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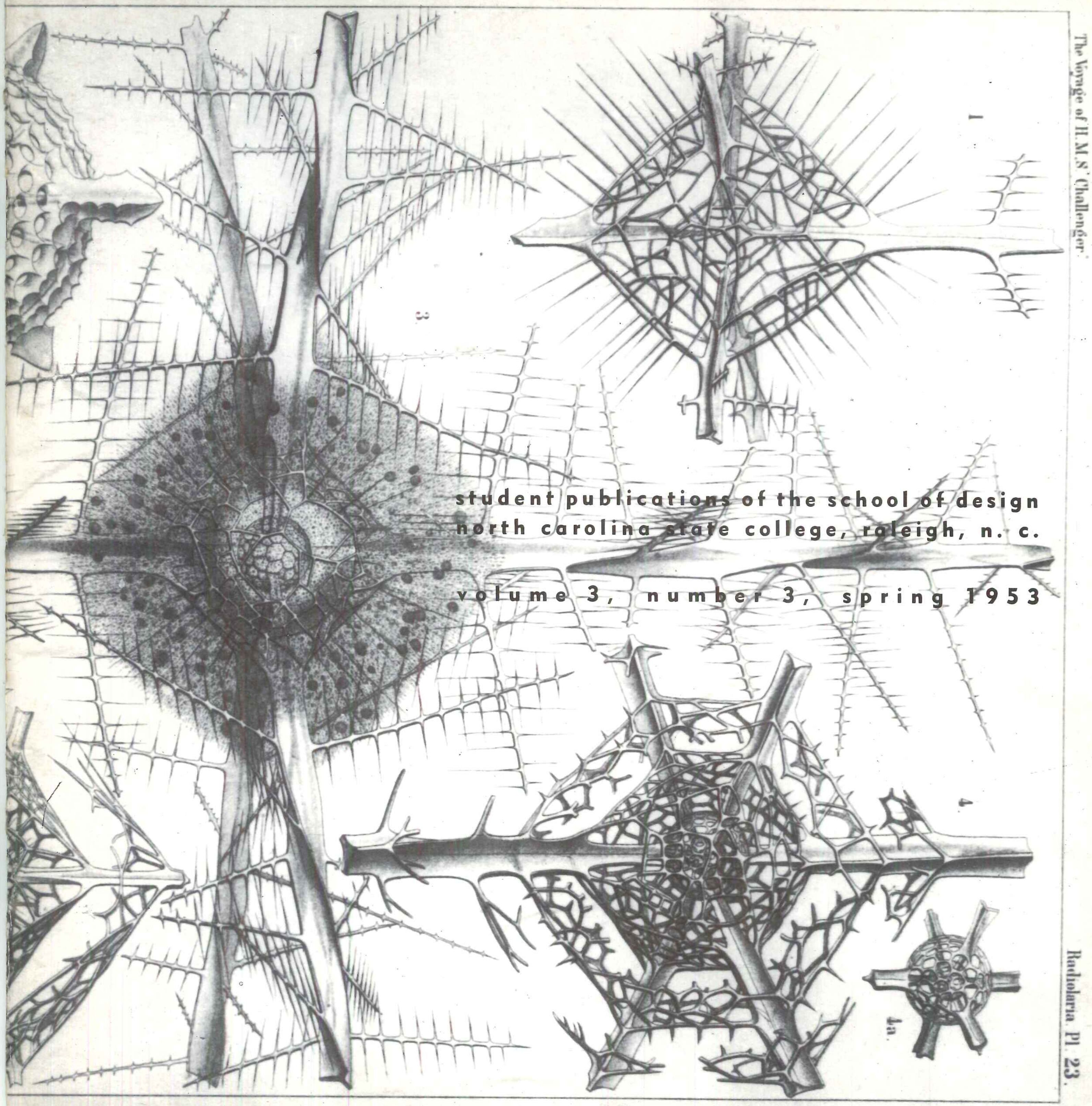

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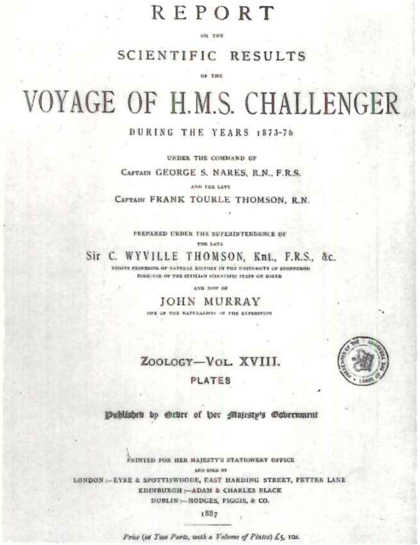
REPORT
ON THE
SCIENTIFIC RESULTS
OF THE
VOYAGE OF H.M.S. CHALLENGER
DURING THE YEARS 1873-76
UNDER THE COMMAND OF
CAPTAIN GEORGE S. NARES, R.N., F.R.S.
AND THE LATE
CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF
THE LATE
Sir C. WYVILLE THOMSON, Knt., F.R.S., &c.
AND NOW OF
JOHN MURRAY

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PLATES

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AS REFERRED TO BY ROBERT LE RICOLAIS
IN CONTRIBUTION TO SPACE STRUCTURES

THIS MAGAZINE WAS ORIGINATED BY THE STUDENTS OF THE SCHOOL OF DESIGN AND IS MAINTAINED AS AN INDEPENDENT STUDENT PROJECT

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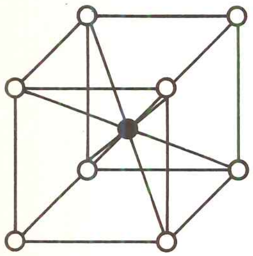
volume 3, number 3, spring 1953, raleigh, north carolina

R. Le Ricolais

CONTRIBUTION TO SPACE STRUCTURES

ROBERT LE RICOLAIS OF PARIS IS WELL KNOWN AS A CONSULTING STRUCTURAL ENGINEER. DURING THE SPRING OF 1952 HE CAME TO THIS COUNTRY AND SERVED ON THE FACULTY OF THE SCHOOL OF DESIGN AS STRUCTURAL CONSULTANT TO THE FIFTH YEAR DESIGN CLASS.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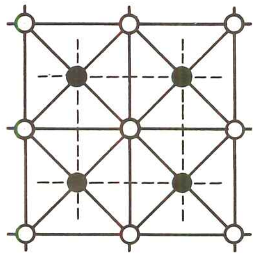
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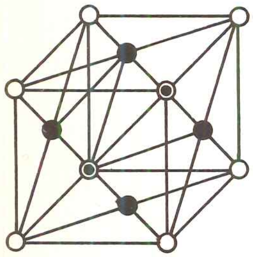
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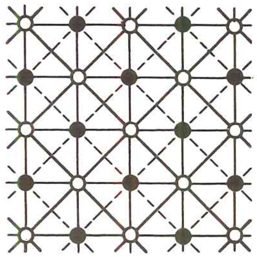
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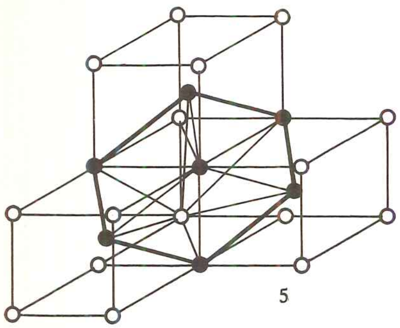
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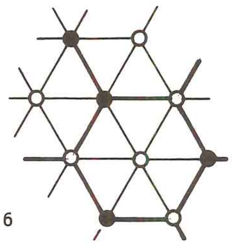
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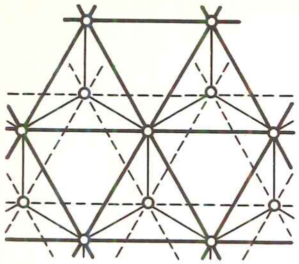
The notion of Structure is taking everyday a greater importance in the field of human knowledge, even with immaterial and abstract concepts; we hear, for instance, of: structure of thoughts, structure of mathematics, and so on.

This pervading intrusion of systematic anatomy of form and morphology is reaching now the art of building. In view of its positive and realistic object, the problem should be relevant in strictly mathematical terms, but we prefer an altogether different approach based on the study of elementary structures of crystals and a brief survey of some very curious natural organisms known as "Radiolaria", together with some experimental facts.

When instead of considering purely the geometric relationship of a configuration by itself, but rather in terms of its environment, geometry made a major step towards abstraction and also towards generalization, we strongly believe that the study of space structures should be considered in the same way, that is to say, with a topological mind. Seeing in space is not as we believe merely having a keen sense of the occupation of space by some physical object, but rather being able to grasp the notion of combinational arrangements in view of obtaining certain peculiar conditions.

Inspection of figures 1 to 12, dealing with the geometrical generation of three dimensional networks, is self explanatory and does not need further comment.

The main object is filling space with periodic configurations each enjoying definite physical properties, which with analogy to solid matter can be defined in terms of "isotropy", just like a moment of inertia with respect to its main axis. The whole problem being a distribution of bars such as to allow a minimum weight for a given area. As can be intuitively perceived, this condition is generally fulfilled when a maximum volume of the indeformable unit cell, or combination of indeformable cells, forms regular polyhedra, or combination of regular polyhedra, for a given bar perimeter. This statement is not only valid for parallel reticular planes such as are figured in square and triangular networks, but hold also in the case of rhomboidal unit cell (Fig. 5), but in that case, all bars are no longer equal, the short diagonal being $2\sqrt{3}/3$ times longer than the hexagonal side of the rhomboedron. This configuration appears as being a minimal, in other words makes minimum the internal energy of the system. The bee's hive tri-hedral lid shows a somewhat similar arrangement.



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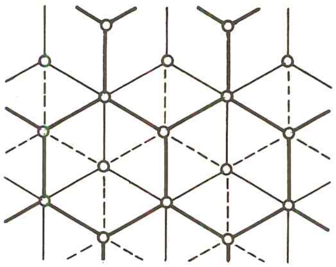

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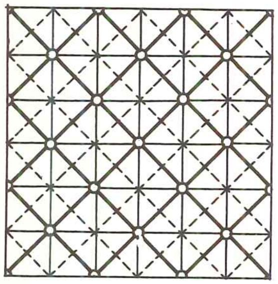

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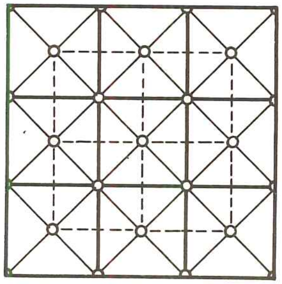

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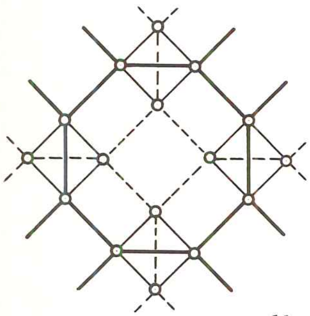

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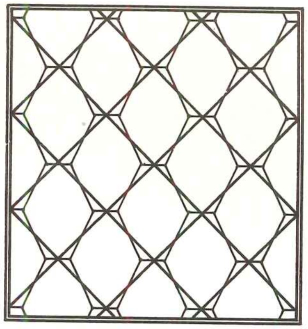

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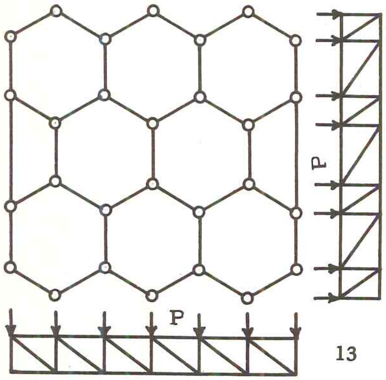

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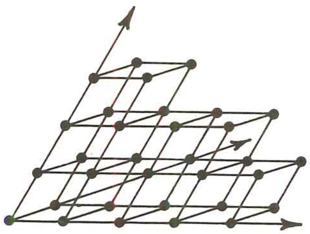

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Inspection of the unit parallelipipedic cell (fig.14) shows its components: the tetra and octahedron. Both square and triangular networks are generated by the combination of these two fundamental volumes. In fact, in an unlimited piling, both configurations would coexist. Considering now a unit cell of triangular network by itself, we find that it has 18 bars, just like a cubic frame with diagonals on its 6 faces. Instead, the square unit has only 17 bars. The first structure will be indeformable. This does not mean that square networks are unfit for structural purposes, but that when dealing with external forces distributed in all direction of space, the triangular network will yield minimum deformation. In the more simple case of vertical forces acting on the 3 dimensional net work, the classical procedure of analysis will easily give the solution, as far as the boundary conditions do not introduce redundant connections. In the case of a great number of cells, the method is simple but tedious, the usual attack is the "Joint by joint procedure," since the conditions of equilibrium require that in both vertical and horizontal planes the sum of the components for forces acting in the bars equal O. This is no place for a complete development, but nevertheless, let us state briefly that in 3 dimensions there are no string polygons, but instead, by virtue of reciprocal figures, a string pyramid. The stress diagram is then a space configuration, as an example fig. 15 will give the procedure for a graphical solution in elementary case. Topologically gifted students will find interesting relationships in such exercises and convenient methods for generalized cases, where algebraic methods may be checked. When dealing with determinate structures these problems present no difficulties.

Fig. 12 is related to a well known experiment of Lord Kelvin's on homogeneous partition of space, and shows a striking example of equilibrium configuration of a soap film. A frame with square diagonal wires is dipped into a soap solution; the square formation becomes instable and in spite of the difference of pull in the main axis, the hexagonal configuration appears.

Even in 2 dimensional trusses this hexagonal arrangement of bars should be more often considered. In fig. 13 is a truss made with hexagonal partition. It is not so much intended to indicate economy of material but a reduction of labor, since the connections are reduced in number, we will see more of this matter in our further development.

Before considering the practical interest of networks in modern design, let us open the book of Nature and make a brief survey of the unexpected intrusion of space frames in biology. Most of the documents shown come from Haeckel's "**Challanger Reports**" and date from 1873. They are related to shells of tiny sea organism called **"Radiolariae"** and belonging to the Protista class, that is to say, neither plants nor animals. This stupendous vocabulary of forms belongs to the ancient era of creation, where strongly geometrical structures prevailed. In my mind, they should be more than a mere curiosity, but studied carefully as highly elaborated pieces of work. From the application in Vierendel's beam, and the geodetic systems of Mr. Buckminster Fuller type they display all the structural knowledge we have. I have endeavored to show that some peculiar species (Sagenoaria Decranon) fig. 16, is a beautiful example of a triangular network, working together with a thin membrane called velum acting in tension. Most of these skeletons, fig. 17 & 18, are made with hollow siliceous tubes, quite similar to those used in air-craft construction. The reason for such economy of material is certainly a mystery of Nature. As it has been computed, the trihedral lid of the bee's hive carries only about 2% economy of material on the total. Refinements of this kind surpass by far our present Science of building.

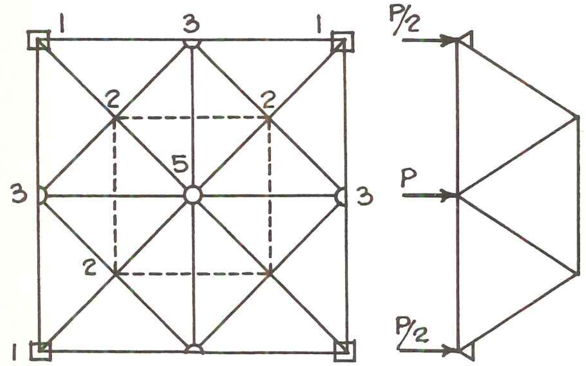
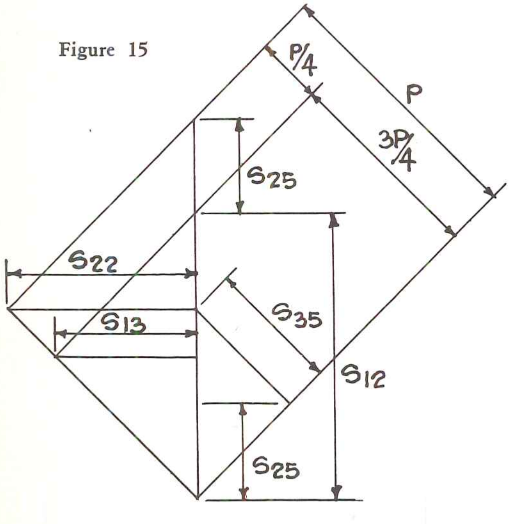
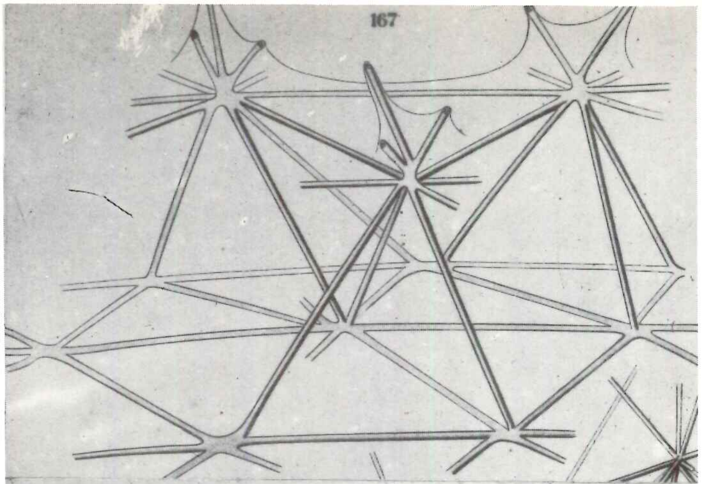
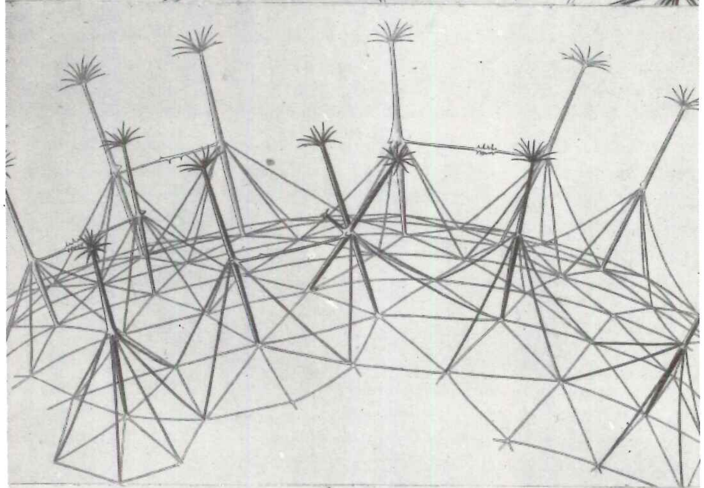


Figure 15







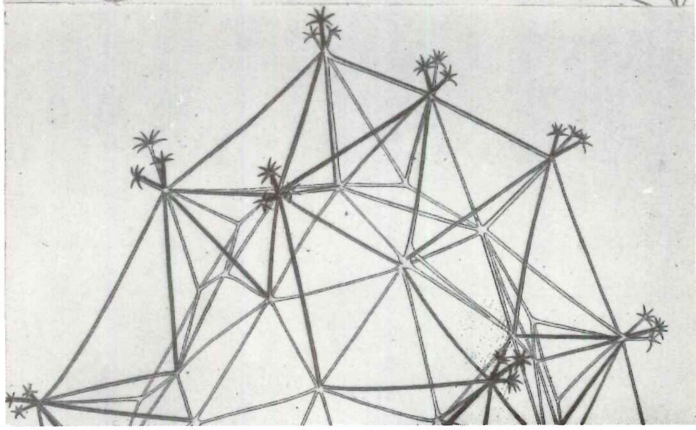


Figure 16

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"H.M.S. CHALLENGER REPORTS"

THREE DIMENSIONAL NETWORKS IN STRUCTURAL DESIGN.

During a very long period, most of our steel structures have been designed to work on a 2 dimensional theme, usually as conventional trusses and connected more or less rigidly between themselves to form a rigid construction. It is worth noting that in spite of living in a 3 dimensional universe, the human concept of space is somewhat abstract, this perhaps on account of representational problems more usually and easily dealt with in 2 dimensions. After all, Monge's invention of orthographic projection is only 150 years old.

Nevertheless the idea of using polyhedronal structures is indeed a very old one. Although dimmed by the dust of history, let us recall Rankine's conception of polyhedronal cells, similar in a way to the bee's hive. Once more, clear minded mathematicians and topologists like Cremona and Maxwell were far ahead of their times. More recently Professor Mayor of Geneva University* devoted his talent to the study of 3 dimensional Statics and devised a method of calculation by the theory of complexes. The Reischtag Hall in Berlin, now destroyed, had been built by one of his students, Mr. Yung, on a 3 dimensional system. Some bridges also have been erected in Germany on the principle of space beams. Very probably numerous examples of 3 dimensional design exists. We have seen in the Cyclades windmill wings built on a very ancient but ingenious system of this kind.

The more obvious utilization of network design is related of course to roof or floor construction. Just like concrete slabs, the bending moments are shared by the two main axis, the optimum condition being when square elements are employed. Before discussing that important problem, we will point out what we consider as a major criticism of our conventional thinking, although this has not much to do with 3 dimensional structures.

Today our buildings are made on the rectangular or square modular unit. Let us assume a square floor, resting on 4 beams of side A supported by 4 columns, carrying a load of Q lb./sq. ft. If instead, we use equilateral triangle of side A′ the number of beams and supports is 3 for the same load area, the ratio between A′ and A is function of the area covered, and: $A'^2/A^2 = \sqrt{3}$ i.e.; $A' = A\sqrt{3} = 1,31\ A$. The distance between supports is increased by 31% with the important advantage of reducing the number of columns in the proportion of 3 to 4. This triangular distribution of supports involves a hexagonal plan, which is on the other hand, far more subtle and richer in combinatorial potentialities than the orthogonal partition.**

Obviously, our industrial rolled sections are not designed for the type of connection wanted, but the possibilities of welding loom so large, than sooner or later, the question will have to be seriously considered. Three dimensional floor panels may be designed either in the orthogonal or the diagonal setting. Although the diagonal system results in an increased number of joints, this disposition is more logical on account of a better symmetry of the lateral eave beams.

According to our computations, for a normally loaded roof (60 Lb/Sq.Ft.) the approximate structural weight would be around 6 to 7 Lbs/Sq.Ft. for an area of 46′ x 46′ on 4 supports (this figure including the peripheric beams). The panel depth of four feet may be an objection to this kind of solution; on the other hand, the introduction of an omni-directional modular cell or unit, may be also questionable. Diagrid solution, which is somewhat a limit case of 3 dimensional network flattened to 2 dimensions appears more practical for the requirements of present day building programs.

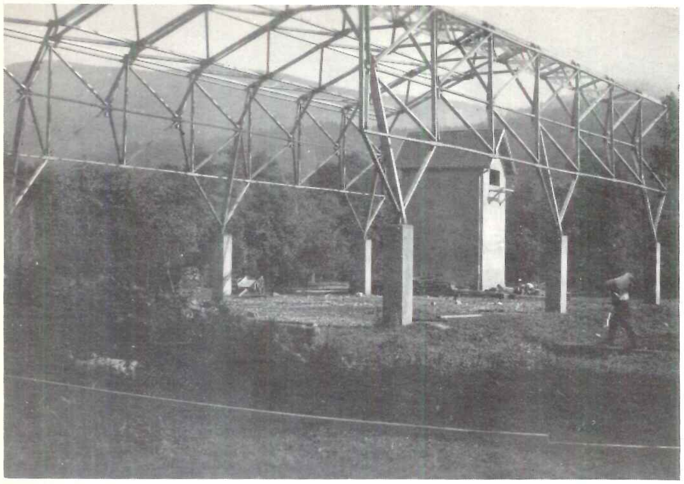
For certain economical reasons, the first applications of networks were made in timber. We apologize for the small realizations of what we consider an interesting conception. Although very poor, France has always preferred extravagant ideas to methodical investigations. This accounts for the slow development of those researches.

One of the first prototypes was erected in Nantes in 1946 (fig. 19). This was a dihedral diagonal network, having a span of 48 ft. with 4 columns spaced 25 ft. apart, covering an area of 1200 sq. ft. Only 1020 board feet of timber was required, and 0.9 lb. of steel per sq. ft. The assembly was made with bolted V plates of simple and inexpensive design. We had no possibilities of using the American ring connector device, which would have much improved the bolt connections.

It was soon apparent that the most interesting aspect of these networks layed in the new forms which they permitted. It appeared also that those statically determinate structures, or perhaps, more exactly practically determinate structures, in the case of diagonal configuration, would behave just like rigid bodies with respect to any special axis. It was with such considerations in mind that another experimental structure was erected at Masevaux, due to the kindness of Koechlin's Mills Factory (fig. 20). Here the whole assemblage took the form of a continuous vault, the longitudinal stiffness of which, allowed the supports to be widely spaced. The thrust was absorbed in a predetermined ratio, between the two main axis. The total area covered was 36′ x 52′ or 1875 sq. ft. the total weight of the structure came to approximately 3.5 lbs. per sq. ft.

* Introduction a la Statique Graphique des Systemes dans l'Espace. 1902; By Prof. B. Mayor. Lib. Payot, Lausannes, Switzerland.

** "Structural Approach in Hexagonal Design." R. Le Recolais, Paris 1953.



R. LE RICOLAIS

Figure 20

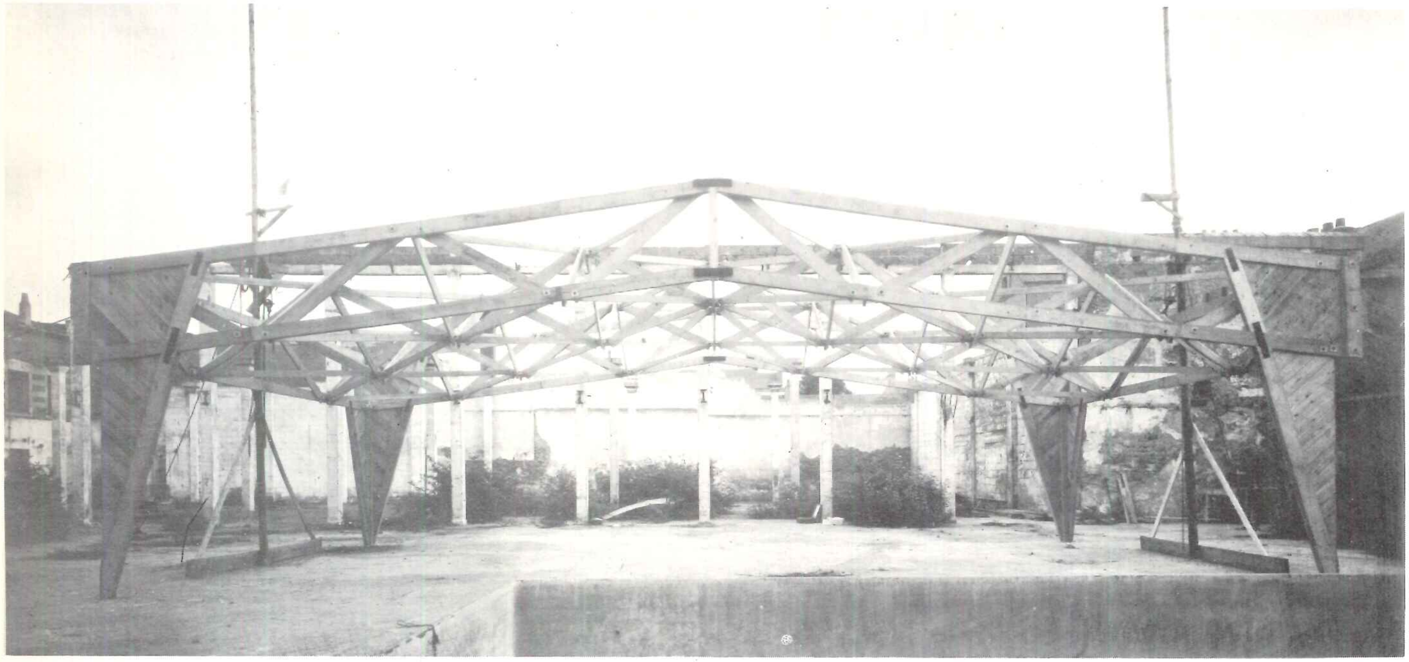
Thus far limited budgets have restricted these experiments to timber but the system appears adaptable to other materials as well. The use of steel should be advantageous, since the continuity at the connections could be obtained through welded joints. Caution should be noted regarding secondary moments involved in that particular instance, and the structure should be calculated as a rigid frame.

This solution based on the property of paraboloids of revolution intersected by parallel vertical planes results in a minimum number of bars of different length, together with an unique type of joint. In the near future, when synthetic materials will be available for roofing purposes, propositions of this kind may be worthy of closer investigations.

As a final comment, we will caution designers against considering 3 dimensional networks as capable of solving all problems with unequalled efficiency. Extrapolation in the possibilities of new systems or new materials are always full of risks and dangers. It is certainly true that this technique belongs to a scale exceeding our present need in building, and presently the restrictions lie in the increased labor involved in the connections. In this respect, we will conclude in saying that the choice of a correct modulus for cell unit is likely to decide the economic factor in function of the type of building wanted. This somewhat common place assertion is particularly important in 3 dimensional design.

R. Le Ricolais
Paris, France
December, 1952

Figure 19



R. LE RICOLAIS

"ARCHITECTURE FROM THE SCIENTIFIC VIEWPOINT"

A PAPER DELIVERED IN A SYMPOSIUM AT N. Y. UNIVERSITY DEPT. OF FINE ART, 17 E. 80TH ST., NYC. FRIDAY, MAY 12, 1939, BY **R. BUCKMINSTER FULLER**

Recently as a superfluous trustee of a School of Design, I came to feel quite emphatically that their approach to design was self-deceptive, an odd characteristic of an organization called "school."

Together not only with the original "Bauhaus" but with hundreds of similar mushroomings in this country, this School starts with scientifically outmoded **limits.** Science today is working both subjectively and objectively in the octaves **above** and **below** the sensorial bands of **perception.** The sensorial bands constitute but 6% of the known octaves of reality.

Of the particular point of departure of the design schools to which I refer, it must be noted, that, while they think themselves "moderns" because they tinker sometimes for long hours with end products of science's design, paradoxically their very sensoriality **dates** them as "medieval"; and by the latter's measure they are neither adequately apprenticed craftsmen, nor sacred enough religious succers to be economically effective.

They start to design in the terms of the obvious characteristics of the latest materials **provided for them by industry,** failing to observe that the phenomenon of "industry" is one in which these materials were the outgrowth of engineering demands to fulfil the unlimited yet individually specific requirements of new-era man. New-era man deals in **dynamic balancing** and selects, sythesizes and shapes the apparatus of his physical environment accordingly, despite having been taught by tradition to **believe** only in static balance.

It is a careless viewpoint that construes objective **manifestations** of the new society such as a new **plastic** or a new **alloy** as constituting unique discoveries of the individual designer, as though he personally had made an original finding of a basic chemical element, whereas he has but naively encountered a **compound** of isolated elements only after years of cooperative effort by the army of anonymous laboratory workers has provided that latest status quo of materialization.

Nothing seems more fatuous than esthetically emotional exclamations of "appreciation" of the physical properties of the myriad of new materials by so-called "industrial designers," which exclamations on one hand indicate that the speaker anticipates public acclaim for his perspicacity in making the "discovery," and, on the other hand, infers that the anonymous industrial individuals who have spent years in developing the materials should have been so blind as to have expended that effort unwitting the dynamics and potentials of their endeavor.

This is **not** to say that I depreciate the vigorous and imaginative efforts of people to polish up their world or to find better ways of living. It **is** to say, however, that I consider it presumptuous and spurious for any teacher to indicate to students that they are to get results by running superficially through the catalogue of objective life, industry, science, philosophy, and art, as a one or even two year hop, skip and jump.

General misapprehension exists regarding "science." First, it is considered by the majority of people to be difficult, ponderous, obscure, annoying. Secondly, science is considered by many harmony loving people to be prosaic, possibly fascinating but nevertheless hard, even cruel and devastating wherefore such schools seek to circumvent the **activities** of science and grasp only at the fruit that falls from its branches to the ground. I would like to dispel these false notions.

First, let me quote Sir Arthur Eddington's definition of science which goes somewhat as follows: "Science is simply the sincere attempt to set in order the facts of experience." It must be remembered however that these **sincere** attempts must be **consistent** and universally applied, playing no favorites, leaving nothing out. As a result of such sustained attempts, scientific laws are developed. These laws are in no way arbitrary as are man-made laws of civil conduct about what people may be permitted to do out of the myriad of things they can do. Scientific laws are statements of observation of consistently observed characteristics and behavior patterns. Technology applies science by composing the phenomena of the individual laws in reciprocal arrangement.

For all these reasons the vast activity of science today is often misappraised by the populace who accuse science of arbitrarily inventing and manufacturing gadgets that are unnecssarily disturbing to the status quo. Often the suggestion is heard that a holiday of scientific activity should take place to allow the world to settle down to some nebulous "security." Inherent in Eddington's definition is the truth that so long as one is orderly in mind, tolerant, and in command of his faculties of perception, he cannot help but observe and **"set in order the facts of his experience,"** at least to a relative degree, wherefore a holiday in scientific activity would mean mass mutilation of the perceptive faculties and universal abrogation of integrity. No, we will have no such holiday. Science is simply unearthing the eternally old tapestry of universal dynamics, which have **always** and for all time been in play and were only obscured from us by our own superstitions and artifices or lack of nervous control and measuring means.

The other night by impulse I reached for a book on my shelves which had been our text book at the Naval Academy 22 years ago. It was the text book on Naval Ordinance and Ballistics—a confidential issue to student officers. I remembered that I had studied it with infinite care, yet had long ago forgotten the specific text. I opened to the first page and read a passage which at that time, pointed as I was at a special engineering art, never occurred to me to possess the universal application which I suddenly found in it after the 22 year interval. To me, now it sounds like sheer poetry, even the perfect love affair. Of course, that is as it should be. Science under the definition I am presenting to you should include all-certainly human beings and their important behavior patterns.

(Quote) "When a force is applied to a body, the effect produced depends upon whether or not the body is free to move. A force applied to a free body produces motion. A force applied to a fixed body produces change of form.

Stress is the mutual action between two bodies, or the parts of one body causing or tending to cause them to move relative to each other; it is any pair of equal and opposite actions each of which is called a force.

In experimental development in industrial research of such items as a new automobile or airplane, or boat, we make a distinction between "botch" and "finished" work. Good engineers try to turn out a "finished" job for they know that industry will not readily adopt half-baked developments despite the fact that the physical principles involved might warrant adoption. It is simply a matter of the old saying, "never show a fool half finished work." The technical difference between **botch** and **finished** work is that the latter requires beyond the rough hull, whose lines may be excellent, adequate inclusion of the problem factors and scientific submission of each problem not only to stress measurements but to the scientific oral, visual, tactile and olfactory frames of reference.

Good architecture it seems to me is thus often produced by engineers who are unconscious of being architects. In fact I am suspicious that what is now being made into "Schools" of contemporary architecture springs precisely from these excellent productions of such unwitting "architects."

You are a little put out by the simplicity of that argument. So am I. It isn't as simple as that. We certainly have to admit that those men who were distant enough from our American articulation to have perspective upon it couldn't resist from saying to themselves about the unconscious American artist: "If he would only whittle off that little splinter and that corner, etc., what he is articulating might be nearly perfect." Sometimes the botch work was allowed, not because the engineer could not have done a finished job, but because of budgetary limits.

This botch surface of the American factory was so stark and strange that it inspired European designers to copy it and do a "finished" job, but not being engineers and only superficially inspired by the phenomenon, they have gone, to a certain degree, preposterously far afield from good engineering.

Now this supervision of our design that has come from abroad in the guise of a new "order" of architecture was excellent as a revolutionary barrage but when it seeks to settle down to become the new entrenched and static academy that is another matter. Listen Gentlemen! It took us 10 years to get rid of the Beaux Arts.

I said earlier that new-era man deals in **dynamic balance** selecting and shaping the apparatus of living despite having been brought up by tradition to believe in **static balance.** That belief, that all the good things were only in the past—"in the good old days"—was probably useful in developing a continuity of the social consciousness, but it has now outlived that usefulness. We have witnessed how it is perishing in architecture. His Royal Britanic Majesty having been at last moved, because he was in "check", the static balance tradition must rapidly vanish. We, who in America have approximately an auto, a telephone, and a radio per family were asked to think in the static tradition of peoples who were developed on foot and possessed none of these instruments of world girdling. We were taught that in order to be a good citizen we were to buy our land and build our permanent home thereon and stay "put."

But now the economic system that taught us has "renigged." First, it sent its gold to us which was the eseence of its intrinsic property theory (though we are going to put it to work in functional uses), and put its all in mobile fleets, merchant and martial, and finally has uprooted its trademark, "H.R.M. God Emperor," and exports "it" too, along the northwest spiral lest it (the trademark) be forced to run away. A runaway King in crisis time is not God Sovereign. No God-King, no empire. Vanished the billion producer-customers. A King moved in anticipation of potential "check" is good enough chess, but it may no longer be maintained by steadfast tradition that **security lies in immobility.** We, here in America, had already found out for ourselves that security lay in mobility, ergo the revolt from reality of 1929 (from reality as dirt) but then of course America was traditionally "gauche" in such matters.

You may say why pick on the King? What has he to do with what you are talking about? I am not picking on George VI as a personality. I am discussing the habits of concept involved in ethical propaganda in maintaining a theoretical economic sovereignity. I speak of the King here as an abstract trademark of the largest business corporation in the world, "The British Empire"—whose anonymous directors see themselves slipping from No. 1 position for the first time in a ½ millenium—and who by the shrewdest statecraft existent hope to pull the cat out of the bag even if it means moving the works to America with the possibility of puppeteering with the invisible strings of indirection, not the least important of which are the ethics and aesthetics twins.

The King still is "king" to the salesman of the British trademark and to the Bank of England but to John Doe U.S.A., without analyzing deeply, an awareness will develop that the King Sovereign of the "static" tradition, "A rolling stone gathers no moss" has himself rolled indeed, and may be rolling for some time. God Emperor of a billion people, half of all humans, has **anticipatingly** moved. He just "went to the fair to buy some blue ribbons," but he may find it logically improper to return per schedule and may "tie up the bonnie brown hair" by two way telecast while the "Repluse" rushes the kiddies "over" to join them at the Fair (temporarily of course). God King temporizes!!

In the meantime jumping from our intuitive reorientation shock we might well ponder over a possible correlation between the multibillions of emigre dollars now here and the delicately imposed emigre "aesthetic" upon our naive factory articulations of rational survival. Somebody is spending a lot of money.

I have a suspicion that America will lose its inferiority complex that made it dress up its buildings for 150 years to conform to European tradition now that the King is doing a run around. I hope so. The result will be that spirituality and beauty will be left to expression by life, the only true abstract.

I never thought when I was first working on the Dymaxion house (which was, and still is, only theory and attitude) that it would take a trip of the King of England to America to prove my point—not "mobility" for mobility's sake but **potential mobility for security's sake.** Architecture for the quick, not the dead.

Richard Buckminster Fuller

STRUCTURAL APPROACH IN HEXAGONAL PLANNING

R. Le Ricolais

GENERAL OUTLOOK

Architectural researches on the Hexagonal Plan are by no means new. Frank Lloyd Wright and other world famed Architects have planned with this theme, but curiously enough, at least as far as we know, it does not appear that such problems have been 'Structurally' focused, except for certain Silos, Hangers, or small individual housing units.

Why Hexagonal Design?

Independently of their specific importance, the arguments may be set as follows:

(a) TOWN PLANNING.

Who could deny the importance of traffic in town planning programs? The primacy of quick and efficient transportation is the basic requirements of a well designed town. Who could also deny the classic inconveniences of the rectangular grid shown by experience to be impractical and costly and harassed by the necessary introduction of diagonal roads?

The "Concentric' system usually preferred is hardly better (congestion of traffic in city centers) and induces lengthy travel between points when peripheral highways are used.

Truly the idea of making roads perpendicular to normal traffic flow is purely paradoxical.

Omitting local interference, the best design for circulation should approximate the 'Bee line' as closely as possible.

This is the solution inherent in the 3axis grid resulting from the division of a planer surface by equilateral triangles.

This 3 axis system is being successfully applied in the planning of the city of New Delhi. It can be shown that even in worst circumstances the bee's line distance is never exceeded by more than 15.5% average distance increase increment. In fig. 1 the grid travel distance from A to B is about 13.5% in excess of a straight line distance between these points.

The 3 axis system can be shown to be some 33% more economical insofar as distance travel between points is concerned than the Concentric system.

The 3 axis system has development possibilities for existing cities, its application has been studied for the City of London.

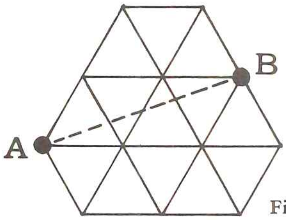


Figure 1

Rational occupation of ground areas indicates to us the use of Hexagonal Design. Following is shown a sketch of an intersection based on the Hexagonal grid together with buildings designed on the hexagonal module.

(b) THE HEXAGONAL CELL

An interesting feature of the Hexagonal cell is the increase of two sides over that of square or rectangular figures. We will see in the structural analysis of the Hexagonal Grid the fundamental importance of this particular point.

The option among six sides of the hexagon for locating adjacent cell aunits is of extreme importance for cell aggregates requiring optimum situations for sun exposures, prevailing winds or for holding building shaded surfaces to minimums.

These two added dimensions should prove to be major assets in the overall flexibility of design.

(c) PERIPHERAL LENGTH REDUCTION.

We will mention but will not emphasize the reduction of perimeter lengths and all the consequent advantages as viz: Shortening of distances, reduction of heat loss, economy and flexibility of interior partitioning.

Reluctant as we are to idulge in unmotivated comparisons, there is some evidence that the Urban texture bears some organic analogical relationship with biological cells. The underlying causes are different in nature and in scale but we do not doubt that they are related by some general geometric and topological laws.

It is one of tomorrow's tasks to give us the key to many problems of this kind.

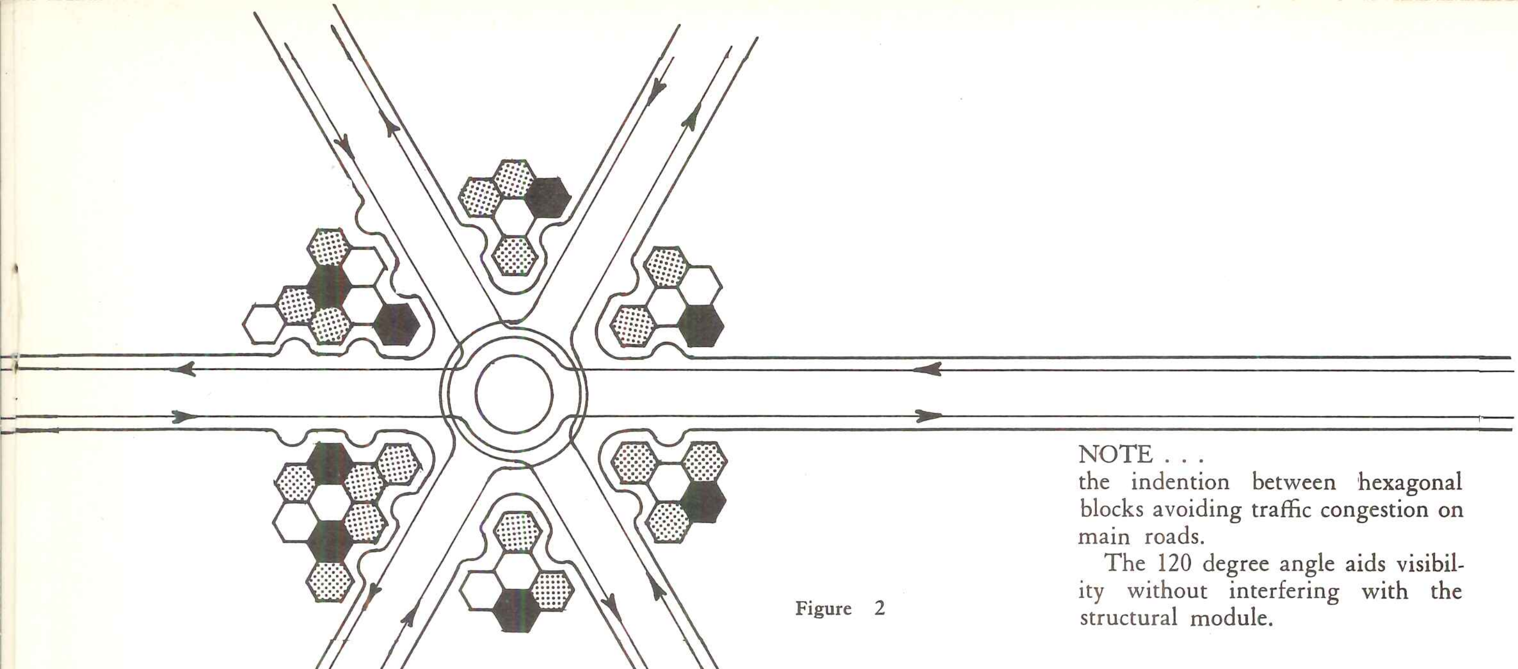


Figure 2

NOTE . . .
the indention between hexagonal blocks avoiding traffic congestion on main roads.

The 120 degree angle aids visibility without interfering with the structural module.

STRUCTURAL ECONOMY OF HEXAGONAL DESIGN

As a matter of fact we readily believe that with conventional Orthogonal design the potentiality of steel construction has diminished to a standstill. Only a fundamental change in the pattern of building is liable to change the issue. i.e. Less Steel per Square Foot, More Square Feet Carried per Column.

The dismissal of the Orthogonal pattern in building has always far reaching consequences and can only be seriously considered if economies of material and labor are indicated for such a radical change.

Are real economies involved? Can definite figures be given, confirmed by some valid proof?

We must answer; YES—decidedly, conscious as we are that the elementary mathematical tool we use should be developed with greater accuracy and refinement. But indeed advanced mathematics are not necessarily requisite for this very simple problem.

Previous to any formal demonstration (we do not present our argument as a formal demonstration, but rather as a basis for discussion) we believe it far more instructive to give the successive steps that lead us to our conclusion.

In spite of the immense advantage of electric welding and its consequent 'continuous frame' characteristics, in spite of highly industrialized components such as light girders or joists, etc., steel structures appear to us as presently lacking that creative ingenuity so largely displayed by builders dealing with prestressed concrete, as if a kind of dead end has been reached in steel usage and performances stabilized into definite or permanent configurations.

ANALYSIS OF HEXAGONAL GRID

Roughly described, the main components of any building are peripheral girders receiving the joists which support the flooring elements on which uniform load is superimposed and bearing—these and of course the columns.

The most economical girder weight conditions are obviously reached when the area inscribed by the columns is a square, the load being evenly distributed along the four sides of the square.

If instead of a square area we take a Hexagon supported by six columns (i.e. one at each vertex), for a unit length of beam the floor area becomes 2.6 times the square area.

In fact this very trivial assertion is the base of the Hexagonal Grid idea.

The results of these foregoing observations are given in more mathematical terms in Calculation Sheet A1.

They can be summarized in two paragraphs.

(1)—COMPARING HEXAGON AND SQUARE OF SAME AREA, EQUALLY LOADED AND HAVING EQUAL DEFLECTION, IN HEXAGONAL DESIGN THE ECONOMY OF PERIPHERAL GIRDER IS 50% WITH RESPECT TO THE ORTHOGONAL SYSTEM.

(2)—WITH IDENTICAL WEIGHT AND IDENTICAL DEFLECTION OF PERIPHERAL GIRDER, THE REDUCTION IN NUMBER OF COLUMNS IN HEXAGONAL DESIGN IS $\sqrt{2}$ TIMES LESS THAN THE NUMBER REQUIRED IN ORTHOGONAL SYSTEM.

There remains now the problem: How to distribute the uniform load to the peripheral girders? The more obvious system seems to be the use of triangular or hexagonal Star beams converging from columns to center.

Unfortunately the Star beam by itself is a very poor solution as is proved by Calculation Sheet A2, so much so that we loose to the Star beam the weight gained in the peripheral girder.

DESCRIPTION OF HEXAFLEX SYSTEM

Having to discard the Star beam, other solutions must be examined. The most satisfactory being the creation of a very simple device: the conversion of the old 'King Post' beam into a three axis system.

As is well known, this system is quite interesting as concerns efficiency. By means of the tension ties an extra support is gained at the hexagon center; furthermore, it induces very low shearing stresses at the supports and labor operations remain minimal. Calculation Sheet A3)

A particular feature of the Hexaflex system requires the pre-tensioning of ties to the extent that dead and live deflections are nullified by a proper camber.

The general disposition is shown in fig 3. Here Hexafiex beams are supported at A1, A3, A5.

The floor load is evenly distributed between three peripheric girders A2A3, A4A5, A6A1. and three Hexaflex beams A10, A30, A50.

Joist depth is equivalent to Hexaflex beam. Note an alternate solution with intermediate beams X1Y1, X2Y2, X3Y3.

This solution being convenient for conditions of long span between columns.

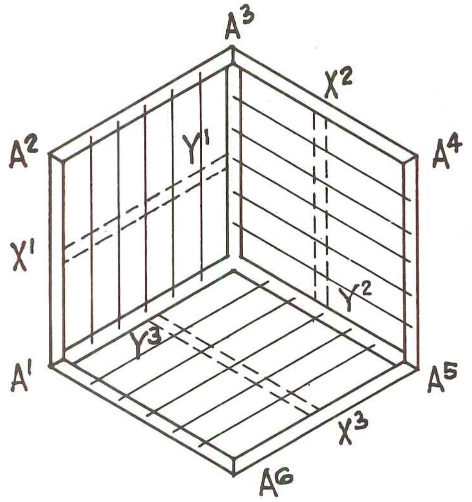
For certain exceptional spans this scheme can be advantageously replaced by 3 Dimensional Hexagonal networks.

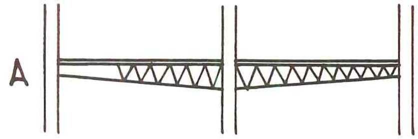
APPROXIMATE WEIGHT COMPUTATION OF A HEXAGONAL FLOORCELL

This computation is made without reference to a real hexagonal cell unit but in terms of an average modular unit of a square floor supported by four columns, locating a six meter bay (19' - 8").

The distance between column supports in the Hexagonal configuration has been taken as 5.43 meters (17' - 10"). The dead load being 500 kg per square meter (104 lbs/sq ft)

The details of the calculation are on Sheet A4, worked out on the base of C.G.S., and French profile Gauge.





The results may be tabulated as follows:

1	Columns	Periph'l Girder	Hexaflex Beam	Tie Rod & Strut	Joists	TOTAL
French Gauge	HN 12	HE 15	HN 26	9.5 x 10 cm. 2		
Weight Kg./M	5.3 lb.	5.3 lb.	19.3 lb.	9.25 lb.	2.4 lb.	
Weight Hex. Grid	54.1 lb.	175 lb.	325 lb.	174 lb.	308 lb.	1025 lb.

Or approximately; 13.5 lbs. of steel Per Sq Ft.

The analysis being completed by table 2.

2	Floor Area in Feet	Area in Feet per Column	Total Weight in steel Lbs per Sq Ft.
Square Grid	382	95	18
Hexagonal Grid	815	136	13.5

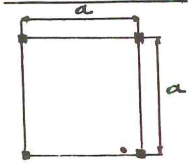
CONCLUDING BY:
Economy of Steel in Hexagonal, versus square grid: 33%
Reduction number of columns, versus square grid: 41%

Sheet A1

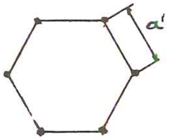
COMPARED ANALYSIS BETWEEN ORTHOGONAL AND HEXAGONAL DISTRIBUTION OF PERIPHERIC GIRDERS

A1

ORTHOGONAL (a)



HEXAGONAL (b)



a) IDENTICAL AREA _ LOAD PER GIRDER IDENTICAL FOR EACH GIRDER : $\frac{6\sqrt{3}}{4} \cdot \frac{a'^2}{6} = \frac{a^2}{4}$ $\frac{a'^2}{a^2} = \frac{1}{\sqrt{3}}$

$$\frac{a}{a'} = \sqrt[4]{3} = 1.315 \qquad (1)$$

ON THE ASSUMPTION OF SAME DEFLECTION, I BEING PROPORT. TO s (SECTION AREA). THE HEIGHT OF PROFILE BEING CT

$$\frac{I_a}{I_b} = \frac{a^3}{a'^3} = 1.315^2 = 2.28 \qquad (2)$$

ω_a, ω_b, BEING THE RESPECTIVE WEIGHT OF GIRDERS : $\omega_a = 4a s_a$, $\omega_b = 6a' s_b$ TOGETHER WITH $s_a / s_b = I_a / I_b$

$$\frac{\omega_a}{\omega_b} = \frac{2}{3}\frac{a s_a}{a' s_b} = \frac{2}{3}\frac{a^4}{a'^4}$$ BUT FROM (1) $a'^4 = \frac{a^4}{3}$ AND

$$\frac{\omega_a}{\omega_b} = 2 \qquad (3)$$

b) ON THE ASSUMPTION OF EQUAL WEIGHT OF GIRDER, LET US FIND THE VALUE OF a', FOR AN IDENTICAL LOAD IN BOTH FLOOR, AND IDENTICAL DEFLECTION. THIS CONDITION GIVES : $\omega_a = \omega_b$ OR

$4a s_a = 6a' s_b$, $s_b / s_a = 4a / 6a' = 2/3 \times a/a'$, AND WE HAVE :

$$\frac{I_b}{I_a} = \frac{s_b}{s_a} = \frac{a'^3}{a^3} = \frac{2}{3} \cdot \frac{a}{a'} \qquad 3a'^4 = 2a^4$$

$$\frac{a}{a'} = \sqrt[4]{\frac{3}{2}} = 1.105 \qquad (4)$$

THE AREA COVERED IN HEXAGONAL CONFIGURATION IS :

$$\frac{3}{2} a'^2 \sqrt{3} = \frac{3\sqrt{3}}{2}\sqrt{\frac{2a^2}{3}} = \frac{3\sqrt{3}}{2} \times \frac{\sqrt{2}}{\sqrt{3}} a^2 = \frac{3\sqrt{2}}{2} a^2$$

LET US FIND THE NUMBER OF COLUMNS PER AREA UNIT :

FOR AN ORTHOGONAL FLOOR : $n_a = 4/a^2$, FOR HEXAGONAL:

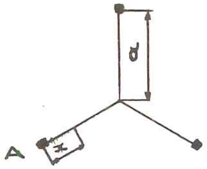
$$n_b = 6/a' \tfrac{3\sqrt{2}}{2} a^2, \quad n_a / n_b = \frac{4}{a^2} \times \frac{3\sqrt{2}/2}{6} = \sqrt{2} \qquad (5)$$

STAR-TRIANGLE BEAM _ UNIFORM LOAD.

(A2)

DEFLECTION _ Q_P LOAD PER BEAM,
q " " UNITAREA
p " " LENGHT

TOTAL LOAD ON HEXAGON:
$\sqrt{3}/4 \cdot a^2 q$



$$Q_P = ap \quad , \quad q = \frac{4\sqrt{3}}{3} a \quad , \quad V_A = Q_P = ap$$

$$M_x^t = -EI \frac{d^2y}{dx^2} = apx - \frac{px^2}{2} \quad , \quad EI\frac{dy}{dx} = \frac{px^3}{3} - \frac{pax^2}{2} + c$$

FOR $\frac{dy}{dx} = 0$, $x = a$

$$c = \frac{pa}{2}a^2 - \frac{pa^3}{6} \quad , \quad c = \frac{pa^3}{3} \quad \text{AND}$$

$$EIy = \frac{px^4}{24} - \frac{pax^3}{6} + \frac{pa^3}{3}x \quad , \text{ WITH } y_{max} \text{ FOR } x = a$$

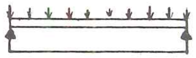
$$EIy = \frac{pa^4}{24} - \frac{pa^4}{6} + \frac{pa^4}{3} = \frac{5pa^4}{24}$$

THUS $$y = \frac{5pa^4}{24EI}$$

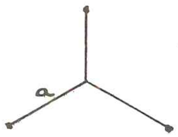
Sheet A2

Sheet A3

COMPARED ANALYSIS WITH CONVENTIONAL BEAM ON 2 SUPPORTS



$$y_2 = \frac{5pl^4}{384EI}$$



$$a = \frac{l}{\sqrt{3}}$$

$$y_3 = \frac{5pa^4}{24EI} = \frac{5pl^4}{216EI} \qquad y_3/y_2 = \frac{384}{216} = 1.78$$

AND $W_3/W_2 = \sqrt{3}$

CONCLUSION : THE STAR BEAM IS OF NO INTEREST.

(A3)

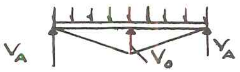
HEXAFLEX BEAM _ CALCULATION OF REACTIONS

$$M = apx - \frac{px^2}{2} \quad , \text{ THE TOTAL ENERGY IS } U = \frac{3}{2EI}\int_0^a M^2 dx$$

$$M^2 = p^2a^2x^2 - p^2ax^3 + \frac{p^2x^4}{4} \quad , \quad U = \frac{3}{2EI}\left| \frac{p^2a^2x^3}{3} - \frac{p^2ax^4}{4} + \frac{p^2x^5}{20} \right|$$

$$\text{FOR } x = a \quad , \quad U = \frac{3}{2EI}\left| \frac{p^2a^5}{3} - \frac{p^2a^5}{4} + \frac{p^2a^2}{20} \right|$$

$$U = 4\frac{p^2a^5}{20} = \frac{p^2a^5}{5}$$



$$V_o = \frac{2U}{y} = \frac{2p^2a^5}{5EI} \times \frac{24EI}{5pa^4} = \frac{48}{25}pa$$

STATIC GIVES: $3V_A - 3pa = -V_o$, $V_A = pa - \frac{V_o}{3}$

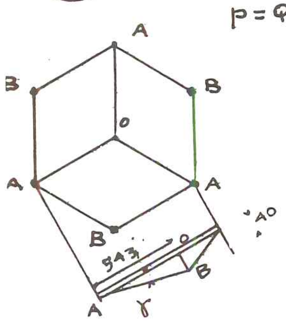
AND $$V_A = \frac{9}{25}pa$$

Sheet A4

HEXAPLEX BEAM_ CALCULATION OF STRESSES AND SECTION AREA_

A4

LENGTH: CENTIMETER_ FORCE: KILO_ $\tan\gamma = \sin\gamma = 40/543 = 0.0736$,



$p = Qp/a = \frac{6400}{543} = 11{,}8$ (ASSUMED LOAD: 500 K° PER SQ. METER.

$N_{OB} = \frac{48}{25}\, pa$, $N_{AB} = \frac{N_{OB}}{2\sin\gamma} = \frac{48\,pa}{3{,}68} = 13{,}1\, pa$

$N_{OB} = \frac{48}{25} \times 11.8 \times 543 = 12.350$ K° , $N_{AB} = 13{,}1 \times 11{,}8 \times 543 = 84.000$

$N_{AO} = N_{AB} = 13{,}1\, pa = 84.000$ K° , $\Omega_{AB} = \frac{84.000}{1440} = 58{,}3$ CM2

TAKING FOR AO: 26 HN _ $\Omega = 119.6$ CM2 _ WEIGHT = 94 K/M.

AND $I/v = 1.154$ CM3. WE HAVE FOR TOTAL STRESS IN OA:

$$R = \frac{N_{AO}}{\Omega} + \frac{M}{I/v} = \frac{84.000}{119.6} + \frac{435.000}{1.154} = 10.79 \text{ K°/CM2}$$

NOTE _ THE PRE-TENSION OF TIE IS ADJUSTED TO EQUALIZE SAG OF PERIPH. GIRDERS.

PERIPHERIC GIRDER _ ASSUMING BUILT IN ENDS AND CONTINUITY:

$$\delta = \frac{Ql^3}{384EI}$$, WHERE WE MAKE $\delta = 1/500 \times 543 = 1.09$ CM

$$I = \frac{6.4 \times 5.43^3 \times 10^9}{384 \times 2 \times 10^6} = 1230 \text{ CM4.}$$

TAKING HE 15 _ WEIGHT: 26 K°/M.

COLUMNS _ FROM TABLES _ HN 12 _ 26 K°/M.

R. LE RICOLAIS

CONCLUSION

Whether these substantial economies can be obtained in practice and whether they tend to outline a revolutionary trend in our present building routines, indeed, we do not know.

The proposed shift to a Hexgonal Grid undoubtedly would so modify deep rooted habits and psychological behavior, that presently no valuable prophecy can be made.

Consider for instance the stately reception room vistas characteristic of the seventeenth century Architecture; consider also the omnipotent dogma of facades, these considerations now utterly inconsequent to the new Isotropic configurations, governed by the inexorable laws of economy.

As already mentioned we are intellectually and intuitively convinced that this economy is not fictitious and equally convinced that such economy is consistent with valuable conveniences such as increased flexibility in inner arrangements, and perhaps far more functional adaptability than occurs in the conventional patterns.

R. Le Ricolais
Paris, France
February, 1953

MIES VAN DER ROHE

THE END OF THE BAUHAUS:

TRANSCRIBED AS IT WAS TOLD TO SIX STUDENTS DURING AN INTERVIEW WITH LUDWIG MIES VAN DER ROHE AT THE SCHOOL OF DESIGN, NORTH CAROLINA STATE COLLEGE, IN FEBRUARY, 1952.

HELEN BALFOUR MORRISON

I became director of the Bauhaus only because Gropius came one morning with the Mayor of Dessau and told me: "The school will break to pieces if you don't take it." He said that if I would take it over it would go ahead. And later in 1932, the Nazis came. Nobody's position was strong enough for that. In 1933 I closed the Bauhaus. Maybe that is interesting to you.

You know the rise of the Nazi movement was not so sudden. It began at Dessau. That was the first state that became by election—Nazi. After the Nazis came to power, the mayor told me they wanted to see what the Bauhaus was doing and so on. They wanted an exhibition for criticism, and he said, "I know you would like a vacation for two weeks. I am delighted to give you a vacation," and I said, "No. I'd like to stay here. I'd like to see these people." And I did.

Then they came. It was a long talk. There was one man; his name was Schulze-Naumburg, and he wrote early, you know, about 1900, works on cultural tendencies in general*, about old buildings and about the factories ruining the country—sentimental, aesthetic, typical of the misunderstanding of his day. He wanted to change. He wanted to save wonderful towns. You cannot save wonderful towns. You can only save wonderful towns by building new ones.

That's all you can do. He was a man in the Nazi movement, very old with a Gold medal.** There were only about ninety that had these gold medals. He was one of these men. And he came, and we gave an exhibition at the Bauhaus. I tried everything, to keep that in order. And we made a wonderful exhibition, and I had a heck of a time, you know, with Kandinsky. Kandinsky had his constructions of old pictures, these geometric analysis. I said, "Do we have to show these?" And he had a fit. So I said, "Keep it." And we put it on the table that was in the center of a huge room. Everything was around and this analysis was on the table. When these people came we had a talk, and then I showed them what we were doing. I moved them, you know, around the walls. They never saw the table.

It was then I knew it was absolutely hopeless. It was a political movement. It had nothing to do with reality and nothing to do with art. I had nothing to lose, nothing to win, you know. I didn't want to win. But now we talk about what really happened in the end.

The city of Dessau decided to close the Bauhaus. They stopped us and they said, "You have to go."

* A series of books under the title: "Deutsche Kulturarbeiten"

** A Gold Party Badge, which only the early members of the party had.

The mayor, who loved the Bauhaus and wanted to help us, said, "Take all the machinery, all the weaving looms, and just leave."

So I rented a factory in Berlin. I did that on my own. It cost me 27,000 marks for three years. It cost 9,000 marks a year. That was a lot of money in Germany, nothing in America. So I rented this factory that was terrible, black. We started to work—all of us—every student. Many Americans who were with us will remember that we cleaned it all up and painted everything white. This was a solid, simple factory painted clean, wonderful, you know. And just on the outside, on the street, there was a broken down wooden fence, closed. You couldn't see the building. And I can assure you there were a lot of people when they came there and they saw this fence went home. But the good ones, they came through and stayed. They didn't care about the fence. We had a wonderful group of students.

One morning, I had to come from Berlin in the streetcar and walk a little, and I had to pass over the bridge from which you could see our building, I nearly died. It was so wrong. Our wonderful building was surrounded by Gestapo—black uniforms, with bayonets. It was really surrounded. I ran to be there. And a sentry said, "Stop here." I said, "What? This is my factory. I rented it. I have a right to see it."

"You are the owner? Come in." He knew I never would come out if they didn't want me to. Then I went and talked to the officer. I said, "I am the director of this school," and he said, "Oh, come in," and we talked some more and he said, "You know there was an affair against the mayor of Dessau and we are just investigating the documents of the founding of the Bauhaus." I said, "Come in." I called all the people and said, "Open everything for inspection, open everything." I was certain there was nothing there that could be misinterpreted.

The investigation took hours. In the end the Gestapo became so tired and hungry that they called their headquarters and said, "What should we do? Should we work here forever? We are hungry and so on." And they were told, "Lock it and forget it."

Then I called up Alfred Rosenberg.*** He was the party philosopher of the Nazis culture, and he was the head of the movement. It was called Bund Deutche Culture. I called him up and said, "I want to talk with you." He said, "I am very busy."

"I understand that, but even so, at any time you tell me I will be there."

"Could you be here at eleven o'clock tonight?"

"Certainly."

My friends, Hilberseimer and Lilly Reich and some other people said, "You will not be so stupid as to go there at eleven o'clock?" They were afraid, you know, that they would just kill me or do something. "I am not afraid. I have nothing. I'd like to talk with this man."

So I went that night and we really talked, you know, for an hour. And my friends, Hilberseimer and Lilly Reich were sitting across the street in a cafe window so they could see when I came out, if alone, or under guards, or what.

I told Rosenberg the Gestapo had closed the Bauhaus and I wanted to have it open again. I said, "You know, the Bauhaus has a certain idea and I think that it is important. It has nothing to do with politics or anything. It has something to do with technology." And then for the first time he told me about himself. He said, "I am a trained architect from the Baltic states, from Riga." He had a diploma as an architect from Riga.I said, "Then we certainly will understand each other." And he said, "Never! What do you expect me to do? You know the Bauhaus is supported by forces that are fighting our forces. It is one army against another, only in the spiritual field." And I said, "No, I really don't think it is like that." And he said, "Why

*** Author of Der Mythus Des XX. Jahraunderts: bible of Nazi philosophy didn't you change the name, for heaven's sake, when you moved the Bauhaus from Dessau to Berlin?" I said, "Don't you think the Bauhaus is a wonderful name? You cannot find a better one." He said, "I don't like what the Bauhaus is doing. I know you can suspend, you can cantilever something, but my feeling demands a support." I said, "Even if it is cantilevered?" And he said, "Yes." He wanted to know, "What is it you want to do at the Bauhaus?" I said, "Listen, you are sitting here in an important position. And look at your writing table, this shabby writing table. Do you like it? I would throw it out of the window. That is what we want to do. We want to have good objects that we have not to throw out of the window." And he said, "I will see what I can do for you." I said, "Don't wait too long."

Then from there on I went every second day for three months to the headquarters of the Gestapo. I had the feeling that I had the right. That was my school. It was a private school. I signed the contract. It was 27,000 marks—a lot of money. And when they closed it I said, "I will not give up that thing." And it took me three months, exactly three months, to get to the head of the Gestapo. He must have had a back door somewhere, you know. And he had a bench in the waiting room not wider than four inches, to make you tired so that you would go home again. But one day I got him. He was young, very young, about your age, and he said, "Come in. What do you want?" I said, "I would like to talk to you about the Bauhaus. What is going on? You have closed the Bauhaus. It is my private property, and I want to know for what reason. We didn't steal anything. We didn't make a revolution. I'd like to know how can that be."

"Oh," he said, "I know you perfectly, and I am very interested in the movement, the Bauhaus movement, and so on, but we don't know what is with Kandinsky." I said, "I make all the guarantee about Kandinsky." He said, "You have to, but be careful. We don't know anything about him, but if you want to have him it is O.K. with us. But if something happens, we pick up you." He was very clear about that. I said, "That is all right. Do that." And then he said, "I will talk with Goering, because I am really interested in this school." And I really believe he was. He was a young man, about your age.

That was before Hitler made a clear statement. Hitler made this statement in 1935 at the opening of the House Der Deutschen Kunst, the House of German Art, in his speech about the cultural policy of the Nazi movement. Before, everybody had an idea. Goebbels had an idea; Goering had an idea. You know, nothing was clear. After Hitler's speech the Bauhaus was out. But the head of the Gestapo told me he would talk with Goering about it and I told him, "Do it soon." We were just living from the money we still got from Dessau. Nothing else came to us.

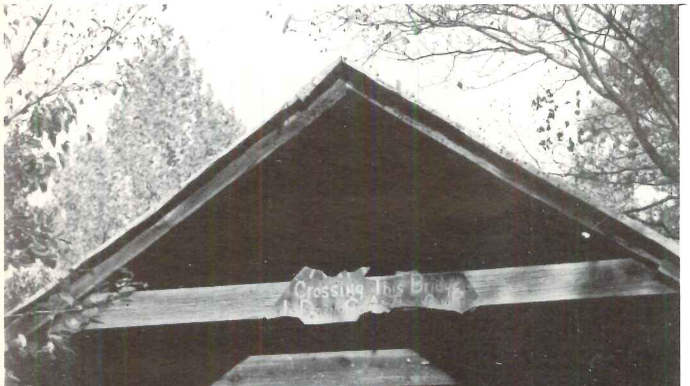
Finally I got a letter saying we could open the Bauhaus again. When I got this letter I called Lilly Reich. I said, "I got a letter. We can open the school again. Order champagne." She said, "What for? We don't have money." I said, "Order champagne." I called the faculty together: Albers, Kandinsky . . . they were still around us, you know, and some other people: Hilberseimer, Peterhans, and I said, "Here is the letter from the Gestapo that we open the Bauhaus again. They said, "That is wonderful." I said, "Now, I went there for three months every second day just to get this letter. I was anxious to get this letter. I wanted to have the permission to go ahead. And now I make a proposition, and I hope you will agree with me. I will write them a letter back: 'Thank you very much for the permission to open the school again, but the faculty has decided to close it!'"

I had worked on it for this moment. It was the reason I ordered champagne. Everybody accepted it, and was delighted. Then we stopped.

That is the real end of the Bauhaus. Nobody else knows it, you know. We know it. Albers knows it. He was there. But the talk about it is absolute nonsense. They don't know. I know.

HISTORIC REGIONAL ARCHITECTURE

W. L. Baumgarten
Professor of Architecture
School of Design
North Carolina State College



HAROLD SMYRE

The School of Design requires that every student during the summer vacation after the Sophomore Year do a research project on "Regional Architecture." This Regional Research project is intended to instill in the student an interest and respect for historic buildings of his native region. Our task is an extension of that of the **Historic American Building Survey,** from which the following information has been obtained:

"It is the purpose of the Historic American Building Survey to study, measure, and draw up the plans, elevations and details of the important antique buildings of the United States. Our architectural heritage of buildings from the last four centuries diminishes at an alarming rate . . . It is the responsibility of the American people that if the great number of our antique buildings must disappear through economic causes, they should not pass away unrecorded.

"The general scope of the Historic American Building Survey contemplates measuring and recording the complete field of Early American Architecture from the earliest aboriginal structures to the latest buildings of the Greek Revival Period. The date selected as a final terminus is 1860, but this is more or less arbitrary as there may be individual buildings of a later date of a character worth recording, and on the other hand, some buildings erected before this date may not be of a character to make it desirable to record them. Buildings of historic importance, such as birthplaces of statesmen, eminent artists or scientists, will be recorded even though their erection was subsequent to the date set.

"It is intended that the survey shall cover construction of all types, from the smallest utilitarian structures to the largest and most monumental. Barns, bridges, mills, toll houses, jails, fences, markers, and in short structures of every description are to be included so that a complete picture of the culture of the time as reflected in the buildings of the period may be put on record."

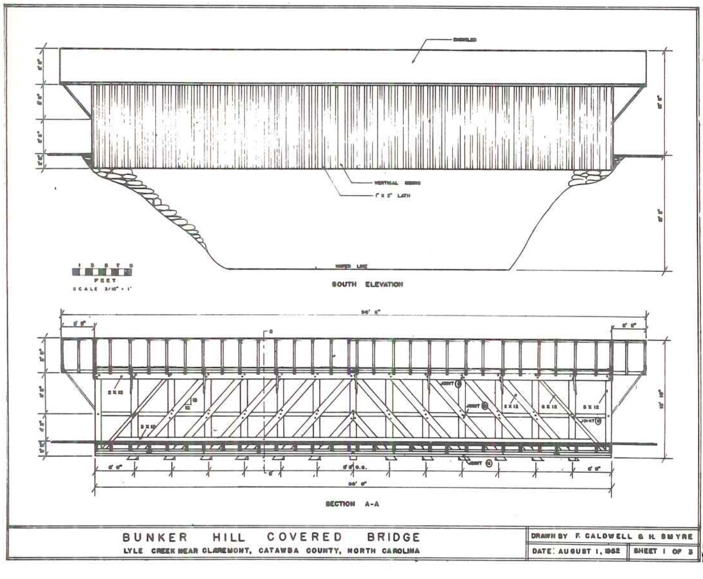
Since there are a number of students from other States enrolled in the School of Design, it is to be expected that this research project will be extended on a national level. Two very good results of the last year's survey are included.

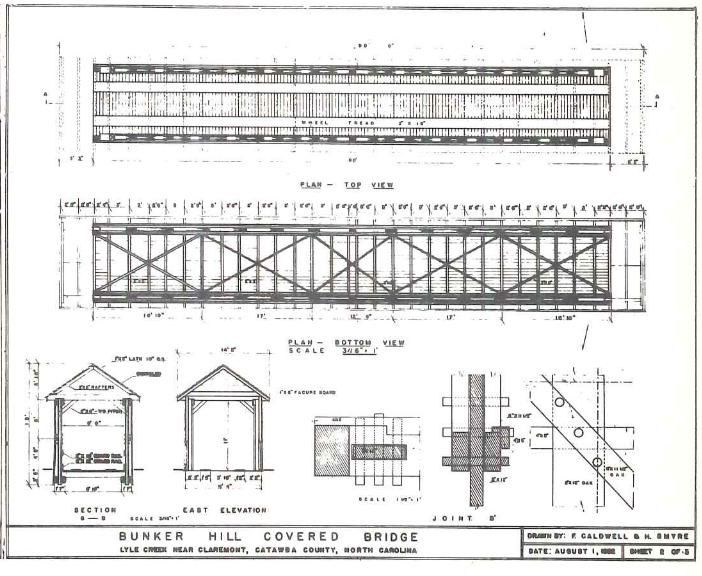
BUNKER HILL COVERED BRIDGE, CATAWBA COUNTY, N. C.

HAROLD SMYRF

In 1783 a rough highway was laid out from Island Ford, Catawba County, to the courthouse of Lincoln County in Lincolnton twenty miles away. In eastern Catawba County near the town of Claremont the old road crossed Lyle Creek over the Bunker Hill Covered Bridge. No information is available concerning the original bridge, but the present structure built in 1890 replaced an identical bridge built about 1850 at the same spot. From verbal testimony of R. F. Conner, grandson of one of the builders, Mr. Raymond L. Hefner, president of the Catawba County Historical Association, identified the builders of the bridge as Andrew L. Ramsour assisted by Eli Kale, George Hollar, Cain Bost, and Rowell E. Conner. The old road is no longer in use, but the Bunker Hill Covered Bridge still stands only a few hundred yards from U. S. Highway 64-70.

Frank Caldwell and Harold Smyre
3rd yr. students



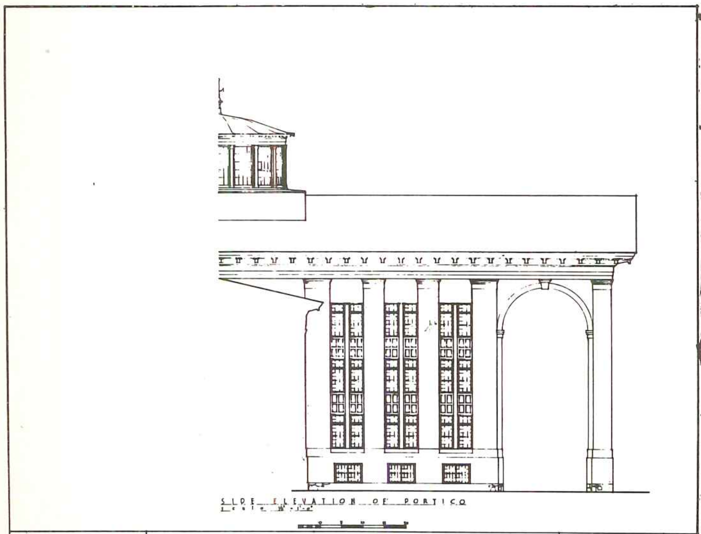


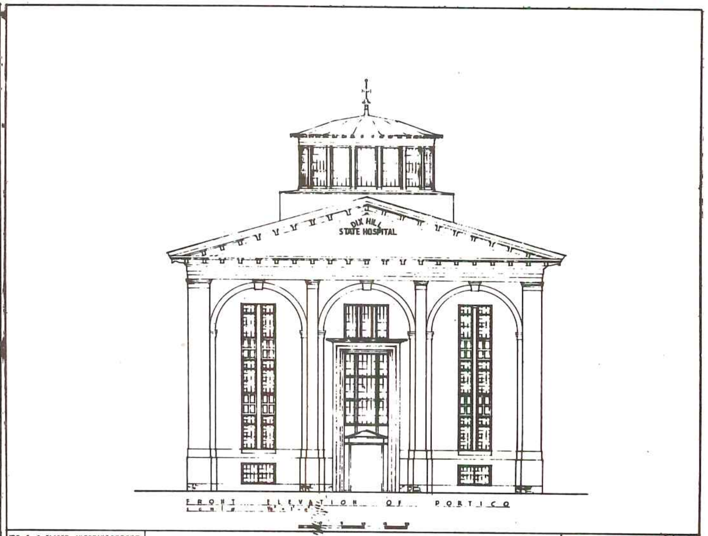
NORTH CAROLINA STATE HOSPITAL, RALEIGH, N. C.

A bill passed by the Legislature of the State of North Carolina on December 30, 1848, largely through the efforts of Dorothea Lynde Dix, provided for the establishment of a State Hospital for the insane. At the time, North Carolina, save the small territory of Delaware, was the last of the thirteen original states which had no provision for the care and cure of its insane citizens. The passage of the bill to provide funds for the hospital, and the subsequent construction and staffing presented almost insurmountable obstacles, but through the untiring efforts of Dr. Edward C. Fisher, superintendent during the construction years, the hospital received its first patient on March 5, 1856.

Ted Peters
5th yr. student

GEORGE MATSUMOTO





DEVELOPMENT OF CONTEMPORARY MUSIC

With the exception of the work of a small group of truly productive composers, the bulk of our contemporary music is insignificant. The music of our more prominent composers such as Stravinsky, Ravel, and Prokofiev, to name a few, might be novel and, perhaps, entertaining, but has contributed relatively little to the progression of artistic thought. "Modern" music is characterized my a conglomeration of superficial traits designed to promote emotional stimulation, which unfortunately, is currently considered by many as the prime requisite of "good" music. Obviously, this consideration is erroneous. Whether or not music should be intensely emotional or purely intellectual is relatively unimportant. This must be entirely dependent upon the discretion of the artist. What is important is that the composer should remain true to his material. Hence, the music a composer is apt to create must not only be a reflection of his ego, but also a function of the technical instrumental development of his day.

The present tendencies inherent in modern music man be attributed, for the most part, to two factors. First, our contemporary music is an outgrowth of the music of the nineteenth century. Music of this period was based on pure emotionalism. Tonality had already reached its zenith in the music of Beethoven, and now composers found themselves working in a medium in which the artistic possibilities had been seemingly exhausted. As a result, music reverted to "human" or "natural" feeling for appreciation. The music of this monophonic period was usually made up of two ingredients—thematic material and harmony. When the two are separated and analyzed, it can be seen that they bear little structural thematic relationship to each other. This is roughly analagous to the architecture of the eclectic period, when classical facades were draped over steel superstructures and the result called art. Second, composers have long since felt that the traditional system of harmonics based on major and minor keys is inadequate for a conclusive rendering of contemporary artistic expression. The resultant desperate expansion of harmonic technique led to the disintegration of tonality. The past several decades has revealed a strong effort by composers to reject traditional harmonics. Radical mutations in chordal arrangement, along with severe changes in tonal modulation, have taken place.

These tendencies, plus a few novel techniques such as rythm modulations, glissando, chromaticism, extended pizzicato, greater volume, etc., forms the bulk of what constitutes contemporary music. All these are unsuccessful, for they are merely distortions of the traditional tonal system and are based on no logic consistent with their use.

Order is the important aspect of music, the aspect which differentiates it from noise. Tonality is secondary, for chords which were considered crude and "unesthetic" a hundred or two hundred years ago are today considered commonplace. The palatability of dissonant chords is relative to the frequency of their use. The fact is that human beings can become accustomed to practically any combination of tones if subjected to them long enough. Hence, the fundamental thematic structure is the most significant quality of music, as the basic structure of any art form is its most important aspect.

About fifty years ago, the late Arnold Schonberg realized that the antiquated harmonic system could be replaced by a system of composition in which each tone is of equal value and bears a direct relationship to a previously arranged sequence of tones. Thus, Schonberg originated the twelve tone system which today stands as the first successful contemporary system of tonal and thematic coordination. Schonberg knew that in order for his system to be useful, it must be capable of introducing coherency, as well as the greatest flexibility, into a composition based upon it. He proposed the use of an arbitrarily arranged sequence of the twelve tones in the octave as a line of reference, rather than the traditional seven tone diatonic scale.

In the twelve tone system, the composer arranges for a particular composition the twelve tones in an arbitrary sequence which, to him, is most suited for the rendering of his artistic ideas. All the thematic and tonal phrases in the composition must be related to the original sequence or to any of the prescribed variations. These variations are affected by inversions, reversals, and transpositions of the original sequence, so that in all, forty eight variations of the first arrangement are possible. Thus, Schonberg constructed a system of musical construction which completely ignores the traditional key system yet retains coherency and expands flexibility. Schonberg's system is based also on a rigorous polyphonic technique in which each thematic segment is indirectly related to its partner or partners. Here, his music, and the music of two of his more successful students, Alban Berg and Anton Von Webern, is reminiscent of the music of eighteenth century contrapuntal artists.

It is interesting to note the amazing parallel which exists between some of the later music of Bach and that of the aspirants of twelve tone technique. Late in his life Bach devised two works which anticipated twelve tone music by two hundred years. In his **Musical Offering** which consists of a series of variations in several forms of a given chromatic theme, Bach referred to pure polyphony. A portion of this work is devoted to several canonic variations of the theme. The character of the Bach's contrapuntal art is anticipatory enough, but in one of the canons, Bach penned an improvisation of the theme for three instruments, *each in a different key*. The implication here cannot be denied. In the other work, **The Art of The Fugue,** Bach demonstrated his ability to produce successful fuges from reversals, inversions, and other mutations of an original theme. Here again each thematic phrase becomes independent, yet closely related to the whole. Though Bach's music was definitely based on the harmonic systems of his day, one cannot help but feel that to him, pure harmony was secondary to thematic structure. Though over two hundred years old Bach's music is a great deal more novel than most of our contemporary efforts. Incidentally, the later music of Beethoven was also strongly anticipatory of twelve tone techniques especially in his last group of string quartets, and most certainly in his **Grosse Fuge, Opus 135.**

Schonberg's origination of twelve tone technique has encouraged the formulation of numerous similar techniques by many of our younger contemporary composers. The general philosophy of these techniques seems to be that the actual substance of the musical material is secondary to the manipulation or modulation of the material. As an outstanding example, John Cage, a contemporary American, has composed a work for *twelve radios,* where what happens to be on the radio frequency prescribed is secondary to the rythm, volume, and time intervals inherent in the work. Mathematics plays an important role in these recent inovations, especially in the works of Pierre Boulex and Cage, where relationships are formed between the various musical components (rythm, time, tone, dynamics) and serial mathematical arrangements. The music becomes a function of the series.

Thus, the twelve tone system and other related techniques stand as a natural step in the evolution of musical development. They are not mere arbitrary formulae for producing "modern" music, but are systems born out of the necessity of integrating thematic and harmonic material in a method consistent to, and expressing, our capabilities. They are not purely theoretical. The most convincing and successful music of the past fifty years has grown from them. Unfortunately, most of these techniques are considered as outrageous and as a hoax on the musical world. Listeners and musicians as well are still so steeped in either tradition or confusion that they do not recognize the real nature of the problem which today confronts musical creation nor the genuis which has solved it.

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Visitors to the School of Design for the Spring Term:

GEORGE NELSON (March 30, 31, April 1, 2) Industrial designer of New York City conducting three seminars for students and one public lecture.

ROBERT ROYSTON (March 30 to April 30) Landscape architect of San Francisco (Eckbo, Royston and Williams) conducting a problem with students of landscape architecture and consultant on problem with students in second year architecture.

GEORGE BOAS (April 1 to May 24) Philosopher from Johns Hopkins University conducting a course in Philosophy of Design for fifth year students of the school.

PAUL BURLIN (May 4, 5, 6) Painter now at the School of Fine Arts, Washington University, St. Louis, conducting a series of seminars for the descriptive drawing classes.

WALTER GROPIUS (June 6, 7) Architect to receive the honorary degree of Doctor of Architecture.

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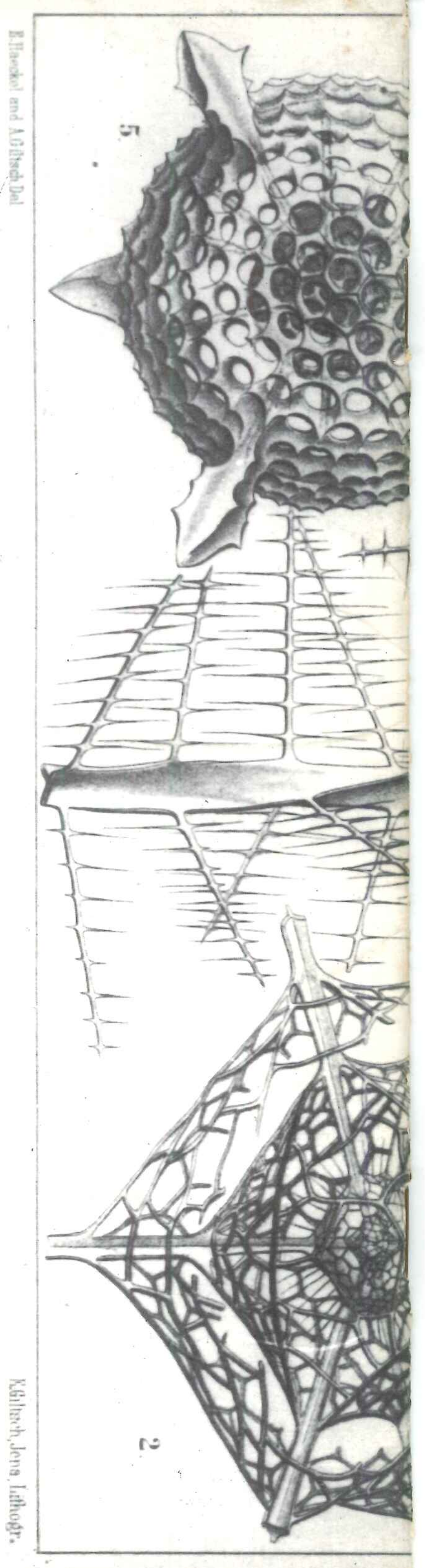

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