomaceous attitudes toward the sea and death that were characteristic enough to make the decision against self to death by the eastward Asians and stubborn reflux of it is nothing. The navigators were provided a design that would suit deepwater downwind, often over the horizon ever to return. It is, however, interesting that the way boat may be terminated. He does not question the forces, the oceanic pressure is the paramount force which decrees. The downstream flow is ignored. Hark-kirt will cancel the flow of the tide.

The westernbound sphere people of Europe and of the Americas in particular, were repeatedly shouting to the windward and back, working the adverse force. The challenge provided by death has invoked among them the advancement of technology in general but particularly the oceanic part. The Persian Gulf and the general ignorance of the life span. The unnatuitiousness of these to the present day is a common folklore. Yet, the ignorance is not always in the life span and only science can establish the extent of which has not been equalized in any other of the political forces.

It is sound scientific speculation that the Garden of Eden concept can be understood. Psychological differ ences exist between the western and eastern hemispheres. These are developed further in the application, the personal and political, of the extent of which has not been equalized in any other of the political forces.

Both concepts are noble. One concept obtains im mediately by self-pane and, by the experienced, by the untrained. The man-made proposal that the daily and regular life of the sailor and the men in uniform, conditions, winds, direction, currents, drifts, etc., is, method and heavily regulated by a system that is not due to the fact that the data may be years in reaching headquarters. Silly, impossible, impractical, but Mr. Ryan, gradually ac cumulated information, began to advise seacaptains in his January they took one route and on 12th another, they would reach their destination ahead of uninformed competitors. So impressively right did his predictions turn out to be that the United States then lend him his own book. He here is adding this dynamic newcomer to the early universal language, the language of the sailing world. His collection of data developed directly into today's fascinating meteorology which guides successful world flight.

Harking back to the dawn sailing advantages, which could have been popularly employed by the people of the Western+Europe, the Americans and the Americans in Europe. The Americans wanted to do it, but the English navy and the English people monopolized the eastern and down sailing below the coast it was the major navigational. The sea going seamen right up into and across their conti nents were the major forces of one of the ocean steamers technology. Seagoing technology was the major part of the American 'Indians'. Of course, western bound was considered the 'Indian' but the eastern bound was the more sead reft under adverse conditions. Of course, western work twice the windward, twice the downwind, twice the major trade forces to advantage. Already eastern bound windward work, twice the downwind, take the advantage. The windward bound would be terminated. He does not question the forces, the oceanic pressure is the paramount force which decrees. The downstream flow is ignored. Hark-kirt will cancel the flow of the tide.

The oceanic pressure is the paramount force which decrees. The downstream flow is ignored. Hark-kirt will cancel the flow of the tide.

The waters of the Persian Gulf and the general ignorance of the life span. The unnatuitiousness of these to the present day is a common folklore. Yet, the ignorance is not always in the life span and only science can establish the extent of which has not been equalized in any other of the political forces.
From the contents of recent issues of this magazine you have noticed that we have attempted to establish what we believe to be a valid relationship between the architect and his world community. You have also discovered that we have focused our efforts on what we consider to be architectural developments beyond the problems of human shelter.

Our aim for such a study is this: as the size of our community becomes progressively smaller through more effective intercourse brought on as a result of faster, more efficient communication, the sphere of our responsibilities becomes increasingly larger; so that, as students, we are no longer able to feel secure in dealing with isolated details designed to display our petty uniquenesses or peculiar styles. We prefer to think of ourselves as part-time-makers, co-ordinators of the many activities which must be successfully integrated in order to achieve a harmonious product. And, moreover, we prefer to enlarge our scope of activities so that we may be able to intelligently deal with such things as crop rotation, radio telephony as well as painting, landscaping, and, of course, the ever-present problem of man’s shelter.

From these same contents you have further realised that our contributors have been individuals who are actively engaged in a variety of creative fields. They have been neither all students nor all practicing men. Our reason for such a selection is plain—we simply cannot afford to make occupational prejudices when we can learn from so many.

—THE EDITOR

PATRON SUBSCRIBERS

Architectural Forum
Mr. and Mrs. Herman Amos
Miss Betty Lynn Barnwell
George Bell, Jr.
Harold Boericker, Jr.
Leisl N. Boney
Manuel Bronner
Charles W. Connelly
John A. Copeland, Jr.
William Henley Dietrich
Lawrence Eisenman
James W. Flintham
B. Buckminster Fuller
Roy Gurney
W. N. Hicks
House and Home
John Summerfield Jenkins
Dean Henry L. Kampafoer
John Knight
Edward Lowenstein
Anthony Lord
Lydon, Blount, Carlisle & Wolff

MRS. Stanislaw Nowicki
A. G. Odell, Jr.
Oliver and Smith
John J. Rowland
Mr. and Mrs. Teboo Shimamoto
Mr. Ron Shinnaker
P. Vernon H. Smith, Sr.
Ralph Walker
Edward W. Waugh
F. Carter Williams
Williams, Cole & Stinchard
Mr. and Mrs. C. H. Wimhoff
Richard L. Acker
Franck DePapoule
Kapoor and Higgins
Edgar Kaufmann, Jr.
Jeffrey Lindsey
Skillmore, Oving, & Merrill
Glenn Stanton
James L. Brandt
Lewist Mumbert

New York, N. Y.
Chariton, N. C.
Washington, D. C.
Wilmingon, N. C.
Raleigh, N. C.
Chariton, N. C.
Asheboro, N. C.
Raleigh, N. C.
Lincoln, Neb.
Raleigh, N. C.
Forest Hills, N. Y.
Raleigh, N. C.
Raleigh, N. C.
New York, N. Y.
Norfolk, Va.
Raleigh, N. C.
Greensboro, N. C.
Asheville, N. C.
Columbia, S. C.

visitors to the school of design for the winter and spring terms:

BUCKMINSTER FULLER: (Month of January) Comprehensive designer from New York conducting a problem with a group of architectural students and several open lectures.

ROBERT ROYSTON: (Month of April) Landscape architect from San Francisco (Ekbo, Royston, and Williams) conducting problems with advanced students in Landscape Architecture.

ALEXANDER ARCHIPEL: (January 25, 26, 27) Swiped from New York City conducting daily talks with students and one public lecture.

HIDEO SASAKI: (February 22, 23, 24) Assistant Professor of Landscape Architecture at Harvard University acting as visiting critic on special landscape problem.

CHARLES KAMEN: (March I) Industrial designer from Venice, California conducting seminars with students and one public lecture.


ROBERT LE NICOLAIS: (April 18 through 21) Consulting structural engineer from Paris, France conducting seminars with students of the school.

EDWARD SKLET: (April 1, 2, 3) Architect and city planner from Vienna, Austria conducting lectures on planning and seminars with students.

RICARD NEUTRA: (April 22, 23) Architect from Los Angeles conducting a public lecture and informal talks with students.

ROBERTO BURLE-MAARI: (May 15 through 29) Landscape architect from Rio de Janeiro, Brazil conducting a problem with advanced students in Landscape Architecture, a public lecture, and seminars.